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DIVWAG MODEL DOCUMENTATION
VOLUME II
PROGRAMMER/ANALYST MANUAL

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CHAPTER 7

GROUND COMBAT MODEL

1. MILITARY ACTIVITY REPRESENTED:

a. The Ground Combat Model simulates the interaction between the direct fire weapons of opposing maneuver units engaged in ground combat. The effects of obstacles intervening between engaged units are simultaneously treated, as are unit reactions to such obstacles.

b. Since combat power may be enhanced by employing combined arms forces against the enemy the model permits simulation of the interaction and the effects of weapons of cross-reinforced units. The effectiveness of the maneuver unit is largely dependent on the combinations and coordination of weapon systems within the unit. The distance of separation of weapon systems is limited so that mutual support is possible when weapon density permits.

c. The impact of the environment is represented in the model. Movement in ground combat is subject to the constraints imposed by the environment wherein optimum ability to move forces by ground is degraded by the effects of adverse weather, terrain, and visibility. The application of firepower is largely controlled by the environment since effectiveness of each weapon system is limited by its associated target acquisition capabilities.

(1) Target acquisition cannot occur unless line of sight exists between the observer and target. Line of sight may be severely limited due to terrain roughness, vegetation, and forestation. A firer may lose line of sight on a moving target before firing a round. A moving target may drop out of line of sight during the time of flight of the round.

(2) Target acquisition is limited by visibility, whether due to adverse weather or night combat operations. Under conditions of reduced visibility, target acquisition is enhanced by the employment of night vision equipment.

d. The interaction of each maneuver unit with an opponent is considered by the model in terms of a maneuver unit's effectiveness and vulnerability.

(1) The maneuver unit's effectiveness is influenced by the level of activity. As the level of activity increases, more weapon systems can acquire targets. As individual moving weapon systems stop to fire, the unit movement rate decreases. The possibility of observing an enemy weapon's signature (i.e., evidence of that weapon firing)

increases with the level of activity. The chance of hitting such a target is less than against an observed target.

(2) The maneuver unit's vulnerability is influenced by the level of activity. A firing system may disclose its position and become a target for enemy fire.

e. Intervening obstacles will delay the progress of advancing units which encounter them and may, in the case of active obstacles (minefields), be a direct cause of losses to an encountering unit. Vulnerability to opposing units' fires may also increase for a unit which encounters an obstacle in that such a unit may be detained while in a relatively unfavorable position and may be unable to return fire as effectively as might otherwise be the case.

2. MODEL DESIGN. The Ground Combat Model is composed of three logically interrelated groups of routines. These are the routines which control the logical flow through the model and bookkeeping functions of the model, the group of routines which simulate the exchange of direct fires between a pair of opposing maneuver units, and those portions of the model which simulate the interactions of a maneuver unit with an obstacle.

a. Direct Fire Exchanges. For one attacking unit the Ground Combat Model processes an engagement by examining the interaction between the attack unit and each defending unit. The interaction of each unit pair is treated independently of other units in the engagement and is accomplished by treating, in sequence, the areas of unit geometry, target acquistion, firepower potential, and firepower effectiveness and assessment.

(1) Unit Geometry.

(a) All combat units are represented as being bounded by rectangles of variable width and depth. Each such rectangle is further subdivided into as many as four rectangular bands of equal area. Each band contains a predetermined percentage of the unit's total equipment of each type based upon the unit type and mission. Equipment of each type in each band is distributed uniformly. Participation in a ground combat engagement is limited to direct fire weapons and targets in the front band of a unit.

(b) To simplify computational problems in the model, each opposing unit pair is treated as though their leading edges were parallel. This is accomplished by rotating about its center the rectangle representing a unit until the unit is represented as facing a desired engagement orientation angle. The engagement orientation angle is calculated for each opposing unit pair based upon the relative motion of the units. This orientation is used to establish the front-to-front distance between opposing units and the extent to which unit fronts overlap, or face each other. The rotation is used only in assessment of direct fires and has no effect on unit orientation within other models of the war game.

(c) Unit velocities are initially specified, at a separation of approximately three kilometers, through gamer input to the movement model. Unit velocity in the Ground Combat Model is limited by mobility class rates within the model's constant data base. If the specified initial velocity does not exceed the mobility class rate of any mobile weapon system in the front band of the unit, it is considered to be the actual initial velocity. If the specified velocity does exceed one or more mobility class rates, the slowest of these rates is substituted as the actual velocity of the unit. All moving weapon systems are considered to move at their mobility class rate in an average direction of 45 degrees offset from the unit movement direction, the difference in unit and weapons system rates being attributable to a difference in postures among the elements. The weapon system postures considered are either stationary or advancing at the system's mobility class rate.

(d) Each unit is positioned mid-way between its initial and final locations for the engagement interaction being processed and areas of responsibility are assigned to each weapon based upon the concept of mutual support. The scheme for area assignment is depicted in Figure IV-7-1. Figure IV-7-1 shows each actively engaged portion of the enemy unit covered by at least two weapons, with some areas covered by three or more weapons. (For computational efficiency the single coverage region, in the general case where 5 percent or less of a unit's rounds are delivered, is ignored, having a minor effect in the overall assessment of casualties.) This figure also demonstrates the model's capability of allowing a unit to concentrate its strength on a portion of the enemy unit. This capability is a result of the unit geometry orientation scheme.

(e) Once the active individual weapon's area of responsibility has been determined, the number of each target type active within this area is determined assuming uniformly distributed targets. Weapon systems and targets laterally displaced away from the edge of the enemy unit as illustrated in Figure IV-7-1 are not considered active. For each searching weapon system only nonzero priority target types are considered. (Weapon target priorities are discussed under firing doctrine below.) The number of targets within each weapon system's area of responsibility is then broken down to the number within that area that are covered two, three, or more times; and the range to

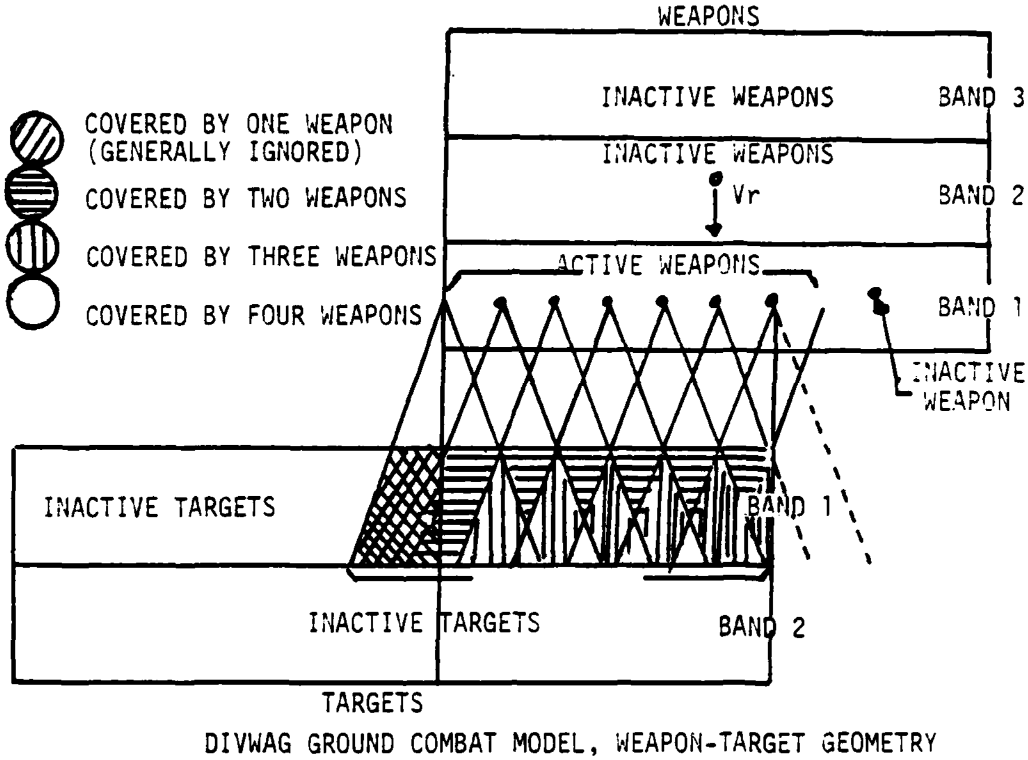


Figure IV-7-1. Weapon-Target Coverage Pattern for Laterally Offset Units the center of each type coverage region is calculated. Targets within each type coverage region are further distributed among possible activities in the two postures defined above. Four target postures are considered:

1. Stationary and not firing.

2. Stationary and having fired one round.

3. Stationary and having fired two or more rounds.

4. Advancing and not firing.

(2) Target Acquisition.

(a) Visual target acquisition methodology is based upon modifications of the IMPWAG report (Reference 3). For each priority target type in each posture in each coverage region type, the probability that the observing weapon system is looking at this target is calculated. Given that the observer is looking at the target, the probability that the target's apparent contrast is detectable is calculated. Apparent contrast is a function of the target reflectance, vegetation, season of the year, time of day, and weather. Given that the observer is looking at the target and that its contrast is detectable, the probability that line of sight exists between the observer and target is calculated. Line of sight probability is calculated using an equation from a Ballistics Research Laboratory study, where the variable parameter has been expanded as a function of terrain, forestation, target type, and target posture. This line of sight parameter is discussed in detail in Appendix A to this chapter.

(b) The probability that the observer detects nothing is calculated using these detection probabilities along with the numbers of each target type, in each posture, in each coverage region type that were calculated by the Unit Geometry Submodel.

(c) This probability is combined with the probability of nondetection of all other sensor types (appropriate to the existing conditions) at the observer's disposal. The capability of each other sensor type comes from fitting curves to existing experimental data. Finally, the probability that the observer detects at least one priority target is calculated. The expected value of the time to detect at least one target and fire is determined from this probability.

(d) Pinpoint probabilities are considered within the Ground Combat Model as follows. Based upon the total number of rounds fired by targets in postures 2 and 3, the probability an observer sees a stationary weapon that fires either one or two rounds is calculated. From this probability and a weapon's single-round pinpoint data (pregame input), the number of observers who pinpoint a target and do not visually observe any other target is calculated.

(3) Firepower Potential. The average time to aim, fire, and deliver a round is added to the expected value of the time to detect at least one priority target. This number is used with the line of sight probability and the number of weapons to determine the number of rounds a weapon system fires. Based upon the total number of rounds fired, the weapon target priorities, and the target acquisition information, the number of rounds fired at each target type in each posture in each coverage region type is determined.

(4) Firepower Effectiveness and Assessment.

(a) The number of conditional casualties is calculated for each target type in each posture in each coverage region type based upon the total number of rounds fired at it. The probability of a hit and the kill probability given a hit are calculated by first determining the hit probability on a standard NATO target at this range (using linear interpolation between known values), using this hit probability to calculate the weapon's error at this range, and finally calculating the hit probability based upon the target's presented area. The kill probability given a hit assumes a linear function in range with known slope and intercept. Applying the firepower potential within the framework of the coverage scheme (see Figure IV-7-1) to account for multiple hits, the number of conditional casualties is calculated.

(b) Based upon these conditional casualties the target's survival probability against each weapon type is calculated and aggregated into a net survival probability against all weapon types. The probability the target is killed by at least one weapon type is then calculated and applied to the number of active targets to generate conditional casualties for assessment.

(c) The adjustment to real casualties provides a correction to properly account for each of three conditions inherent to the model design.

1. The lethalities of multiple weapons carried by the same transport are modified to account for their simultaneous utilization.

2. The lethalities of all weapon systems in both forces are modified to account for return fire.

3. The lethalities of all weapon systems in each force are modified to account for their simultaneous utilization.

b. Obstacle Interactions. Interactions between an attacking maneuver unit and an obstacle, as portrayed in the Ground Combat Model, are included in the following potential actions on the part of a maneuver unit: encounter of an obstacle, selection of an appropriate reaction upon encounter, bypassing an obstacle, breaching or making possible the passage through an obstacle, passage through a breached obstacle, and withdrawal from an obstacle deemed impassable. Barrier interactions are not portrayed for defending units.

(1) Encounter of an Obstacle. Within DIVWAG, the leading trace of an obstacle is represented by a line segment. A unit advancing within the Ground Combat Model is said to encounter an obstacle when the center of the leading edge of the unit's representative rectangle crosses the obstacle line segment. If the obstacle is active (a minefield) and was not previously known by the encountering unit, discovery losses may be inflicted by the field.

(2) Countermeasure Decisions. Upon encounter of an obstacle, several reactions or countermeasures may be available to the encountering unit. Based upon the severity with which the encountering unit is engaged, appropriate reactions are prescribed in the data base, in order of priority. The encountering unit selects and, after appropriate delay, puts into execution the highest priority countermeasure feasible for that unit.

(3) Bypass Option. Within tactical limitations parametrically described in the data base, a unit may simply move around the edge of an obstacle. The extent to which this option is selected can be controlled both by the relative stringency of the limitations loaded in decision tables and by the ability to designate an obstacle as "unbypassable."

(4) Breach Option. Upon encounter the unit may elect to breach an obstacle. Two general breach categories may be portrayed:

(a) The hasty breach is intended to portray cases in which combat vehicles actually pass into the field hoping to open lanes. The vehicles may be portrayed as using mechanical clearing devices, such as plows or rollers, or may be simulated as simply "bulling" through the field.

(b) The deliberate breach is intended to portray cases where lanes are opened with the expenditure of some consumable items and, of course, time, but no direct losses due to the field are expected. Use of explosive line charges is typical of this type operation.

(5) Passage. Given an obstacle with sufficient open lanes to pass the unit, the model portrays the funneling effect of such a passage. Sufficiency of lanes is established with the same data used to select obstacle countermeasures.

(6) Withdrawal. Should a unit encounter an active obstacle and have no feasible countermeasure, that unit will withdraw from contact with the obstacle and with any unit covering the obstacle by direct fires.

3. GROUND COMBAT MODEL CONTROL AND DIVWAG SYSTEM INTERFACE.

a. External Control. External control of the Ground Combat Model is effected through the DIVWAG Scenario Language (DSL). Using DSL, a gamer can control which units will engage in the model, when engagements will initiate and conditions under which engagements will terminate.

(1) Battle Paragraphs. The DSL battle paragraph is the basic vehicle for control of the Ground Combat Model, where a battle is understood to be the exchange of direct fires among a specific group of opposing units. The basic information contained in a battle paragraph are a battle name, a list of battle units and a list of battle termination conditions. For one game period there may be up to 23 battle paragraphs and each battle paragraph may list up to 16 units of each force.

(2) Battle Initiation. A named battle is initiated when a unit, listed in that battle's battle paragraph, receives a DSL ADVANCE order, immediately followed by an order to ENGAGE in the named battle. Upon initiation, the force to which the initiating unit belongs is established as the attacking force, and the opposing force as the defending force.

(3) Battle Participation. A unit is said to be active or participating in a given named battle in the sense that it is able to interact with opposing units by the exchange of direct fires under control of the Ground Combat Model.

(a) A unit can be active in only one named battle at a time and when active in a given battle it will engage only those units listed in the appropriate battle paragraph.

(b) Once a unit becomes active in a battle, all simulated actions of the unit are under control of the Ground Combat Model and the DSL unit scenario is no longer followed. Control returns to the unit scenario only upon termination of the battle.

(c) To be active in a given named battle a unit must be listed in the appropriate battle paragraph, the battle must be initiated and the unit must be acting upon a battle-type order (ADVANCE, PREPARE or WITHDRAW). The following cases are possible:

1. The unit which initiates a battle is, of course, active in that battle.

2. When a battle is initiated all units in the battle paragraph which are acting upon a battle-type DSL order will become active in the battle unless already active in a different battle.

3. Should a unit appear in a battle paragraph and not have a battle-type order when the battle is initiated, the unit will become active in that battle if it receives a battle-type order while the battle is in progress.

(4) Battle Termination. An ongoing named battle terminates when a unit or situational condition, specified by the gamer in the appropriate battle paragraph, is attained or when the game period ends.

(a) Upon battle termination the exchange of direct fires and the effects of obstacles cease to be represented by the Ground Combat Model for those units that were active in the given battle.

(b) Upon battle termination all units in the battle paragraph will start a new order in their DSL unit scenarios. The only exception is a unit active in a different named battle. Thus, battle termination may interrupt the ongoing action of a unit not active in the named battle.

b. Logical Control Within the Model. Once a named battle has been initiated and active units are specified, logic internal to the Ground Combat Model controls the timing and sequence of events as well as the check for termination conditions. Major areas of control logic are provided for three cycles: the basic cycle controls units not in contact with barriers; the barrier cycle controls a unit in contact with a barrier; and the interruption cycle is used to terminate a battle.

(1) Action on Initiation. At the time a battle is initiated a battle control table is established and a Ground Combat event is

scheduled for the initiating unit. The battle control table contains a list of units in the battle paragraph, a mode flag for each unit and an assessment time for each unit. As long as a unit's mode is set to zero, the unit is not active in the battle. When a unit becomes active in a battle, its mode flag is set to one and a Ground Combat event is scheduled, if the unit is an attacking unit, for assessment five minutes after the unit becomes active. When a unit becomes active in a battle that unit's assessment time, in the battle control table, is set to the time at which the unit became active in the battle.

(2) GCM Timing. The effects of direct fires are accounted for within the Ground Combat Model on a post-assessment basis. That is, at the simulated time of assessment the effects which took place between the last assessment time and the current time are accounted for on an after-the-fact basis. The expected value calculations used in this assessment depend on an assumption that conditions of the battle, particularly with respect to weapon performance and the relative positions of opposing elements, remain generally stable over the length of time being represented.

(a) In the absence of barriers, a basic five minute assessment increment is used. Thus the status of units involved in an on-going battle is updated every five minutes, unless some barrier interaction is involved. The five minute increment was selected based on results of sensitivity testing of the model.

(b) As a moving unit encounters and reacts to a barrier, the assumption of generally stable conditions is violated. Thus, each time the nature of the unit's barrier interaction changes, the exchange of direct fires is updated to the time of the change. Length of time a unit will be in a given "state" with respect to a barrier can, in most cases, be calculated within the model prior to the actual assessment and a general rule has been established for the length of direct fire assessments when under barrier influence. If the "state" will last less than seven minutes, direct fires will be simulated in one increment of the length needed to cover the time until transition to a new "state." If the unit will be in the "state" for over seven minutes, direct fires will be assessed every five minutes, with the final increment not allowed to be less than two minutes duration.

(3) Action on Entry to the Model. The overall logical flow of the model is shown in Figure IV-7-2. The model is entered in response to a scheduled GCM event for some attacking unit. After establishing basic data and obtaining the battle control table, a check is made on existence of a battle termination condition. If a termination condition does exist, the interrupt cycle is entered to halt all action going on in this battle. If not, either the basic or obstacle cycle of operation

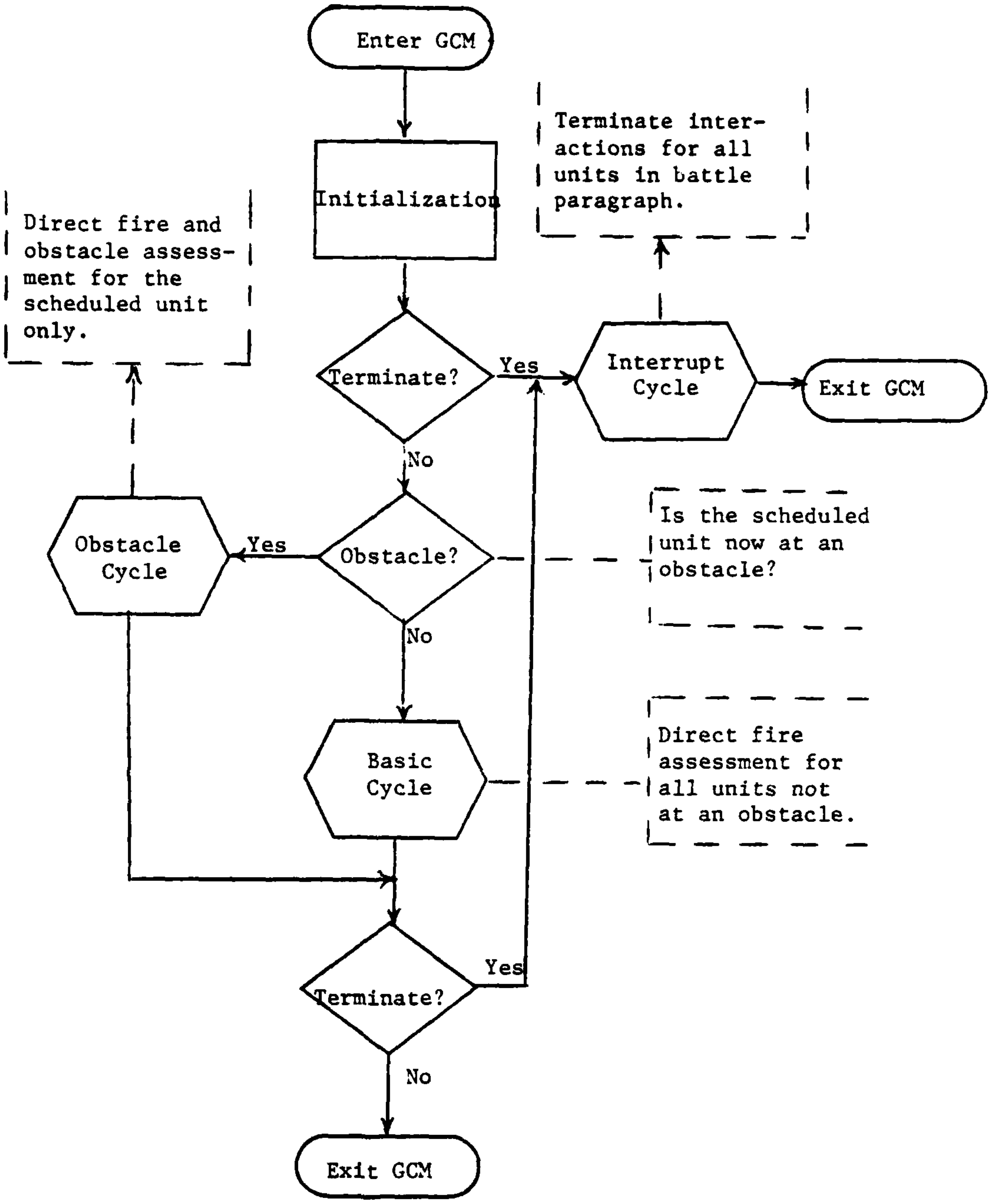


Figure IV-7-2. Overall logical flow of GCM.

is entered, depending upon whether the attack unit for which the model was called is involved with a barrier. Upon assessment in the appropriate cycle, termination conditions are again checked and the battle is either interrupted, if a termination condition is met, or the unit is scheduled for a future GCM event.

(4) Basic GCM Cycle. Once an attacking unit causes initiation of the basic cycle of GCM operation for a given battle, all attacking units active in the battle whose status can be updated under the basic cycle are assessed. Thus for a given battle all assessments in which the attack unit is not involved with a barrier are accomplished upon one entry to the model. The logical progression of the basic cycle of operation is illustrated at Figure IV-7-3. Looping over all attack units not involved with a barrier, the major steps are:

(a) Determine if the unit will encounter a barrier. The unit is about to be assessed for some period of time over which combat has taken place. If in this period of time the unit was in motion and its motion caused a barrier encounter, assessment will be made only for the time up to barrier encounter. Thus determination of encounter is made prior to simulation of the exchange of direct fires to establish the length of this exchange to be simulated. The length is the period from this attack unit's last assessment time to the time of barrier encounter or, if no encounter, to the current assessment time.

(b) The exchange of direct fires is simulated for this attacking unit. The simulation, discussed in detail in Paragraph 4, is made independently for each defending unit active in the named battle.

(c) If the unit did encounter a barrier, discovery losses due to the barrier itself may be assessed and an appropriate reaction to the barrier is selected. The discovery and decision logic, as well as logic for determining barrier encounter and simulating the various reactions, is presented in detail in Paragraph 5, below.

(d) The unit's next entry into the GCM model is scheduled. If no encounter took place, next entry will be in five minutes, the basic GCM increment time. If an encounter did take place, next entry will be after an appropriate decision and countermeasure implementation delay, added to the time of encounter. The unit's last assessment time is set in the battle control table to time of encounter or, if no encounter, to current time.

(5) Obstacle Cycle. The obstacle cycle of operation is entered for a simulated unit that has encountered and is currently involved with an obstacle while under control of the Ground Combat Model. The nature of the current barrier interaction is indicated by the unit's mode flag

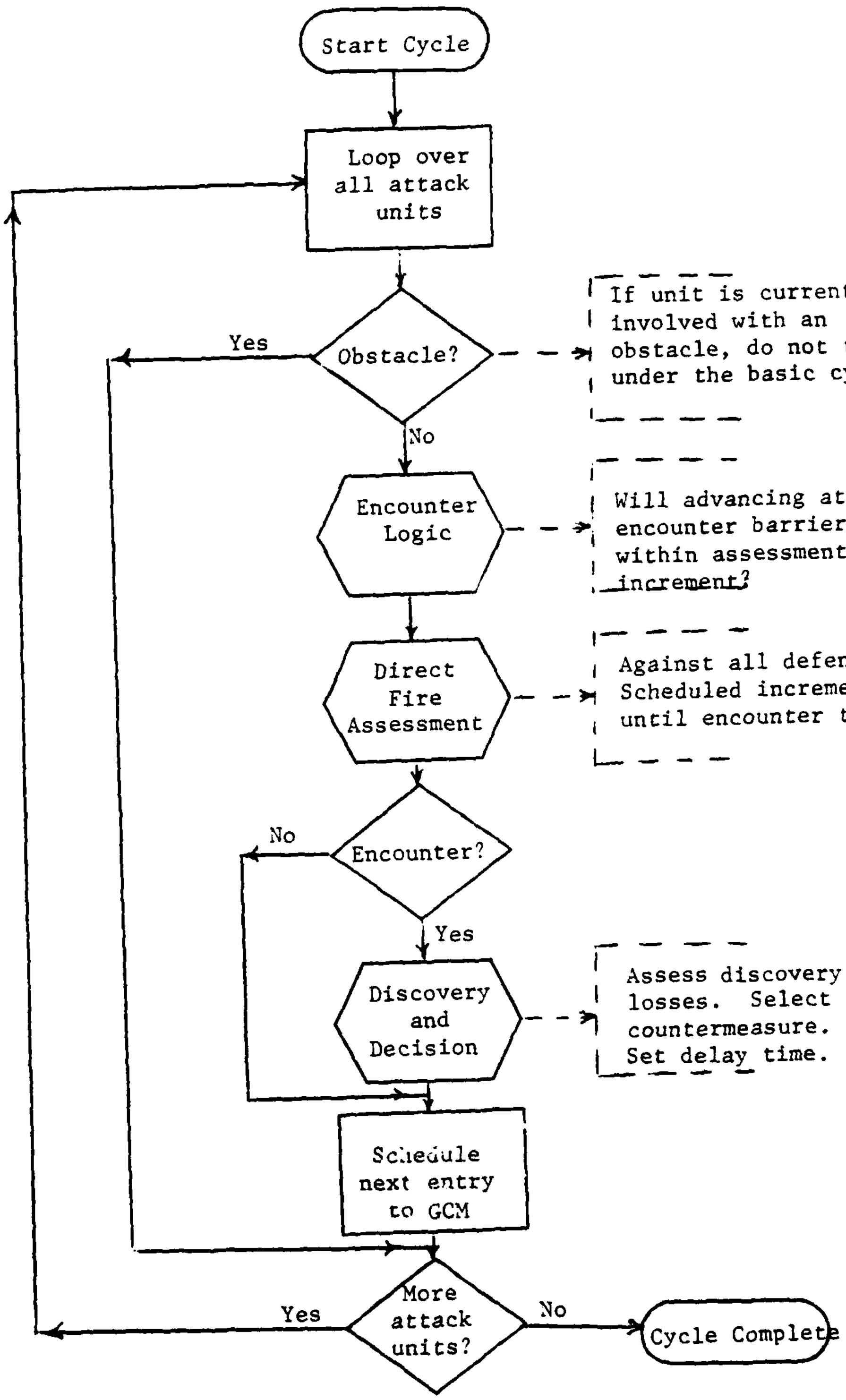


Figure IV-7-3. Basic GCM Cycle.

in the battle control table. Under this cycle of operation, three steps take place:

(a) This unit's exchange of direct fires with all defenders active in the named battle is updated to current time.

(b) Results of the unit's interaction with the barrier are assessed as appropriate. These may be movement of the unit, losses or expenditures by the unit and/or changes to the status of the barrier itself.

(c) The state of the unit/barrier interaction is updated if necessary and the next GCM assessment for this unit is scheduled.

(6) Interruption Cycle of Operation. The interruption cycle of operation is invoked when one of the DSL-stipulated conditions for the termination of an ongoing battle is met or the battle must be terminated at the end of a game period. This is actually a combination of the previously described cycles of operation. This cycle updates all assessments to current time and interrupts any ongoing barrier interactions prior to battle termination.

(a) The logic of the basic cycle of operation is first called to update all attack units not involved with a barrier. Should a unit encounter a barrier in this time period, discovery losses are assessed but no countermeasure is selected.

(b) Any units which just encountered a barrier are then assessed for direct fires to bring assessment up from encounter time to current time.

(c) All units still involved with a barrier are assessed for direct fires and the barrier interactions are interrupted. The details of barrier activity interruption depend on the nature of the activity being interrupted and are presented in Paragraph 5.j. below.

c. DIVWAG System Interface. Beyond the control mechanisms discussed above, interface of the Ground Combat Model with the overall DIVWAG system generally is accomplished through the various data files which are dynamically changing in the course of a game.

(1) At the end of each simulated combat increment, the unit status file is updated for each unit involved in an exchange of direct fires during that increment to reflect losses, expenditures and consumption during that increment.

(2) During a given simulated combat increment, location of all attackers being treated in the increment is updated to account for unit motion. Locations of all defender units are updated for any motion at the end of each increment.

(3) At the time a unit exchange of direct fires is simulated, sensing reports are generated. One report is generated for each opposing unit by each unit involved in the direct fire exchange. The reports are processed within the DIVWAG System's Intelligence and Control Model and may thus cause aerial attack or area fires upon the reported units.

(4) As units encounter and react to obstacles, the system's barrier and facility file is updated to maintain current intelligence status on the obstacles as well as to reflect any changes in the physical status of the obstacle.

(5) Ambient weather and terrain conditions at the time and location of each engagement are referenced from the appropriate environment files and influence the battle primarily through their impact on the target acquisition process.

4. DIRECT FIRE EXCHANGES.

a. General. The exchange of direct fires in the Ground Combat Model is simulated by the sequential treatment of four logical areas involved in an exchange of fires: unit geometry, target acquisition, firepower potential, and firepower effectiveness and assessment. The basic logic of this simulation is designed to treat one pair of opposing units. A driver routine is also required to establish the unit pairs to be treated at any one time, as well as to establish the required data for model execution. The driver is called for direct fire assessments under the basic, obstacle or interruption cycles of operation as discussed above.

b. Driver for Direct Fire Exchange. The simulation of direct fires requires data describing the unit pair to be treated, the conditions prevailing at time of the exchange and the weapons involved. These are provided by driver logic which, under call of one of the GCM operation cycles, loops through all defender units for the attack unit under consideration. The flow of this logic is shown in Figure IV-7-4.

(1) The loop through defender units is over all units designated as defenders within the battle control table (or, equivalently, the battle paragraph) which are active in the battle at time of assessment.

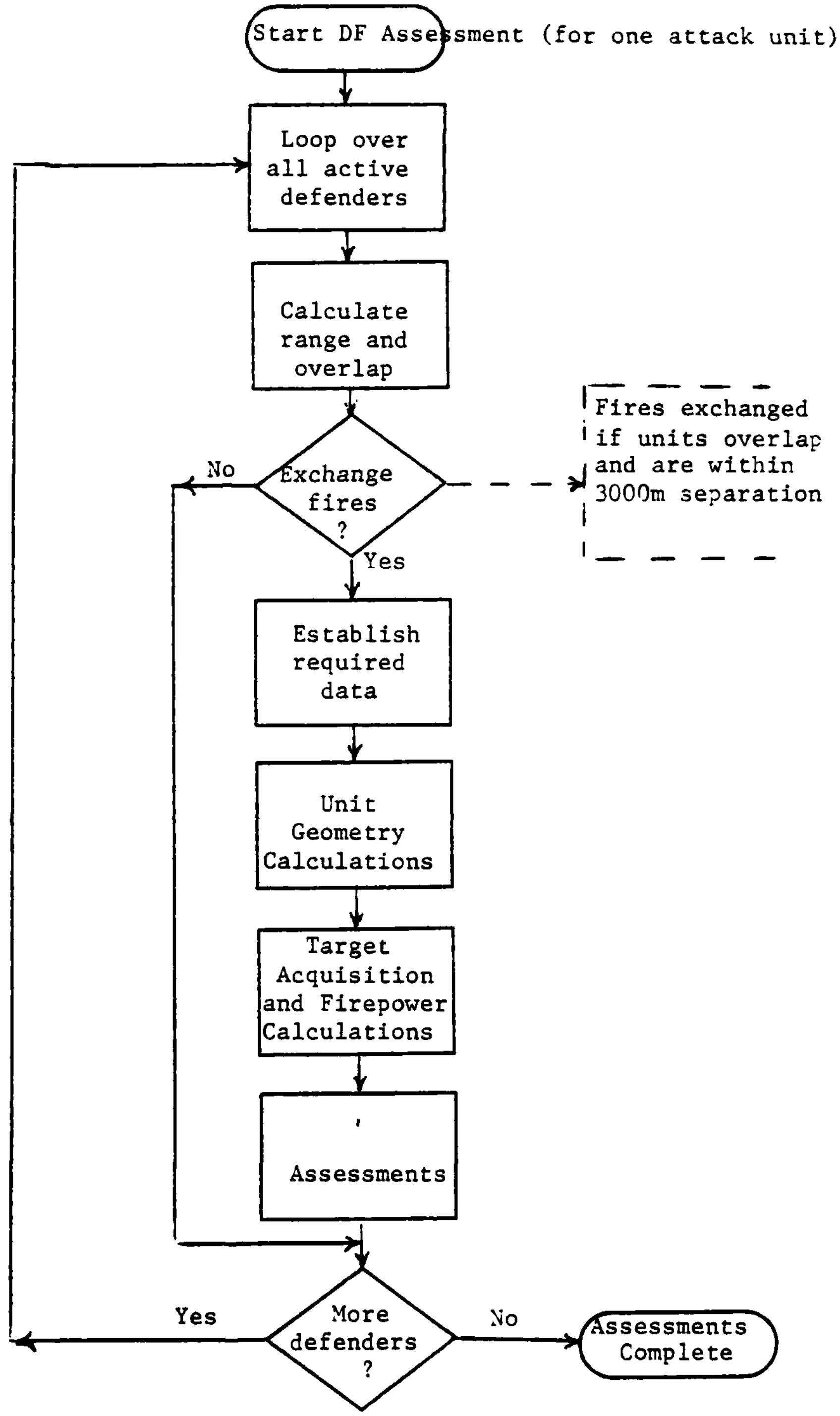


Figure IV-7-4. GCM Direct Fire Assessment Flow.

(2) A preliminary check is made on the range between this unit pair and the amount of unit overlap. The calculations used are considered part of the unit geometry logic and, as such, are presented below. If the unit pair do not overlap, or if front to front range is beyond 3000 meters, no further calculations are required for this unit pair.

(3) If a unit pair overlaps and the units are within 3000 meters of each other, the direct fire calculations will be made. Thus the appropriate data must be established.

(a) The time to be accounted for by this assessment starts with the last assessment time of the attack unit. The unit geometry model requires the unit locations, objectives, sizes and velocities at the start time of assessment. These are available from the unit status files of the opposing units.

(b) The identification of direct fire weapons to be treated is gotten from the GCM constant data base. The quantity of these weapons in the front band of each unit is developed from item strength in the unit status file and the distribution of items within a unit from the constant data base.

(c) Various environment files are accessed to obtain visibility-related data used by the target acquisition logic.

1. Visible range comes from the weather file.

2. The sky-ground ratio (relative brightness of the horizon and background) is determined for attacker and defender, in each case by interpolating on values corresponding to looking into the sun and looking away from the sun, based on current time of day or night and position of the units.

3. The roughness and vegetation (RV) index and forest type index are averaged over the leading band of each unit. If the average RV index is greater than 5, the terrain is considered poor; otherwise, it is considered good. If the average forest index is less than 0.5, the terrain is considered to be unforested; otherwise, it is forested. The terrain and forest type at the site of each unit is then used to determine input values for the line of sight parameters for each target. The average index is used to select the appropriate background reflectance.

(4) With the necessary data established, the actual calculations for assessment of the direct fire exchange take place.

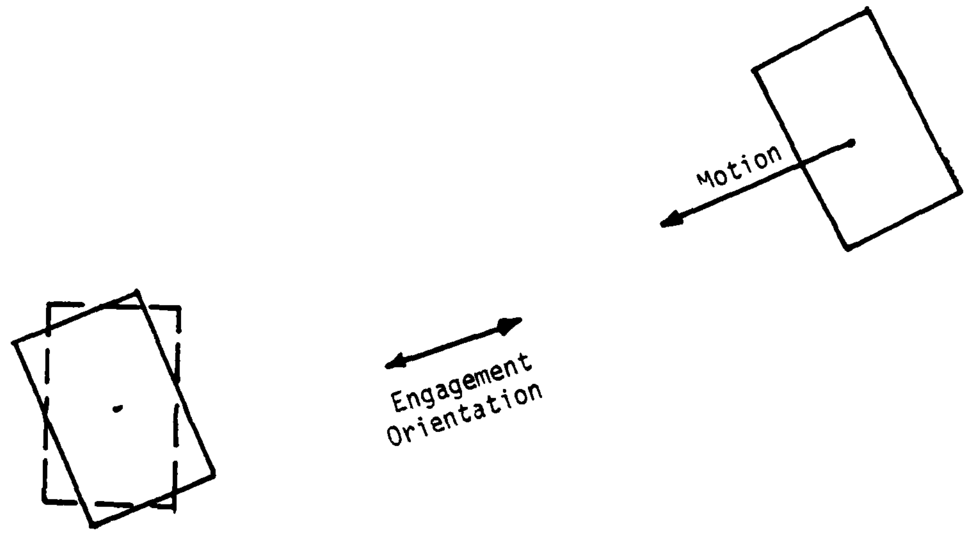
(5) When the assessment of one unit pair is complete, the process is repeated for the next defending unit. When all defenders are completed, the process is done for this attacking unit.

c. Unit Geometry Calculations.

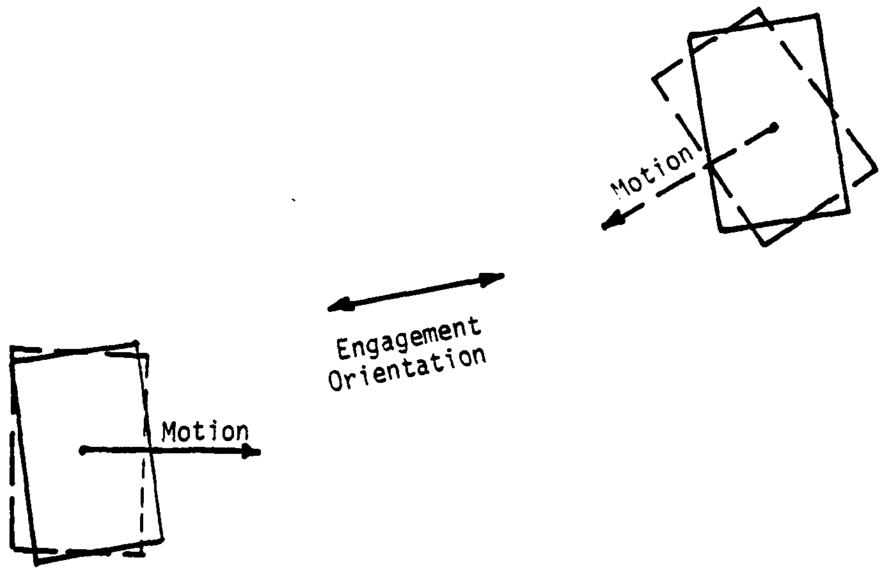
(1) General. The primary function of the unit geometry calculations is to establish the individual weapon type to target type coverage patterns for a pair of opposing units. To accomplish this, the calculations progress from treatment of the relative geometry of two opposing units, treated as entities, through consideration of areas of responsibility and coverage as well as distribution of each weapon type within a unit.

(2) Engagement Orientation. Ground Combat Model calculations are made on the basis of parallel opposing unit fronts. Since this is not the general case in DIVWAG, each unit pair is aligned on an engagement orientation angle, for the purpose of the direct fire calculations only. The engagement orientation angle is based on the orientation of each unit as implied by unit objectives. The two cases which will most frequently occur in application of the model are illustrated in Figure IV-7-5 where the solid rectangle represents the unit oriented for GCM direct fire calculations and the dashed rectangle is the unit's normal orientation.

(a) Within the DIVWAG system, a ground unit's orientation is implied by the unit's movement objective if the unit has a move-type order pending, or defaults to the general battlefield orientation in the absence of a movement objective. Within GCM the only possible pending orders are ADVANCE or WITHDRAW, which have an associated objective and implied orientation, and PREPARE which has the default orientation. Where one unit has an ADVANCE or WITHDRAW order and the second unit of an opposing unit pair has a PREPARE order, the implied orientation of the unit with an objective is used as the engagement orientation. This results in a rotation of one unit as illustrated in the upper portion of Figure IV-7-5. Where both units have an implied objective, the engagement orientation is selected to minimize rotation of each unit. This is accomplished by orienting the engagement midway between the unit orientations, illustrated in the lower portion of Figure IV-7-5. When neither unit has an implied orientation the default general battlefield orientation is used as the engagement orientation.



Case A. One Unit Moving.



Case B. Both Unit Moving.

Figure IV-7-5. GCM Engagement Orientation.

(b) Calculation of the engagement orientation is based on unit locations and objective where:

(X_A, Y_A) = attacker location

(X_{AO}, Y_{AO}) = attacker objective

(X_D, Y_D) = defender location

(X_{DO}, Y_{DO}) = defender objective

1. Distance to objectives and direction cosines of line between a unit and its objective are computed as:

$$R_A = \sqrt{(X_{AO}-X_A)^2 + (Y_{AO}-Y_A)^2} \quad \text{(IV-7-1a)}$$

$$R_D = \sqrt{(X_{DO}-X_D)^2 + (Y_{DO}-Y_D)^2} \quad \text{(IV-7-1b)}$$

$$U = (X_{AO}-X_A)/R_A \quad \text{(IV-7-2a)}$$

$$V = (Y_{AO}-Y_A)/R_A \quad \text{(IV-7-2b)}$$

$$W = (X_{DO}-X_D)/R_D \quad \text{(IV-7-2c)}$$

$$Z = (Y_{DO}-Y_D)/R_D \quad \text{(IV-7-2d)}$$

2. The battle orientation angle, ϕ, is solved for depending upon the orders of the involved units.

a. If both units have a PREPARE order, ϕ is set to the general battlefield orientation, as defined in Chapter 5, since both units will be on this orientation.

b. If only one unit has an ADVANCE or WITHDRAW order, implying motion, the battle orientation is set at that implied motion. Thus:

$$\phi = \arctan (V/U) \quad \text{(IV-7-3a)}$$

if the attacker only has implied motion, or

$$\phi = \arctan (Z/W) \qquad \text{(IV-7-3b)}$$

if the defender only has implied motion.

c. If both units have implied motion the desired battle orientation is the angle which bisects the acute angle between the two units' direction lines. This is equivalent to the direction of the vector sum or vector difference of the direction vectors depending whether the angle between the vectors is acute or obtuse. The assumption is made that if both units have an ADVANCE or WITHDRAW order, they are approaching toward or separating from each other and thus traveling in generally opposite directions. This implies an obtuse angle between direction vectors and indicates vector subtraction for the required angle. Thus:

$$\phi = \arctan (V-Z) \ / \ (U-W) \qquad \text{(IV-7-4a)}$$

if both units have the same order (ADVANCE or WITHDRAW) and

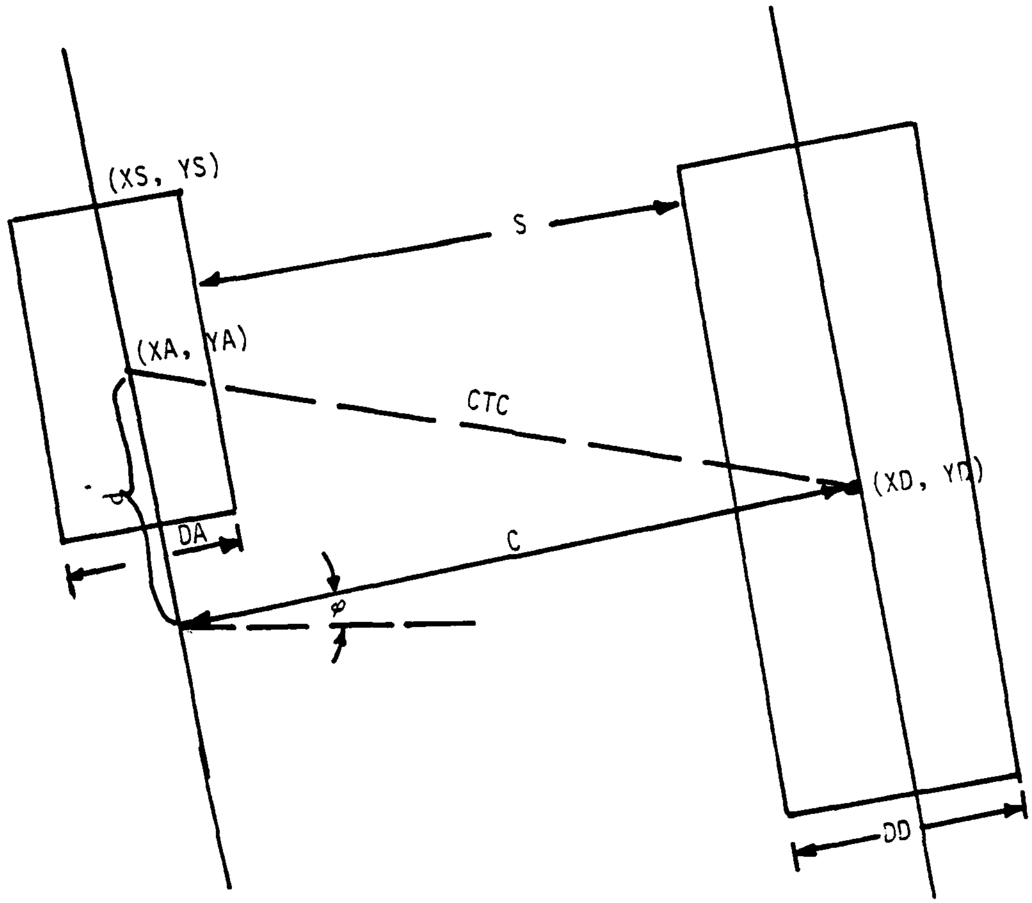
$$\phi = \arctan (V+Z) \ / \ (U+W) \qquad \text{(IV-7-4b)}$$

if the units have different orders.

3. The battle orientation is required only to provide an angle of inclination within the mathematical coordinate system. The direction is not of interest. Thus, for example, a due east ($\phi = 0^o$) battle orientation is totally equivalent to a due west ($\phi = 180^o$) battle orientation. The east-west line is required for further calculations, not the easterly or westerly directions. For the sake of convention, the principal angles of ϕ between $\pm \pi/2$ radians are used.

(3) Front to Front Separation.

(a) Figure IV-7-6 illustrates a pair of unit rectangles rotated to the battle orientation ϕ. Since unit fronts are parallel, the problem is one of computing the perpendicular distance between parallel lines. Within the model, the distance between parallel lines drawn through the center of each unit is computed and the half-depths subtracted to obtain front to front distance.



XS = XA - sin φ
YS = YA + cos φ
S + C - ½ (DA + DD)

Figure IV-7-6. Separation Calculations.

(b) Given the center point coordinates of the attack unit (X_A, Y_A), and the battle orientation, ϕ, the center line parallel to the unit front through the unit center is required. The line is defined by computing a point (X_S, Y_S).

$$X_S = X_A - K \sin \phi \qquad \text{(IV-7-5a)}$$

$$Y_S = Y_A + K \cos \phi \qquad \text{(IV-7-5b)}$$

The constant K is arbitrarily set to the unit width. Any value of K gives a point on the desired line and the pair of points (X_A, Y_A) and (X_S, Y_S) define the line.

(c) Distance between unit center lines is calculated by dropping the perpendicular from the defense unit center (X_D, Y_D) to the attack unit center line. Thus, if the slope of the center lines is

$$M = (Y_A - Y_S) \;/\; (X_A - X_S) \qquad \text{(IV-7-6)}$$

then the simultaneous equations

$$Y_P - Y_A = M(X_P - X_A) \qquad \text{(IV-7-7)}$$

$$Y_P - Y_D = (-1/M)(X_P - X_D) \qquad \text{(IV-7-8)}$$

are solved for the point of intersection of the attack center line and the perpendicular (X_P, Y_P), and distance from this point to (X_D, Y_D) is the desired distance, C, from center line to center line. The front to front distance is then

$$S = C - 1/2\ (D_A + D_D) \qquad \text{(IV-7-9)}$$

where D_A and D_D are depths of attack and defend unit respectively.

(d) The front to front distance used for exchange of direct fires is

$$S_E = 1/2\ (S_I + S_F) \qquad \text{(IV-7-10)}$$

where S_I and S_F are distances at the beginning and end of the time increment to be portrayed. S_I is calculated using initial unit locations and S_F is calculated using locations the units will attain at the end of the increment, considering rates and directions of unit movement, if any.

(4) Engagement Front. The calculations for direct fire exchanges require computation of the amount of unit front overlap, once units are rotated to the battle orientation. This overlap is the front upon which the unit pair is engaged. The size of the engagement front is determined by examining its relation to the lateral offset of unit centers, d', as measured along a unit center line.

(a) As shown in Figure IV-7-6, d' is length of the third leg of a right triangle which has the line between unit centers as its hypotenuse and the perpendicular from one unit center to the other unit's center line as the second leg. Thus, with center to center distance CTC and center line perpendicular distance C

$$d' = \sqrt{CTC^2 - C^2} \qquad \text{(IV-7-11)*}$$

(b) If the widths of attacking and defending units are W_A and W_D, respectively, inspection of Figure IV-7-8* illustrates the relation of engagement front W_E to d'. When d' is as great as the sum of the unit half-widths, there is no overlap. When d' is less than half the absolute difference of unit widths, engagement front is equal the front of the narrower unit. Between these limiting cases, engagement front is linear with respect to d'. Imposing the boundary conditions of the limiting case to the linear form $W_E = md'+b$, the solution for the non-trivial case becomes:

$$W_E = \frac{2 \min \left\{W_A, W_D\right\} \left[d' - (W_A + W_D) / 2\right]}{\left| W_A - W_D \right| - (W_A + W_D)} \qquad \text{(IV-7-27)}$$

(5) Coverage Pattern.

(a) Figure IV-7-9 is an enlargement of a portion of the target unit of Figure IV-7-10, and both serve to define the variables

*Note: Equation numbers IV-7-12 through IV-7-26 and figure number IV-7-7 are not used.

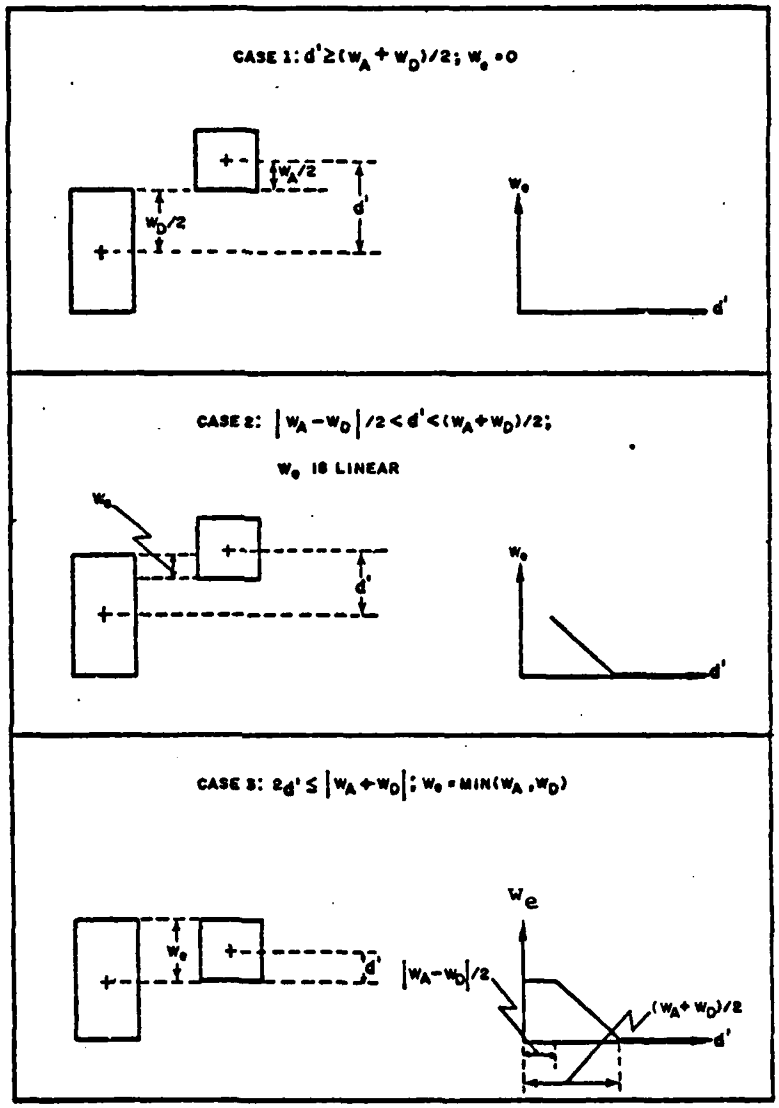


Figure IV-7-8. Relationship Between the Engagement Frontage and the Variable d'

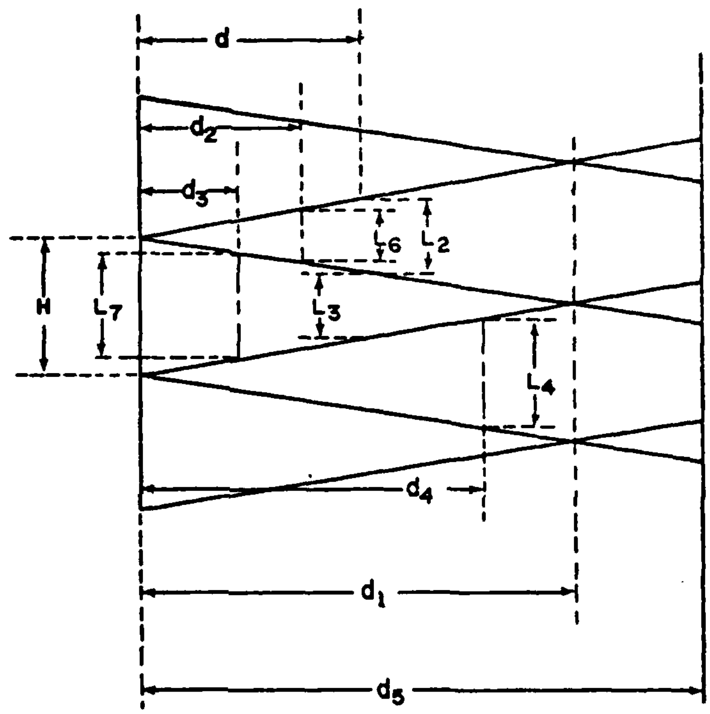


Figure IV-7-9. Coverage Pattern Variables, Detailed

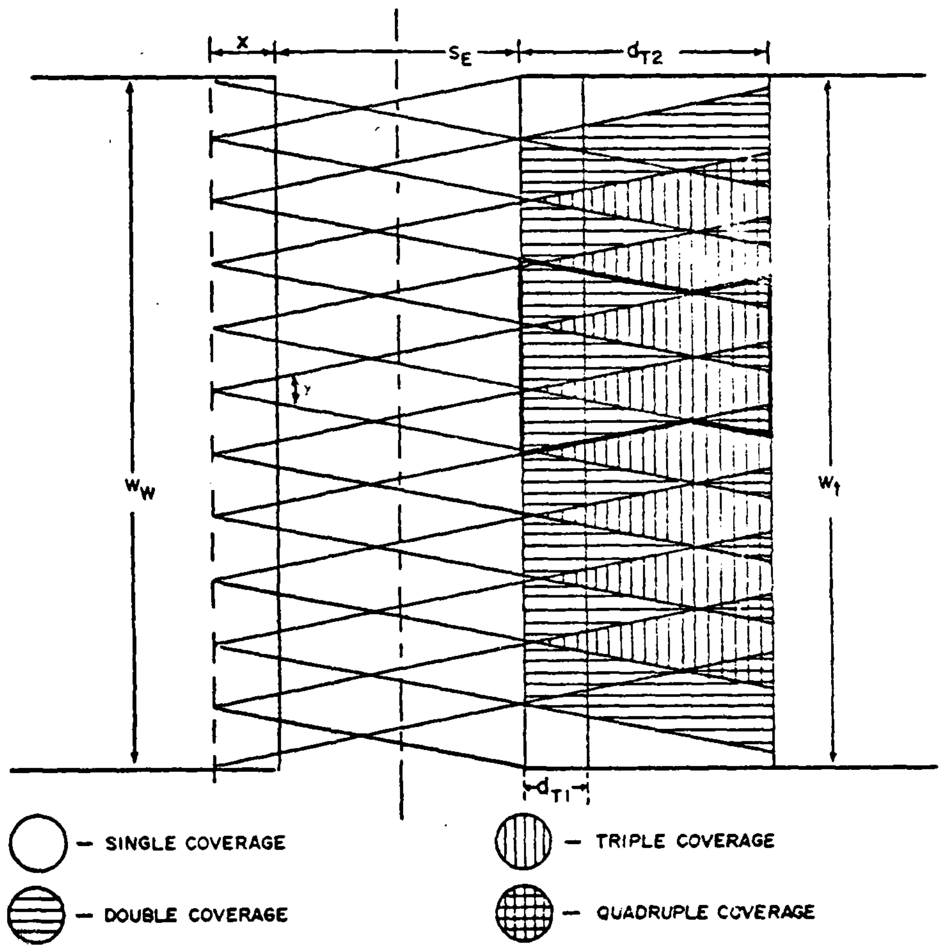


Figure IV-7-10. Coverage Pattern Variables used to determine the areas and ranges to each type of coverage region. The area of each type coverage region is required to determine the portion of the target unit and the number of targets with which each weapon can interact. The range to each type coverage region is required to determine target acquisition capabilities that depend strongly on the observer-target separation. Although the problem is not addressed explicitly, an angle of responsibility (y, in Figure IV-7-10), acknowledges interweapon communications by allowing a weapon to acquire a target outside this angle and not fire at it. In Figure IV-7-10, S_e is the separation, defined by Equation IV-7-10. In this example the weapon unit width, ^wW, the target unit width, ^wT, and the engagement front ^we, are equal. The depth of the target unit's leading band is d_T, where d_{T1} and d_{T2} show the coverage pattern in two possible unit sizes. If f_{i1} is the fraction of weapon system i in band 1 and N_i is the initial number of weapon system i on hand, then the number of weapon system i which is active is given by Equation IV-7-28:

$$n_i = f_{i1} N_i \, ({}^we / {}^wW) \, [X / (d_w / 2)] \qquad \text{(IV-7-28)}$$

where X is defined by Equation IV-7-32 and d_w is the depth of the front band of the weapon unit. n_i is rounded to an integer value and the interweapon spacing, H, is computed using Equation IV-7-29:

$$H = w_e / (n_i - 1) \qquad \text{(IV-7-29)}$$

The n_i active weapons are assumed to be equally spaced along a line a depth X into the weapon unit. The depth X is related to the expected value of the line of sight probability by Equation IV-7-30:

$$X = \int_{S_e}^{S_e + d_w} P_{LOS}(r)\, dr \qquad \text{(IV-7-30)}$$

Where line of sight probabilities are computed using the equation from the Ballistics Research Laboratory study, Terrain and Ranges of Tank Engagements (Reference 2).

$$P_{LOS}(r) = (1 + 2r/\overline{r}) \exp(-2r/\overline{r})$$

Substituting for P_{LOS} (r) and performing the integration yields Equation IV-7-31:

$$X = (S_e + \bar{r})\, e^{-2S_e/\bar{r}} - (S_e + d_w + \bar{r})\, e^{-2(S_e + d_w)/\bar{r}} \qquad \text{(IV-7-31)}$$

where $\bar{r}$ is the line of sight parameter and d_w is the depth of the front band of the weapon unit. To prevent placing the weapons behind the center of the front band, X is redefined by Equation IV-7-32:

$$X = \mathrm{Min}(X,\ d_w/2) \qquad \text{(IV-7-32)}$$

Figure IV-7-9 shows that the first intersection of coverage lines within the target unit occurs at a depth into the target unit, labeled d_1 in the figure, of (1/2) $(S_e + X)$. Calculation of the coverage areas is most conveniently broken into two cases:

$$0 \le d_T \le d_1 \text{ and } d_1 \le d_T \le 2d_1$$

1. The distance d in Figure IV-7-9 corresponds to the case where the first intersection of coverage lines occurs behind the target unit's leading band. In this case no portion of the unit is covered by more than three weapons. The area of one triple coverage region is:

$$A_3 = dL_2 \ / \ 2 \qquad \text{(IV-7-33)}$$

but from similar triangles:

$$L_2 \ / \ d = H \ / \ (S_e + X) \ / \ 2 \qquad \text{(IV-7-34)}$$

Solving Equation IV-7-34 for L_2 and substituting the result into Equation IV-7-33 leads to Equation IV-7-35:

$$A_3 = H \cdot d^2 \ / \ (S_e + X) \qquad \text{(IV-7-35)}$$

The area of one double coverage region is:

$$A_2 = [(L_3 + H) / 2] d \qquad \text{(IV-7-36)}$$

But from the figure:

$$L_2 + L_3 = H \qquad \text{(IV-7-37)}$$

Solving Equation IV-7-37 for L_3, substituting Equation IV-7-34 for L_2 and inserting the result into Equation IV-7-36 leads to Equation IV-7-38:

$$A_2 = (H - L_2 + H) \cdot d/2$$

$$= H \cdot d - 1/2 \frac{H \cdot d^2}{1/2 \ (S_e + X)}$$

$$= H d - d^2 / (S_e + X) \qquad \text{(IV-7-38)}$$

In this case there is no quadruple coverage region within the leading band and hence $A_4 = 0$. The ranges to the various coverage regions are taken to be the distances from the observer to the points within each region where there are as many targets within the range as beyond it. Since targets are uniformly distributed within each region, the depth into each region which divides the area in half is required. From Figure IV-7-9 similar triangles relate d_2, L_6, and L_2 according to Equation IV-7-39:

$$d / d_2 = L_2 / L_6 \qquad \text{(IV-7-39)}$$

The requirement of dividing the area in half is expressed in Equation IV-7-40:

$$L_6 d_2 / 2 = (dL_2 / 2) / 2 \qquad \text{(IV-7-40)}$$

Solving Equation IV-7-39 for L_6, substituting into Equation IV-7-40, and solving for d_2 leads to Equation IV-7-41:

$$(L_2 d_2 / d)(d_2 / 2) = dL_2 / 4$$

$$d_2{}^2 = d^2 / 2$$

$$d_2 = d / \sqrt{2}$$

$$= 0.707d \qquad \text{(IV-7-41)}$$

Thus, the range to a triple coverage region is given by Equation IV-7-42:

$$R_3 = S_e + X + 0.707 \cdot d \qquad \text{(IV-7-42)}$$

It is next required to determine the distance d_3 that divides the trapezoid into two equal areas. Mathematically this requirement is stated in Equation IV-7-43:

$$(L_7 + H) \cdot d_3 / 2 = [(L_3 + H) \cdot d / 2] / 2 \qquad \text{(IV-7-43)}$$

Substituting Equations IV-7-34 and -37 for L_3 into Equation IV-7-43 yields Equation IV-7-44:

$$(L_7 + H) \cdot d_3 = H[d - d^2 / (S_e + X)] / 2 \qquad \text{(IV-7-44)}$$

From Figure IV-7-9 it is seen that Equation IV-7-45 relates d_3 to L_7:

$$(S_e + X) / 2H = [(S_e + X) / 2 - d_3] / L_7 \qquad \text{(IV-7-45)}$$

Solving this equation for L_7 and substituting the result into Equation IV-7-44 leads to the expression in Equation IV-7-46 for d_3:

$$d_3{}^2 - (S_e + X) \cdot d_3 + (S_e + X)(d - d^2 / [S_e + X]) = 0 \qquad \text{(IV-7-46)}$$

This equation is immediately solvable using the quadratic equation yielding Equation IV-7-47:

$$d_3 = 1/2\ (S_e + X) - \sqrt{1/4\ (S_e + X)^2 - (S_e + X)\ d\ /\ 2 + d^2/2} \qquad \text{(IV-7-47)}$$

where inspection of the result led to the choice of the minus sign. Thus R_2 is given by Equation IV-7-48:

$$R_2 = 3\ (S_e + X)\ /\ 2 - \sqrt{(S_e + X)^2 - 2(S_e + X) \cdot d + 2d^2}\ /\ 2 \qquad \text{(IV-7-48)}$$

2. The distance d_5 in Figure IV-7-9 corresponds to the case where $d_1 \leq d_T \leq 2d_1$. In this case part of the target unit is covered by four weapons. The area of the double coverage region is constant at the value it has for $d = d_1$. Substituting $d_1 = (S_e + X) / 2$ into Equation IV-7-38 leads to Equation IV-7-49:

$$A_2 = H\ (S_e + X)\ /\ 4 \qquad \text{(IV-7-49)}$$

The area of a triple coverage region is the sum of the areas of the triangle defined by $d = d_1$ and the remaining trapezoid to the right of this line, as indicated in Equation IV-7-50:

$$A_3 = [H\ (S_e + X)\ /\ 2]\ /\ 2 + H\ [d - (S_e + X)\ /\ 2 - [d - (S_e + X)\ /\ 2]^2\ /\ (S_e + X)] \qquad \text{(IV-7-50)}$$

The second term in Equation IV-7-50 results from substituting $d - (S + X) / 2$ for d in Equation IV-7-38, which described a similar trapezoid. Equation IV-7-50 may be simplified to the form of Equation IV-7-51:

$$A_3 = H[2d - d^2\ /\ (S_e + X) - (S_e + X)\ /\ 2] \qquad \text{(IV-7-51)}$$

There is a portion of the target unit covered by four observers. The area of the quadruple coverage region is that of a triangle idential in shape to the triple coverage region of case 1. In this case the quadruple coverage area may be expressed by Equation IV-7-52:

$$A_4 = H[d - (S_e + X) / 2]^2 / (S_e + X) \qquad \text{(IV-7-52)}$$

that results from the substitution of $d - (S_e + X) / 2$ for d in Equation IV-7-35. The range to the double coverage triangular area is determined by letting $d = (S_e + X) / 2$ in Equation IV-7-48. The result is expressed in Equation IV-7-53:

$$R_2 = 1.146 (S_e + X) \qquad \text{(IV-7-53)}$$

To determine R_3 it is necessary to find d_4 that divides the area formed by the triple coverage triangle and trapezoid in half, as expressed in Equation IV-7-54:

$$L_4 d_4 / 2 = H[2d - d^2 / (S_e + X) - (S_e + X) / 2] / 2 \qquad \text{(IV-7-54)}$$

From the figure it is seen that Equation IV-7-55 relates L_4 to L_5.

$$L_4 / d_4 = H / (S_e + X) / 2 \qquad \text{(IV-7-55)}$$

Solving for L_4 and substituting into Equation IV-7-54 yields, after some rearrangement, Equation IV-7-56:

$$d_4 = \sqrt{d(S_e + X) - d^2 / 2 - (S_e + X)^2 / 4} \qquad \text{(IV-7-56)}$$

Thus, R_3 can be determined by Equation IV-7-57:

$$R_3 = S_e + X + \sqrt{d(S_e + X) - d^2 / 2 - (S_e + X)^2 / 4} \qquad \text{(IV-7-57)}$$

R_4 is very similar to the R_3 for case 1 and is expressed by Equation IV-7-58:

$$R_4 = 3 (S_e + X) / 2 + .707 [d - (S_e + X) / 2]$$
$$= 1.146 (S_e + X) + .707 \cdot d \qquad \text{(IV-7-58)}$$

The depth of active targets, Y, is computed using Equation IV-7-58a:

$$Y = (S_e + \bar{r})\ e^{-2S_e / \bar{r}} - (S_e + d_T + \bar{r})\ e^{-2S_e + d_T) / \bar{r}} \quad \text{(IV-7-58a)}$$

which is similar to Equation IV-7-31 except the integration is now performed over the target unit depth. When the value of Y exceeds the value of $S_e + X$ it is necessary to adjust the values of R_k and A_k to allow the firing unit to cover all those targets that are eligible to return fire. Equations IV-7-58b provide the necessary adjustment while retaining the relative values to each range and area:

$$A_K = (A_k)_{initial} \cdot [Y / (S_e + X)] \quad \text{(IV-7-58b1)}$$

$$R_k = [(R_k)_{initial} - (S_e + X)] \cdot [Y / (S_e + X)] + S_e + X \quad \text{(IV-7-58b2)}$$

where the initial values are those computed earlier in the paragraph and where K = 2, 3, and 4.

(b) Referring to Figure IV-7-10 it is seen that there are a total of n_i-1 double coverage regions, n_i-2 triple coverage regions, and n_i-3 quadruple coverage regions. Thus, the total area covered is given by Equation IV-7-59:

$$A = (n_i-1)\ A_2 + (n_i-2)\ A_3 + (n_i-3)\ A_4 \quad \text{(IV-7-59)}$$

(c) The angle of responsibility for an individual weapon is given by Equation IV-7-60:

$$\gamma = 2 \cdot \tan^{-1} [H / (S_e + X)] \quad \text{(IV-7-60)}$$

(6) Target Distribution:

(a) The number of active targets is determined as for active weapons and expressed by Equation IV-7-61:

$$m_j''' = f_{j1}\ m_j\ (W_e / W_T)\ (Y / D_T) \quad \text{(IV-7-61)}$$

where Y was defined by Equation IV-7-58a and where:

m_j''' = number of active targets

f_{j1} = fraction of targets j in band 1

m_j = initial number of targets j

W_e = engagement front

W_T = target unit width

Since it is possible that the front band of the target unit is deeper than case 2 above allows (i.e., $D_T \gg S_e + X$), a further correction to the active targets is required as indicated in Equation IV-7-62:

$$m_j'' = m_j''' \cdot \text{Min}\,(S_e + X,\ D_T) \;/\; D_T \qquad \text{(IV-7-62)}$$

(b) Since these m_j active targets are uniformly distributed throughout the area given in Equation IV-7-59, the number of active targets per coverage section can be expressed by Equation IV-7-63:

$$m_{jk} = \frac{m_j'' \cdot A_k}{A}\ ;\ k = 2, 3, 4 \qquad \text{(IV-7-63)}$$

where A was defined by Equation IV-7-59.

(c) These targets are further subdivided into stationary and moving postures. If the target unit velocity is v_T and the mobility class rate for target j is v_j, then the fraction of targets moving can be expressed by Equation IV-7-64:

$$f_1 = v_T \cdot \sqrt{2} \;/\; v_j \qquad \text{(IV-7-64)}$$

where the $\sqrt{2}$ accounts for the increased path length associated with movement offset 45 degrees from the unit movement direction. Similarly, the stationary fraction is given by Equation IV-7-65:

$$f_2 = 1 - f_1 = 1 - v_T \cdot \sqrt{2} / v_j \qquad \text{(IV-7-65)}$$

Thus, the number of targets of type j in posture l in a single coverage section of type k is given by Equation IV-7-66:

$$m_{jkl} = m_{jk} \cdot f_l : \begin{cases} j = 1,2,\ldots,8 \\ k = 2,3,4 \\ l = 1,2 \end{cases} \qquad \text{(IV-7-66)}$$

where m_{jk} was defined by Equation IV-7-63.

d. Target Acquisition Submodel:

(1) General:

(a) The Target Acquisition Submodel calculates the time dependent probability of a single observer detecting a single target using unaided vision. This probability is calculated for each target type in each posture at the range corresponding to the center of each type coverage region.

(b) The submodel also calculates the probability of detection for other sensor types, assuming a range dependent detection function of the form $P_D(r) = ae^{-br}$, where the values of a and b must be determined from experimental data. These detection functions are further assumed to have a time dependence of the form $P_D(r,t) = 1 - (1 - P_D(r))^t$ in order to meaningfully combine them with the unaided visual detection probabilities.

(c) From these combined detection probabilities the submodel calculates the expected value of the time to detect at least one priority target. The detection probabilities against all target, posture, range combinations are converted to reflect their values at this time.

(d) The probability of pinpointing (i.e., detecting evidence of the target having fired) each type stationary target is calculated by the submodel based upon the number of targets that have recently fired either one or two rounds and experimental pinpoint probability data.

(2) Unaided Vision

(a) Unaided visual target detection is determined using the time dependent detection function from IMPWAG (Reference 3) with several modifications to fit the structure of the Ground Combat Model.

(b) Visual observation of a target is described by the following three-step process: looking, detecting, and resolving/identifying.

1. Detection is not possible if the amount of light reflected from the target, relative to the background, provides an insufficient stimulus to the eye of a human observer. In this case, when the target's apparent contrast is below some threshold value, an observer could look for an infinitely long time and not detect the target. If the apparent contrast of the target is at or above some threshold value an observer who is looking directly at the target will have some probability of detecting it. An observer who is not looking at the target will have some probability increasing, as a function of time, of eventually looking at it and detecting it.

2. Observation will not occur unless the observer can resolve/identify the target. A target which subtends an angle greater than the minimum angle of resolution can be resolved.

(c) The probability of observation can be expressed by Equation IV-7-67:

$$P_O = P_{R/D} \cdot P_D = P_{R/D} \cdot P_{D/L} \cdot P_L \qquad \text{(IV-7-67)}$$

where:

P_O = probability of observation

$P_{R/D}$ = probability of resolution given detection

P_D = probability of detection

$P_{D/L}$ = probability of detection given looking at the target

P_L = probability of looking at the target

(d) The probability of resolution given detection, $P_{R/D}$, will be either zero or one. The value for $P_{R/D}$ is zero if the visual angle subtended by the target is less than the minimum visual angle of resolution, and one if the visual angle is greater than the minimum required.

(e) The probability of detection given a look, $P_{D/L}$, is based upon Blackwell's experiments (Reference 4) and Linge's work (Reference 5) that found a relationship between the probability of detection and the targets relative contrast. The relative contrast, C_r, defined by Blackwell is given in Equation IV-7-68:

$$C_r = \frac{\text{Apparent contrast}}{C_{50}} \qquad \text{(IV-7-68)}$$

where C_{50} is that contrast which has a probability of being detected of 0.50.

1. The probability of detection as a function of C_r is expressed by Equation IV-7-69:

$$P_{D/L} = \Phi\left(\frac{C_r - 1.0}{.482}\right) \qquad \text{(IV-7-69)}$$

where:

$$\Phi(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{\frac{-t^2}{2}}\, dt \qquad \text{(IV-7-70)}$$

Equation IV-7-70 is solved using Hasting's approximation number 43 (Reference 7). Equation IV-7-69 then takes the form of Equation IV-7-71:

$$P_{D/L} = 0.5 \pm 0.5\,(1 - Y \cdot \Phi'(X)) \qquad \text{(IV-7-71)}$$

where:

$$\Phi'(X) = 1.12838\, e^{\frac{-X^2}{2}}$$

$$Y = 0.308428N - 0.084971\, N^2 + 0.6627698\, N^3$$

$$N = \frac{1}{1 + .33267 \cdot |X|}$$

$$X = \frac{C_r - 1.0}{0.482}$$

The ± in Equation IV-7-71 takes on the sign of X.

2. Citing the definition of meteorological range from the Glossary of Meteorology (Reference 6) as the range at which a target is barely detectable, C_{50} will be defined as the apparent contrast at the meteorological range of a target having inherent unit contrast, or:

$$C_r = \frac{C_A}{0.02} = 50\, C_A \qquad \text{(IV-7-72)}$$

In order to find C_r for Equation IV-7-71 it is sufficient to determine C_A, the apparent contrast. The NDRC report (Reference 1) provides Equations IV-7-73 through IV-7-75.

The apparent contrast C_A may be written:

$$C_A = \frac{\Delta B_r}{B_r} = \frac{B_r - B'_r}{B_r} \qquad \text{(IV-7-73)}$$

where:

B_r = target brightness at range r

B'_r = background brightness at range r

$$\Delta B_r = B_o\, e^{-\beta' r}$$

$$= (B_o - B'_o)\, e^{-\beta' r} \qquad \text{(IV-7-74)}$$

where:

B_o = target brightness at source

B_o' = background brightness at source

β' = atmospheric attentuation coefficient

r = range from target to observer

$$B_r = B_H (1 - e^{-\beta' r}) + B_o e^{-\beta' r} \qquad \text{(IV-7-75)}$$

where:

B_H = horizon brightness

The apparent contrast of target j at range r_k may be calculated by substituting Equations IV-7-74 and IV-7-75 into Equation IV-7-73:

$$C_{A_{jk}} = \frac{C_{oj}}{1 + \frac{B_H}{B_o} (e^{\beta' rk} -1)} \qquad \text{(IV-7-76)}$$

The quantity B_H / B_o in Equation IV-7-76 is the ratio of horizon brightness to background brightness, referred to as the sky-ground ratio. C_{oj}, the intrinsic contrast, is defined by Equation IV-7-77:

$$C_{oj} = \frac{\rho_j - \rho_B}{\rho_j} \qquad \text{(IV-7-77)}$$

where ρ_j and ρ_B are the reflectances of the target and background. Reflectance is the fraction of incident light reflected. The quantity β' is determined from Equation IV-7-78:

$$\beta' = \frac{3.912}{R_V} \qquad \text{(IV-7-78)}$$

where R_V is the visible range. Equation IV-7-78 is the standard definition of β', forcing the visibility to 2 percent at the visible range.

(f) The probability of looking, P_L, is determined by considering the portion of the observer's field of view which is occupied by the target and the observer's capability of resolving a target that is not directly along the direction of a glimpse. In a single glimpse the observer's direction of view will be randomly located within his search angle. The target will also have a random location within the area being searched. The probability that the vectors locating these directions are at an angle between α' and α' + dα' is determined using Figure IV-7-11. Figure IV-7-12 is a typical plot of γ versus δ and may be used to extract an estimate of the probability of angular separation between the observer's "looking angle" and the line along which the observer will see the target. The diagonal lines are equations of constant α'; therefore, the probability that the angular separation is between α' and α' + dα' is proportional to the area of the shaded trapezoid. The area of this trapezoid is calculated by Equation IV-7-79 and approximated by Equation IV-7-79a:

$$A = 1/2 \left(\frac{\theta - \alpha'}{\cos 45^o} + \frac{\theta - (\alpha' + d\,\alpha')}{\cos 45^o} \right) \quad \cos 45^o \, d\alpha' \qquad \text{(IV-7-79)}$$

$$\approx (\theta - \alpha')\, d\alpha' \qquad \text{(IV-7-79a)}$$

Hence, the probability of angular separation a is:

$$P(\alpha)\, d\alpha = k\,(\theta - \alpha)\, d\alpha \qquad \text{(IV-7-80)}$$

where k is the constant of proportionality determined by normalizing Equation IV-7-80. Evaluating the integral of Equation IV-7-81:

$$\int_0^\theta (\theta - \alpha)\, d\alpha = \frac{\theta^2}{2} \qquad \text{(IV-7-81)}$$

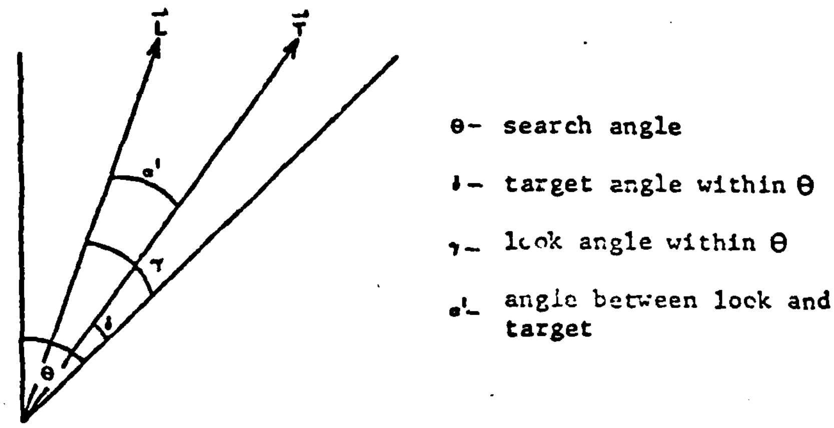


Figure IV-7-11. Search Vector Geometry

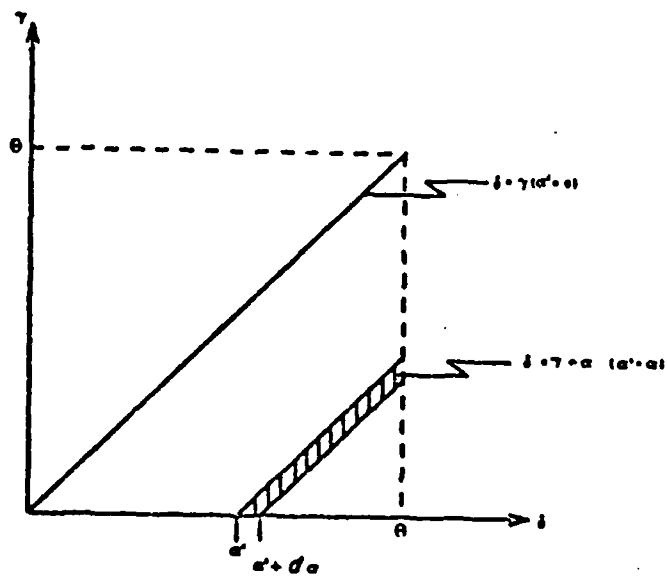


Figure IV-7-12. Typical Variation of γ versus δ yields the normalization factor $\frac{2}{\theta^2}$. Substituting the normalizing factor into Equation IV-7-80 yield Equation IV-7-82:

$$P(\alpha)\,d\alpha = \frac{2(\theta - \alpha)}{\theta^2}\,d\alpha \qquad \text{(IV-7-82)}$$

(g) Visual acuity is used to derive the probability of looking, P_L. This is done by first defining off angle as the angle between the direction of sight and the direction of the target. Visual acuity and off angle, α', are related by Equation IV-7-83:

$$VA = 2\,\frac{1}{1 + 0.643\,\alpha'} \qquad \text{(IV-7-83)}$$

which is the equation of the curve of Figure IV-7-13, from References 8 and 9.

1. Visual acuity is commonly expressed as the ratio $\frac{d}{d_N}$ where d_N is the distance at which the normal eye can resolve a given object, and d is the distance at which the specific eye being assigned a visual acuity value can resolve the same target. Since the angle subtended by the target is inversely proportional to its distance from the observer, visual acuity can be expressed by Equation IV-7-84:

$$VA = \frac{d}{d_N} = \frac{\Phi_N}{\Phi} \qquad \text{(IV-7-84)}$$

where:

Φ_N is the angle of subtense necessary for a normal eye to resolve a given object, Φ is the angle of subtense of the specific eye required to resolve the same object.

The minimum visual acuity, (VA)', required to resolve a target subtending an angle β and having minimum angle of resolution θ_1 is obtained from Equation IV-7-84 by equating Φ_N to $2\,\theta_1$ and Φ to β.

$$(VA)' = \frac{2\,\theta_1}{\beta} \qquad \text{(IV-7-85)}$$

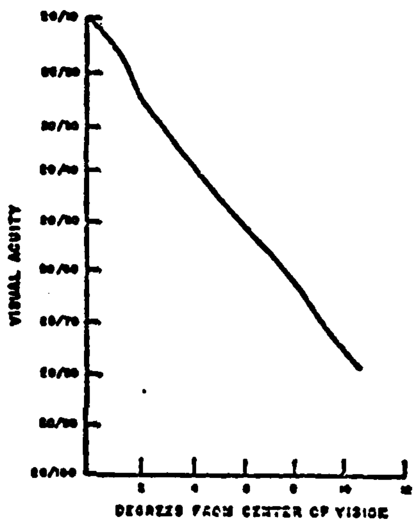


Figure IV-7-13. Visual Acuity versus Off Angle

2. The factor of 2 in Equation IV-7-85 is necessary to convert to the same visual acuity scale used in Ludvigh's works (References 8 and 9), wherein normal visual acuity was assigned a value of 2.

3. Equation IV-7-83 can be equated to Equation IV-7-85 and solved for α', yielding Equation IV-7-86 which defines the maximum off-angle for which resolution is possible.

$$\alpha' = \frac{1}{.643} (\beta / \theta_1 - 1) \qquad \text{(IV-7-86)}$$

4. Integrating Equation IV-7-82, and using as an upper limit the value of α' calculated in Equation IV-7-86, the probability the observer will resolve the target is given by Equation IV-7-87:

$$P_L = \int_0^{\mathrm{Min}(\alpha', \theta)} P(\alpha) d\alpha \qquad \text{(IV-7-87)}$$

The value Min (α', θ) is used in the upper limit since $P(\alpha') = 0$ for $\alpha' \geq \theta$.

(h) θ_1 is taken to be 47 seconds or 0.000228 radians as the minimum angle of resolution, as suggested by Jenkins and White (Reference 13). β, the angle subtended by a target, is computed using Equation IV-7-88:

$$\beta = 2 \tan^{-1} \frac{\sqrt{0.02957 \cdot a_{j1}}}{R_k} \qquad \text{(IV-7-88)}$$

where a_{j1} is the target area (square feet) of target j in posture 1, and R_k is the range to coverage type k. The area of a stationary target within the attacking unit is taken to be one-half its full presented area. The area of a stationary target within the defending unit is reduced to one-fourth its exposed value. The factor of 0.02957 enters from the ratio $1 / [(\pi) \cdot (3.28)^2]$ where 3.28 is the conversion from meters to feet. The term $P_{R/D}$ in Equation IV-7-67 is determined using Equation IV-7-89:

$$P_{R/D} = \begin{cases} 0, & \beta < \theta_1 \\ 1, & \beta \geq \theta_1 \end{cases} \qquad \text{(IV-7-89)}$$

Thus, the single glimpse detection probability for unaided visual observers of a single target type j in posture 1 at range R_k can be expressed by Equation IV-7-90:

$$P'_{jkl} = \frac{1}{\sqrt{2\pi}} \quad \Gamma(\beta, \theta_1) \quad \int_{-\infty}^{W} e^{\frac{-x^2}{2}} \, dx$$

$$\bullet \; 2\int_{0}^{B} \frac{\theta - y}{\theta^2} \, dy \qquad \text{(IV}$$

where:

$$\Gamma(\beta, \theta_1) = \begin{matrix} 0, & \beta < \theta_1 \\ 1, & \beta \geq \theta_1 \end{matrix}$$

from Equation IV-7-89:

$$W = \frac{1}{0.482} \left[\frac{50\,(\rho_j - \rho_B)}{\rho_j \left[1 + \frac{B_H}{B_0}(e^{\beta' \cdot R_k} - 1)\right]} \right]^{-1}$$

from Equations IV-7-72, -76, and -77; and

$$B = \text{Min} \left[\frac{1}{.643} \left(\frac{\beta}{\theta_1} - 1 \right), \theta \right]$$

from Equations IV-7-86 and -87 and with

β = angle subtended by the target (Equation 4-88)

θ_1 = minimum resolution angle

γ = search angle (taken to be 45°)

ρ_j = target reflectance

ρ_B = background reflectance

B_H/B_O = sky-ground ratio

β' = atmospheric attenuation coefficient (Equation IV-7-78)

R_k = range to coverage type k

x, y = dummy integration variables

(3) Other Sensor Types:

(a) Equation IV-7-90 gives the detection probability for a single glimpse, taken to require 2.0 seconds according to Paul W. Kruse (Reference 10). For other sensor types the detection probability must be converted to a 2-second time interval before it can be meaningfully combined with the above.

(b) Most existing experimental data provide a detection probability for at least two ranges and a mean time to detect. Let P_1 and P_2 be the detection probabilities at ranges r_1 and r_2, respectively, and let t_D be the mean time to detect. The detection probabilities per second are determined by Equation IV-7-92, which assumes detection varies as indicated in Equation IV-7-91.

$$P(t) = 1 - (1 - P\ (\text{per sec}))^{t} \qquad \text{(IV-7-91)}$$

$$P(\text{per sec}) = 1 - (1 - P(t))^{1/t} \qquad \text{(IV-7-92)}$$

where P(t) is the probability of detection at time t. Substituting P_1, P_2, and t_D into equation IV-7-92 and converting to the probability per 2 seconds leads to Equations IV-7-93:

$$P_1 \text{ (2 sec)} = 1 - (1 - P_1 \text{ (exp)})^{2/t_D} \qquad \text{(IV-7-93a)}$$

$$P_2 \text{ (2 sec)} = 1 - (1 - P_2 \text{ (exp)})^{2/t_D} \qquad \text{(IV-7-93b)}$$

Assuming the detection probability is exponential in range, as indicated by Equation IV-7-94, Equations IV-7-93 and the values of r_1 and r_2 may be substituted to solve for a and b, as indicated in Equations IV-7-95:

$$P = a\, e^{-br} \qquad \text{(IV-7-94)}$$

$$a = P_1 \text{ (2 sec)} e^{\left\{\frac{-r_1 (\ln P_2 \text{ (2 sec)} - \ln P_1 \text{ (2 sec)})}{r_2 - r_1}\right\}} \qquad \text{(IV-7-95a)}$$

$$b = \frac{\ln P_2 \text{ (2 sec)} - \ln P_1 \text{ (2 sec)}}{r_1 - r_2} \qquad \text{(IV-7-95b)}$$

An a and b are calculated for each sensor type q. Thus, for any sensor type q the 2-second detection probability at range R_k can be calculated using Equation IV-7-96:

$$P'_{kq} = a_q\, e^{-b_q \cdot R_k} \qquad \text{(IV-7-96)}$$

(c) A check is made on each sensor type to see if it is in use (according to day or night conditions). Observers are assumed to always use unaided visual detection capabilities. The detection probabilities for those sensors q in use and for unaided vision are multiplied by the line of sight probability of Equation IV-7-97 to yield P_{jkl} and P_{jklq}:

$$(P_{LOS})_{jkl} = \left(1 + \frac{2 \cdot R_k}{\bar{r}_{jl}}\right) e^{-(2 \cdot R_k / \bar{r}_{jl})} \qquad \text{(IV-7-97)}$$

$$P_{jkl} = P'_{jkl} \cdot P_{LOS_{jkl}} \quad \text{(IV-7-98)}$$

$$P_{jklq} = P'_{kq} \cdot P_{LOSjkl} \quad \text{(IV-7-99)}$$

where P'_{jkl} and P'_{kq} are defined by Equations IV-7-90 and IV-7-96.

These results are then combined to yield the probability of detecting at least one target type j in posture l at range R_k using Equation IV-7-100:

$$PD_{jkl} = 1 - (1 - P_{jkl}) \cdot \prod_q (1 - P_{jklq}) \quad \text{(IV-7-100)}$$

(4) Correction for Target Density:

(a) Equation IV-7-100 was derived for a single target in each region. In general, for the detection probability P_N with N targets the resultant probability can be expressed by Equation IV-7-101:

$$P_N = 1 - (1 - P)^N \quad \text{(IV-7-101)}$$

If N is noninteger Equation IV-7-101 can be expressed more generally by Equation IV-7-102, where P_T is the probability a target is there; i.e., fractional target.

$$P_N = 1 - \prod_{\substack{\text{all} \\ \text{possible} \\ \text{targets}}} (1 - P \cdot P_T) \quad \text{(IV-7-102)}$$

Substituting Equations IV-7-66 and IV-7-100 into Equation IV-7-102 yields PD_{jkl}, the probability of detecting at least one of m targets of type j in posture l at range R_k, as indicated in Equation IV-7-103:

$$PD'_{jkl} = 1 - [1 - PD_{jkl}]^{m_{jkl}^{(I)}} \cdot [1 - m_{jkl}^{(R)} \cdot PD_{jkl}] \quad \text{(IV-7-103)}$$

where $m_{jkl}^{(I)}$ is the integer part of m_{jkl} and $m_{jkl}^{(R)}$ is the remainder.

(b) The probability of detecting at least one priority target is computed by Equation IV-7-104:

$$PD = 1 - \prod_{\substack{\text{all} \\ \text{priority} \\ \text{targets } j}} \prod_{k=2}^{4} \prod_{l=1}^{2} (1 - PD'_{jkl})^k \qquad \text{(IV-7-104)}$$

The k appears as an exponent since each observer's area contains k sections of coverage type k.

(5) Expected Time to Detect a Target:

(a) PD in Equation IV-7-104 is the probability of detecting at least one priority target among all targets in both postures throughout the weapon system's area of responsibility in 2-second time interval. The general expression for the probability resulting from n time intervals is given in Equation IV-7-105:

$$PD^{(n)} = 1 - (1 - PD)^n \qquad \text{(IV-7-105)}$$

The expected value of the number of time intervals required to detect at least one target is given by Equation IV-7-106:

$$\langle n \rangle = \frac{1}{PD} \qquad \text{(IV-7-106)}$$

and hence the expected time in seconds to detect is given by Equation IV-7-107:

$$\langle t \rangle ' = 2 \cdot \langle n \rangle = \frac{2}{PD} \qquad \text{(IV-7-107)}$$

(b) The time to detect is modified to reflect the possibility that an acquired target is outside the weapon's area of responsibility using Equation IV-7-108 which assumes that search is uniform throughout the search angle. γ is defined by Equation IV-7-60 and θ is the angle within which useful targeting information can be obtained. The current version of the model has no capability for target information exchange among observing weapon systems, and consequently the ratio of γ/θ is set to one.

$$\langle t \rangle = \frac{\gamma}{\theta} \langle t \rangle ' \qquad \text{(IV-7-108)}$$

(c) Finally, all detections probabilities are converted to reflect their proper values at time t = < t > combining Equations IV-7-101, -103, and -106 into Equation IV-7-109.

$$PD''_{jkl} = 1 - (1 - PD'_{jkl})^{\langle n \rangle} \qquad \text{(IV-7-109)}$$

(6) Pinpoint Probabilities:

(a) The Target Acquisition Submodel calculates independently the pinpoint target acquisition probabilities PP_j from the single round pinpoint probabilities PP'_j and the number of stationary targets j which have recently fired one or two rounds, N_{f1j} and N_{f2j}, that are discussed further in paragraph 3g, below.

(b) From N_{f1j} and N_{f2j} the number of recent firers in each weapon's area of responsibility is determined using Equations IV-7-110:

$$n_{f1j} = N_{f1j} \frac{\sum_{k=2}^{4} k \cdot A_k}{A} \qquad \text{(IV-7-110a)}$$

$$n_{f2j} = N_{f2j} \frac{\sum_{k=2}^{4} k \cdot A_k}{A} \qquad \text{(IV-7-110b)}$$

where A was defined in Equation IV-7-59 and the sum is the total area covered by one weapon. The probability of not pinpointing a target j is calculated by Equation IV-7-111:

$$\overline{PP}_j = 1 - PP'_j \cdot P_{LOS_{j22}} \qquad \text{(IV-7-111)}$$

where the first subscript 2 represents the median range and the second refers to the stationary posture. Making use of Equation IV-7-102 the probability of pinpointing at least one target j is given by Equation IV-7-112:

$$PP_j = 1 - \overline{PP}_j^{\,n_{f1j}(I)} \cdot (1 - n_{f1j}(R) \cdot (1 - \overline{PP}_j))$$

$$\cdot\ \overline{PP}_j^{\,2n_{f2j}(I)} \cdot (1 - n_{f2j}(R) \cdot (1 - PP_j))^2 \qquad \text{(IV-7-112)}$$

where, as before, the I and R refer to the integer and remaining parts of the n's.

e. Firepower Potential Submodel:

(1) General.

(a) The Firepower Potential Submodel uses the target acquisition probabilities generated by the previous submodel and the weapon-target priority assignments to determine the distribution of fires against each target type. Fires are further distributed among the different types of coverage regions and the postures of each target type.

(b) The number of rounds fired by each weapon type is then calculated based upon the expected value of the time to detect at least one priority target, the time to aim and fire the weapon, and the flight time of the round.

(2) Distribution of Fires.

(a) Fires are first allocated among weapon/ammunition combinations linked to the same transport vehicle. If the minimum and maximum range limitations are such that only one weapon/ammunition combination may be applied, that combination is assumed to be used by all vehicles. If the minimum and maximum range limitations of several weapon/ammunition combinations common to a single type transport vehicle are such that more than one combination may be applied, the weapon unit is broken into firing zones as follows. The minimum and maximum depths within the weapon unit in which each weapon/ammunition combination may fire is calculated using Equations IV-7-113.

$$F_i = \text{Max } (0, R_{min_i} - S_e - d_T) \qquad \text{(IV-7-113a)}$$

$$B_i = \text{Min } (R_{max_i} - S_e, 2x) \qquad \text{(IV-7-113b)}$$

Equations IV-7-113 are solved for each combination i carried by the transport for which target acquisition information is being considered. R_{min_i}, R_{max_i}, F_i and B_i are the minimum and maximum effective ranges and minimum and maximum depths within the weapon unit where the combination is allowed to fire. d_T is the front band depth of the target unit, S_e is the engagement front to front separation, and x was defined by Equation IV-7-32. The set of F_i and B_i generated by all applicable weapon/ammunition combinations results in a series of zones, as depicted in Figure IV-7-14. Within this figure zone IV is defined by inserting R_{min_1} = 50m and R_{max_1} = 100m into Equations IV-7-113. The resulting values of F_1 = 0 and B_1 = 200m allow only those weapons in zone IV to fire. Other zones are defined by the range capabilities of the other weapons. Within each zone p the number of weapon/ammunition combinations n_p which share at least one common priority 1 target type is determined. Fires are allocated uniformly, within zones, for such weapon/ammunition combinations as shown in Equation IV-7-114:

$$Frac_{ip} = 1 / n_p \qquad \text{(IV-7-114)}$$

[for those combinations i which
share a common priority 1 target]

where $Frac_{ip}$ is the fraction of combination i in zone p which fires combination i. If a zone p contains only one combination i, or if combination i does not share a common priority 1 target type with other combinations in the zone, $Frac_{ip}$ is defined by Equation IV-7-115:

$$Frac_{ip} = 1 \qquad \text{(IV-7-115)}$$

[for those combinations i which do
not share a common priority 1 target]

The net fraction of combination i which fires throughout the weapon unit is determined using Equation IV-7-116:

$$Frac_i = \sum_p Frac_{ip} \cdot d_p/d_w \qquad \text{(IV-7-116)}$$

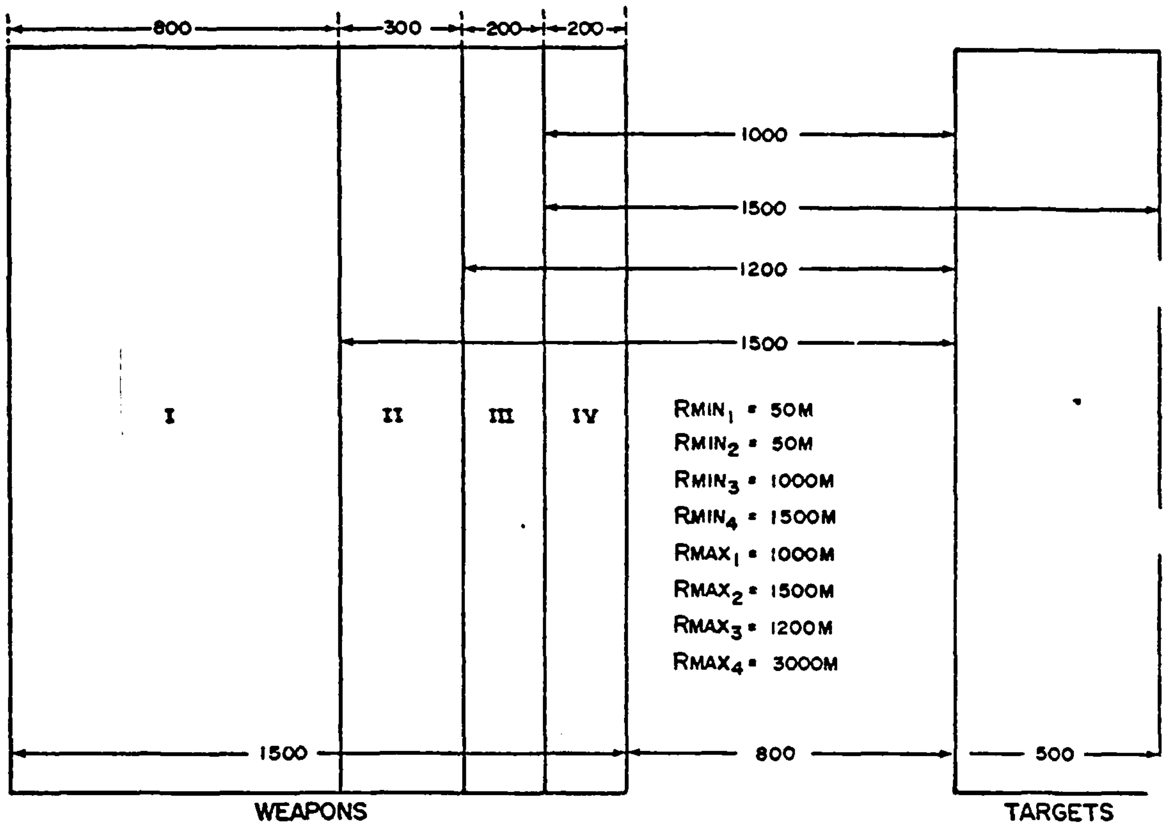


Figure IV-7-14. Example of Zones Defined by Weapon/Ammunition Range Capabilities where d_p is the depth of zone p.

(b) The target acquisition probabilities are then combined with the target priorities to distribute the rounds that each weapon type i will fire at each target type j in each posture at each range. First, the priority 1 targets are considered. The probability $P_{j(1)}$ in Equation IV-7-117 is the probability that at least one priority 1 target j has been detected by time $\langle t \rangle$, defined in Equation IV-7-108.

$$P_{j(1)} = 1 - \prod_{\substack{j \\ \text{priority} \\ 1}} \prod_{k=2}^{4} \prod_{l=1}^{2} (1 - PD''_{jkl}) \qquad \text{(IV-7-117)}$$

PD''_{jkl} was defined in Equation IV-7-109. The probability of acquiring at least one second priority target j and not having acquired a first priority target is calculated in Equation IV-7-118:

$$P_{j(2)} = \left\{ 1 - \prod_{\substack{j \\ \text{priority} \\ 2}} \prod_{k=2}^{4} \prod_{l=1}^{2} [1 = PD''_{jkl}] \right\} \cdot (1 - P_{J(1)}) \qquad \text{(IV-7-118)}$$

(c) A calculation is made for the n^{th} priority target using Equation IV-7-119:

$$P_{j(n)} = \left\{ 1 - \prod_{\substack{j \\ \text{priority} \\ n}} \prod_{k=2}^{4} \prod_{l=1}^{2} [1 - PD''_{jkl}] \right\} \cdot \prod_{q'=1}^{n-1} (1 - P_{j(q')}) \qquad \text{(IV-7-119)}$$

These probabilities represent the fraction of eligible weapons i that will attempt to fire at each target priority class j(n).

(d) Within each target priority class rounds are distributed by range and posture as follows. $P_{j(n)}$ is the fraction of eligible firers that fire at targets type j(n) where n is the priority assignment.

The fractions of acquisitions by range and posture are taken to be the simple ratios of Equation IV-7-120:

$$F_{jkl} = \frac{P''_{jkl}}{\sum_{k=2}^{4} \sum_{l=1}^{2} P''_{jkl}} \qquad \text{(IV-7-120)}$$

(e) $Frac_i$ was determined in Equation IV-7-116 to be the fraction of weapons of type i in range of some target in the target band; hence, the number of stationary eligible firers of type i is given by Equation IV-7-121:

$$n_i'' = n_i \cdot Frac_i \cdot (1 - v_w \cdot \sqrt{2} / v_i) \qquad \text{(IV-7-121)}$$

where n_i was defined by Equation IV-7-28, v_w is the weapon unit velocity, and v_i is the mobility class rate for weapon type i. Thus, the number of firers i firing at each target type by range and posture can be expressed by Equation IV-7-122:

$$n_{ijkl} = n_i'' \cdot F_{jkl} \cdot \frac{P_{j(n)}}{\sum_{q'} PD''_{q'kl}} \cdot PD''_{jkl} \qquad \text{(IV-7-122)}$$

where q' is the number of priority n targets.

(3) Number of Rounds Fired:

(a) The number of rounds fired is calculated as follows. One round is fired by each weapon that fires on a stationary target. One round is fired by each weapon that fires on a moving target and maintains line of sight. A second round is fired if line of sight is maintained after the first round. A second round is fired at stationary targets only by a fraction $(1 - PK_{ijk2})$ of the original firers, where PK_{ijk2} is the kill probability for weapon i against a stationary target j at range R_k. PK is discussed further in paragraph 3f, below. Thus, the number of rounds fired can be expressed by Equations IV-7-123:

$$RN_{ijk1} = n_{ijk1}[P_{LOS_{jk1}} + P^2_{LOS_{jk1}}] \quad \text{(IV-7-123a)}$$

$$RN_{ijk2} = n_{ijk2}[\, 1 + (1 - PK_{ijk2})] \quad \text{(IV-7-123b)}$$

(b) Equations IV-7-123 give the number of rounds fired by time $\langle t \rangle + 2 \cdot T_{iafd}$, where T_{iafd} is the time required for weapon i to aim, fire, and deliver a round. The actual number of rounds fired during an interation is determined by multiplying Equations IV-7-123 by the ratio T divided by $(\langle t \rangle + 2 \cdot T_{iafd})$ where T is the engagement iteration time.

(4) Pinpointed Targets.

(a) Rounds fired at pinpointed targets are calculated independently considering only those eligible weapons not firing at observed targets. The number of weapons is given by Equation IV-7-124:

$$n_{ipp} = n_i'' - \sum_{n} \sum_{k=2}^{4} \sum_{l=1}^{2} n_{ijkl} \quad \text{(IV-7-124)}$$

The pinpoint detections are ordered by priorities just as were the observed targets, yielding Equation IV-7-125, which is analogous to Equation IV-7-119:

$$P_{j(n)pp} = PP_{j(n)} \cdot \prod_{j(1)} [1 - PP_{j(1)}] \ldots . \prod_{j(n-1)} [1 - PP_{j(n-1)}] \quad \text{(IV-7-125)}$$

(b) Each firing weapon fires only one round, and the number of rounds fired is given by Equation IV-7-126, which is analogous to Equation IV-7-122.

$$RN_{ijpp} = n_{ipp} \cdot \frac{P_{j(n)pp}}{\sum_{q'} PP_{q'}} \cdot PP_j \cdot \frac{T}{\langle t \rangle + T_{iafd}} \quad \text{(IV-7-126)}$$

(5) Firing Rates:

(a) The firing rate for each active weapon of type i is determined by Equation IV-7-126a, which is simply the ratio of total expenditures against all target types and postures to the number of firers.

$$\text{Rate} = \left(\sum_{j=1}^{8} \sum_{k=2}^{4} \sum_{l=1}^{2} RN_{ijkl} + \sum_{j=1}^{8} RN_{ijpp} \right) \Big/ n_i'' \qquad \text{(IV-7-126a)}$$

(b) The firing rate computed using Equation IV-7-126a is compared to the maximum sustainable combat rate of fire as specified in the constant data. If the maximum rate is less than that obtained above, all expenditures by weapon type i are reduced using Equations IV-7-126b and IV-7-126c:

$$RN_{ijkl} = (RN_{ijkl})_{\text{initial}} \cdot \text{Rate}_{\text{Max}_i} \;/\; \text{Rate} \qquad \text{(IV-7-126b)}$$

$$RN_{ijpp} = (RN_{ijpp})_{\text{initial}} \cdot \text{Rate}_{\text{Max}_i} \;/\; \text{Rate} \qquad \text{(IV-7-126c)}$$

where $\text{Rate}_{\text{Max}_i}$ is the maximum sustainable combat rate of fire for weapon type i.

f. Firepower Effectiveness Submodel:

(1) General.

(a) The Firepower Effectiveness Submodel determines the effect of each type round fired at each target type by interpolating between experimental data points to determine both the probability of a hit and the probability of a kill given a hit. The resulting kill probability is applied at the different ranges corresponding to the different coverage regions as well as to the different target postures.

(b) The survival probability for each target type is calculated based upon the total number of rounds entering each coverage region, thereby accounting for the possibility of multiple hits by more than one weapon.

(c) Conditional casualties for each target type are then computed to reflect the range limitations of each opposing weapon type.

This is accomplished by dividing the engaged portion of the target unit into four bands and assessing losses only in those bands within range of the weapon.

(d) These conditional casualties are then distributed among the firing weapons to account for the effect of firing order.

(2) Weapon-Target Kill Probabilities:

(a) The effect of each type round against each target type can be expressed by Equation IV-7-127:

$$P'_{K_{ijkl}} = P_{K/H_{ijkl}} \cdot P_{H_{ijkl}} \qquad \text{(IV-7-127)}$$

where $P_{K/H_{ijkl}}$ is the probability of a kill given a hit by weapon i on target j in posture l at range R_k, and $P_{H_{ijkl}}$ is the corresponding hit probability.

(b) Experimental hit probabilities for up to six range values for each weapon type are required by a pregame load routine which in turn generates six values of the NATO hit probability (probability of hitting a square target 7-1/2 ft. x 7-1/2 ft.) corresponding to the weapon's minimum range, maximum range, and four intermediate values, all at equal range increments. The Ground Combat Model then performs a linear interpolation on these values to determine the NATO hit probability at any intermediate range. The resulting value is then used to solve for $\sigma^2(r)$ using Equation IV-7-128:

$$P_{H_{NATO}}(r) = 1 - e^{-R^2/2\,\sigma^2(r)} \qquad \text{(IV-7-128a)}$$

or:

$$\sigma^2(r) = -R^2/2\ln\left(1 - P_{H_{NATO}}\right) \qquad \text{(IV-7-128b)}$$

where R is the radius of a circular target having an area equal to that of a standard NATO target.

$$R^2 = (7.5)^2 / \Pi = 17.9 \text{ ft}^2 \qquad \text{(IV-7-129)}$$

Equations IV-7-128b and IV-7-129 and a radius corresponding to the target's presented area are then substituted into an equation analogous to Equation IV-7-128a to solve for $P_{H_{ijkl}}$ as indicated in Equation IV-7-130:

$$P_{H_{ijkl}} = 1 - e^{-(A_{jl} / \Pi) / (17.9)^2 / \ln[1 - P_{H_{NATO_{ik}}}]}$$

$$= 1 - (1 - P_{H_{NATO_{ik}}})^{A_{jl} / 56.25} \qquad \text{(IV-7-130)}$$

where A_{jl} is the presented area of target j in posture l. The exposed area of stationary targets is again reduced as indicated in a preceding paragraph under target acquisition.

(c) The hit probability against a pinpointed target is based upon the experimental results of Project PINPOINT (Reference 11). Citing this reference, a pinpointed target is one which has been located to within ±25 yards of its true location. For ranges less than 500 meters the pinpoint probability was found to be range independent. At these ranges the major error in hitting a target is the horizontal error in location. The Ground Combat Model determines the probability of hitting a pinpointed target by Equation IV-7-131, where the area of the fully exposed target, in square feet, is used.

$$P_{H_{ijpp}} = \frac{\text{Target width}}{\text{50 yds.}}$$

$$= \frac{2}{\sqrt{\pi}} \left(\frac{\sqrt{A} \cdot \frac{1}{9} \text{ yds}^2 / \text{ft}^2}{\text{50 yds.}} \right)$$

$$= 0.00752 \sqrt{A} \qquad \text{(IV-7-131)}$$

$P_{K/H_{ijkl}}$ in Equation IV-7-127 is assumed to be closely approximated by the linear function in range of Equation IV-7-132:

$$P_{K/H_{ijkl}} = m_{ijrk} + b_{ij} \qquad \text{(IV-7-132)}$$

where the slope m_{ij} and intercept b_{ij} are determined by at least squares fit to experimental data.

(3) Conditional Casualties:

(a) The number of rounds entering each coverage section directed at target j in posture l is computed using Equation IV-7-133:

$$TRN_{ijkl} = RN_{ijkl} \ / \ (n_i + 1 - k) \qquad \text{(IV-7-133)}$$

RN_{ijkl} and n_i were defined by Equations IV-7-123 and IV-7-28, respectively. The factor $(n_i + 1 - k)$ is the number of each type coverage sections.

(b) Conditional casualties, as if this weapon were firing alone and not receiving return fire, are then calculated using Equation IV-7-134:

$$CK_{ij} = \sum_{k=2}^{4} \sum_{l=1}^{2} (n_i + 1 - k) \cdot m_{jkl} \cdot P_{K_{ijkl}} \qquad \text{(IV-7-134)}$$

In Equation IV-7-134, m_{jkl} was defined in Equation IV-7-66 and CK_{ij} are the conditional kills of target type j by weapon type i. The term $(n_i + 1 - k)$ is again the number of sections of coverage type k, and $P_{K_{ijkl}}$ is determined from Equation IV-7-135.

$$P_{K_{ijkl}} = 1 - (1 - P'_{K_{ijkl}})^{T_{ijkl}^{(I)}} \cdot (1 - T_{ijkl}^{(R)} P'_{K_{ijkl}}) \qquad \text{(IV-7-135)}$$

$P'_{K_{ijkl}}$ is given by Equation IV-7-127. T_{ijkl} is found using Equation IV-7-136:

$$T_{ijkl} = TRN_{ijkl} \ / m_{jkl} \qquad \text{(IV-7-136)}$$

where I refers to the integer portion of T_{ijkl} and R to the remainder. Substituting Equations IV-7-135 and -136 into Equation IV-7-134 and again interpreting a fractional round as the probability of a whole round, the conditional casualties are expressed by Equation IV-7-137:

$$CK''_{ij} = \sum_{k=2}^{4} \sum_{l=1}^{2} (n_i + 1 - k) \cdot m_{jkl}$$

$$\cdot \left\{ 1 - (1 - P_{K'_{ijkl}}) \, T^{(I)}_{ijkl} \; (1 - T_{ijkl} \, P_{K'_{ijkl}}) \right\} \qquad \text{(IV-7-137)}$$

To Equation IV-7-137 is added the conditional kills against pinpointed targets, which is determined in an analogous fashion and presented in Equation IV-7-138:

$$CK'_{ij} = CK''_{ij} + n_i \, (n_{f1j} + n_{f2j})$$

$$\cdot \left\{ 1 - (1 - P_{K'_{ijpp}}) \, T^{(I)}_{ijpp} \; (1 - T^{(R)}_{ijpp} \; P_{K_{ijpp}}) \right\} \qquad \text{(IV-7-138)}$$

$P_{K'_{ijpp}}$ is found by inserting Equation IV-7-131 into Equation IV-7-127, and T_{ijpp} is calculated in Equation IV-7-139:

$$T_{ijpp} = RN_{ijpp} \, / \left\{ n_i \, (n_{f1j} + n_{f2j}) \right\} \qquad \text{(IV-7-139)}$$

where n_{f1j} and n_{f2j} were defined in Equation IV-7-110 as the number of firing targets per weapon.

g. Casualty Adjustments. The conditional casualties of Equation IV-7-138 are for weapon type i acting in isolation with no other friendly fires or return fires. Adjustments are required to compensate for the dynamics of the situation.

(1) First, the effect of other firing weapon types is considered by determining the survival probability for each target j against all types of incoming rounds. This is accomplished by subdividing the leading band of the target unit into four equal area rectangles with the depth of each equal to one-fourth the total band depth. The survival probability in each subband is then computed considering only those weapons which are capable of firing into each band. The following criteria are used to establish which weapons fire into which bands.

Weapon i fires into	if
None (of the engaged target unit)	$R_{max_i} \leq S_E$
Front 1/4	$0 < R_{max_i} - S_E \leq 0.375d_t$
Front 2/4	$0.375d_t < R_{max_i} - S_E \leq 0.625d_t$
Front 3/4	$0.625d_t < R_{max_i} - S_E \leq 0.875d_t$
All	$0.875d_t < R_{max_i} - S_E$
Back 3/4	$0 < R_{min_i} - S_E - d_w \leq 0.875d_t$
Back 2/4	$0.375d_t < R_{min_i} - S_E - d_w \leq 0.625d_t$
Back 1/4	$0.625d_t < R_{min_i} - S_E - d_w \leq 0.875d_t$
None	$R_{min_i} - S_E - d_w > 0.875d_t$

CK'_{ij} from Equation IV-7-138 is then converted to an average survival probability by Equation IV-7-140, which is applied to each applicable subband.

$$PS_{ijy} = 1 - F_y \, CK'_{ij} \,/\, (m_j \,/\, 4) \qquad \text{(IV-7-140)}$$

In Equation IV-7-140, $m_j / 4$ is the number of targets of type j in each subband and F_y is the fraction of subband y covered by weapon type i. The net survival probability of target j in each subband y is computed using Equation IV-7-141.

$$PS_{jy} = \prod_{\substack{\text{all i firing} \\ \text{into band y}}} PS_{ijy} \qquad \text{(IV-7-141)}$$

(2) The survival probabilities of Equation IV-7-141 are converted to conditional casualties to account for all possible permutations of firing order among differing weapon types carried by the same transport. From Reference 12 this is accomplished by solving Equation IV-7-142a:

$$CK_{ijy} = \frac{m_j}{4} \int_0^T \left(\frac{1 - PS_{ijy}}{T} \right) \prod_{\substack{q=1 \\ q \neq 1}}^{NWT} \left\{ 1 - \left(\frac{1 - PS_{qjy}}{T} \right) t \right\} dt \quad \text{(IV-7-142a)}$$

where NWT is the number of weapon types, t is the integration variable, and the product runs over all weapon types q carried by the same transport as weapon type i. The model utilizes Gauss-Legendre integration, the 10-point formula, to evaluate Equation IV-7-142a. This solution is exact for polynomials of degree 15, the highest degree possible for 16 weapon types. Application of this integration technique yields the result provided in Equations IV-7-142b, c, and d:

$$CK_{ijy} = \frac{m_j}{4} \; (1 - PS_{ijy}) \cdot \sum_{q'=1}^{5} w_q' \; (A1 + A2) \; / \; 2 \quad \text{(IV-7-142b)}$$

$$A1 = \prod_{\substack{q=1 \\ q \neq 1}}^{NWT} 1 - (1 - PS_{qjy}) \; (1 + r_q') \; / \; 2 \quad \text{(IV-7-142c)}$$

$$A2 = \prod_{\substack{q=1 \\ q \neq 1}}^{NWT} 1 - (1 - PS_{qjy}) \; (1 - r_q') \; / \; 2 \quad \text{(IV-7-142d)}$$

where the r_q' and w_q' are the roots and weight of the Gauss-Legendre 10-point formula. The values of these parameters are specified in Equation IV-7-142e:

$w_1 = 0.295524225$ $\quad r_1 = 0.148874339$

$w_2 = 0.269266719$ $\quad r_2 = 0.433395394$

$w_3 = 0.219086362$ $\quad r_3 = 0.679409568$

w_4 = 0.149451349 r_4 = 0.865063367

w_5 = 0.066671344 r_5 = -.973906528 (IV-7-142e)

the total conditional casualties is the sum over all subbands of Equation IV-7-142b.

$$CK_{ij} = \sum_{y=1}^{4} CK_{ijy} \qquad \text{(IV-7-143)}$$

The casualties in Equation IV-7-143 have now been corrected to reflect the net lethality of each firing transport, but are still conditional in that the problem of return fire has not been addressed.

(3) The solution of the return fire problem is oriented toward the lethality and vulnerability of transport types as opposed to discrete weapon types. First, the individual weapon kills are accumulated to kills by each transport, or weapon system, using Equation IV-7-144:

$$\hat{L}_{A_{jk}} = \sum_{i \text{ in } k} CK_{A_{ji}} \qquad \text{(IV-7-144a)}$$

$$\hat{L}_{D_{kj}} = \sum_{i \text{ in } j} CK_{D_{ki}} \qquad \text{(IV-7-144b)}$$

In Equation IV-7-144a, $CK_{A_{ji}}$ are the conditional kills of attacking target j by defending weapon i. The sum over i is over all weapons i linked to defender weapon system k, and $L_{A_{jk}}$ are the total conditional attacking target j losses due to defending weapon system k. Equation IV-7-144b is a similar description of total defending target k losses due to attacking weapon system j. The losses calculated in Equation IV-7-144 are then converted to kill fractions using Equation IV-7-145:

$$\hat{K}_{A_{jk}} = \frac{\hat{L}_{A_{jk}}}{n_{A_j}} \qquad \text{(IV-7-145a)}$$

$$\hat{K}_{D_{kj}} = \frac{\hat{L}_{D_{kj}}}{n_{D_k}} \qquad \text{(IV-7-145b)}$$

where n_{Aj} and n_{Dk} are the number of attacking systems j and the number of defending weapon systems k; $\hat{K}_{A_{jk}}$ is the conditional fraction of attacking target j killed by defending weapon system k; and $\hat{K}_{D_{kj}}$ is the fraction of defending target k killed by attacking weapon system j. These kill fractions are then processed by repeated iterations that converge to a solution of Equations IV-7-146:

$$X_j = \sum_k (1 - \hat{K}_{A_{jk}} \cdot Y_k) \qquad \text{(IV-7-146a)}$$

$$Y_k = \sum_j (1 - \hat{K}_{D_{kj}} \cdot x_j) \qquad \text{(IV=7-146b)}$$

In Equation IV-7-146, X_j and Y_k are the surviving fractions of attacking weapon system j and defending weapon system k, respectively.

(4) The solution of these equations is used to compute losses by first solving Equations IV-7-147:

$$K_{A_{jk}}' = \hat{K}_{A_{jk}} \cdot y_k \qquad \text{(IV-7-147a)}$$

$$K_{D_{kj}}' = \hat{K}_{D_{kj}} \cdot X_j \qquad \text{(IV-7-147b)}$$

In Equation IV-7-147a, $K_{A_{jk}}'$ is the fraction of attacking target j killed by the surviving fraction of defending weapon system k, with a similar description of $K_{D_{kj}}'$ in Equation IV-7-147b. These resulting kill fractions still fail to account for the simultaneous firing of all transports within each unit. The true kill fractions are obtained by Gauss-Legendre integration with the results given in Equation IV-7-148.

$$K_{A_{jk}} = n_{A_j} \cdot K_{A_{jk}}' \cdot \sum_{q'=1}^{5} W_q' \, (A1 + A2) / 2 \qquad \text{(IV-7-148a)}$$

$$K_{D_{jk}} = n_{D_k} \cdot K_{D_{kj}}' \cdot \sum_{q'=1}^{5} W_q' \, (D1 + D2) / 2 \qquad \text{(IV-7-148b)}$$

$$A1 = \prod_{\substack{q=1 \\ q \neq k}}^{NWT} \left\{ 1 - K_{A_{jq}}' \, (1 + r_q') / 2 \right\} \qquad \text{(IV-7-148c)}$$

$$A2 = \prod_{\substack{q=1 \\ q \neq k}}^{NWT} \left\{ 1 - K_{A_{jq}}' \quad (1 - r_q') \; / \; 2 \right\} \qquad \text{(IV-7-148d)}$$

$$D1 = \prod_{\substack{q=1 \\ q \neq j}}^{NWT} \left\{ 1 - K_{D_{kq}}' \quad (1 + r_q') \; / \; 2 \right\} \qquad \text{(IV-7-148e)}$$

$$D2 = \prod_{\substack{q=1 \\ q \neq j}}^{NWT} \left\{ 1 - K_{D_{kq}}' \quad (1 - r_q') \; / \; 2 \right\} \qquad \text{(IV-7-148f)}$$

Finally the kills due to discrete weapon types are extracted from the weapon system kills using Equations IV-7-149:

$$K_{A_{ji}} = K_{A_{jk}} \cdot CK_{A_{ji}} / \hat{L}_{A_{jk}} \qquad \text{(IV-7-149a)}$$

$$K_{D_{ki}} = K_{D_{kj}} \cdot CK_{D_{ki}} / \hat{L}_{D_{kj}} \qquad \text{(IV-7-149b)}$$

Similarly the real expenditures are determined using Equations IV-7-150:

$$ARN_{ik} = (K_{D_{ki}} / \hat{K}_{D_{ki}}) \; (RN_{ijpp} + \sum_{k=2}^{4} \sum_{l=1}^{2} RN_{ijkl}) \qquad \text{(IV-7-150a)}$$

$$DRN_{ij} = (K_{A_{ji}} / \hat{K}_{A_{ji}}) \; (RN_{ijpp} + \sum_{k=2}^{4} \sum_{l=1}^{2} RN_{ijkl}) \qquad \text{(IV-7-150b)}$$

where ARN_{ik} is the number of rounds fired at defending target k by attacking weapon i and DRN_{ij} is the number of rounds fired at attacking target j by defending weapon i.

h. Supporting Fire and Intelligence. Each unit pair exchanging direct fires may generate a sensing report of the opponent, may request supporting fires on the opponent and may fire integral mortars at the opposing unit. These actions are all based on target acquisition during the simulated assessment increment.

(1) Sensing Report Information.

(a) Sensing report information is computed based on what is seen of the enemy unit through the combat increment being assessed. The probability of detection for each of four observer teams is calculated by the use of $\langle n \rangle = t_s/2$ in Equation IV-7-109 where t_s is the length of the combat increment. The detection probability of Equation IV-7-109, PD''_{jkl}, is assigned to the number of targets in each coverage section given by Equation IV-7-66, M_{jkl}, to give N_j detected targets of type j:

$$N_j = \sum_{k=2}^{4} \sum_{l=1}^{2} (N_{fo} + 1 - k) \cdot PD''_{jkl} \cdot M_{jkl} \qquad \text{(IV-7-151)}$$

with $N_{fo} = 4$, the number of observer teams. Targets are then identified by type as tanks, APCs, other vehicles or personnel and are summed over each class.

(b) Estimated activity of the opposing unit is "attacking" or "defending", depending upon which force is established as the attacker in GCM. Actual velocities and direction of movement, if any, are used as the estimated speed and unit direction.

(c) Estimated target location is the center of that portion of the unit actually engaged, with the unit aligned on its normal DIVWAG orientation rather than the "engagement orientation" to which the unit may be rotated by the GCM geometry calculations.

1. From Figure IV-7-15, it may be observed that the center of the engaged portion of the unit is removed from the unit center by a distance XX normal to the unit front and YY parallel to the unit front where, given unit width and depth, W_μ and d_μ and engagement width W_e, if the unit has N bands:

$$XX = 1/2 \frac{(d_\mu \cdot N - 1)}{N} \qquad \text{(IV-7-152)}$$

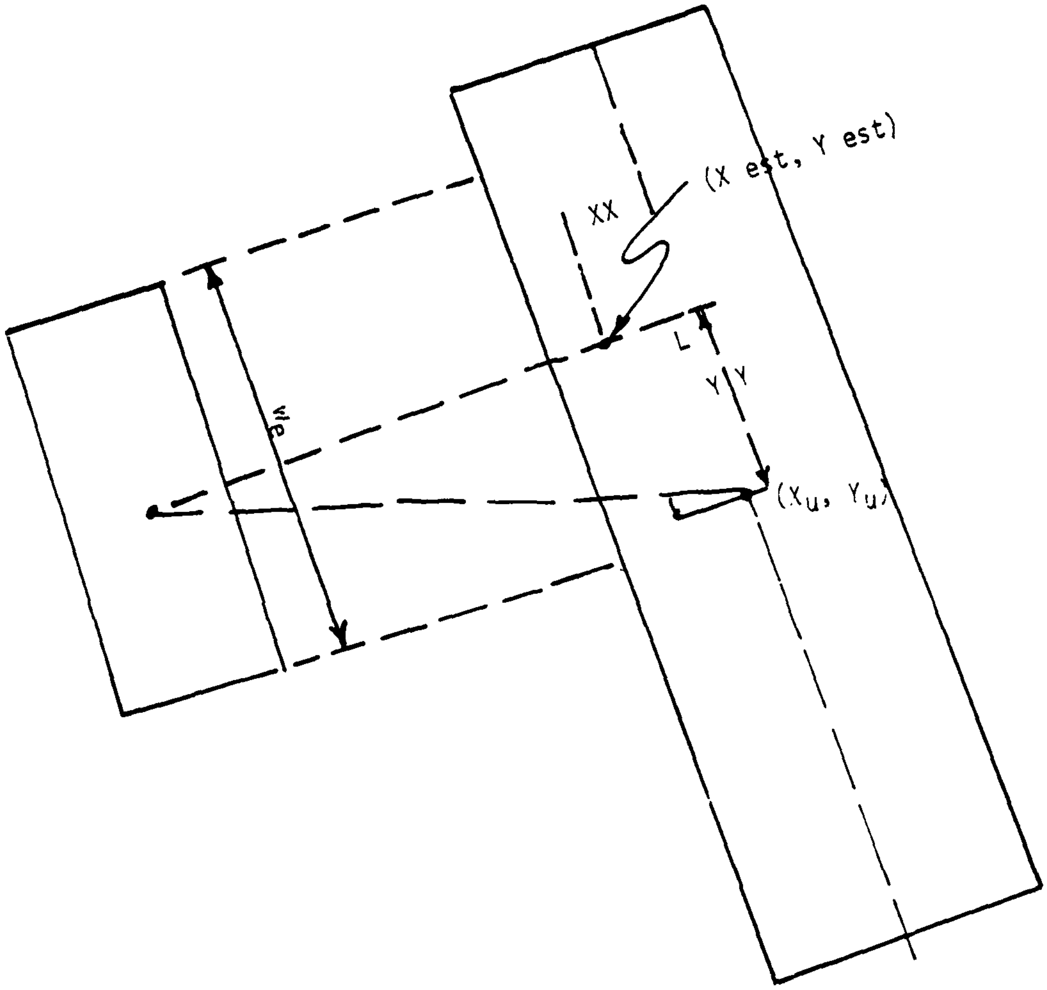


Figure IV-7-15. Estimated location.

$$YY = 1/2 \left| (W_\mu - W_e) \right| \qquad \text{(IV-7-153)}$$

The value computed above for YY is incorrect if the entire sensing unit front band is engaging part of the sensed unit. In that case, the center of the sensed portion of the larger unit must be on the line through the smaller unit's center and normal to the unit fronts. Then, YY is developed as the third leg of a right triangle, as illustrated in Figure IV-7-15.

2. The distance XX may be resolved into its X and Y components based on the DIVWAG orientation of the sensed unit. Since it is known that XX must be in a direction toward the unit front, if the unit is oriented at angle θ , the components of XX must be

$$XX_x = XX \cos \theta \qquad \text{(IV-7-154a)}$$

$$XX_y = XX \sin \theta \qquad \text{(IV-7-154b)}$$

3. The distance YY is in a direction plus or minus 90^o from θ, depending on relative location of the unit pair. If the angle between unit centers is greater than θ (in the sense of a counter-clockwise rotation from θ to the angle between units, limited by π radians) then $\phi = \theta + 90^o$ and if the angle between units is less than θ , $\phi = \theta - 90^o$. YY is then decomposed into components.

$$YY_x = YY \cos \phi \qquad \text{(IV-8-155a)}$$

$$YY_y = YY \sin \phi \qquad \text{(IV-8-155b)}$$

4. The estimated location is then arrived at as, for unit center X_u and Y_u:

$$Xest = X_u + XX_x + YY_x \qquad \text{(IV-8-156a)}$$

$$Yest = Y_u + XX_y + YY_y \qquad \text{(IV-7-156b)}$$

(2) Reporting. A sensing report is generated for input to the INCS model, both for information purposes and for fire support request purposes, if no report has been generated by the sensing unit for this sensed unit within the last 10 minutes.

(3) Mortar Fires. If a unit generates a sensing report for the INCS model, firing of any mortars organic to the sensing unit may also be scheduled by the Ground Combat Model. Assessment of the effects of these fires is made by the Area Fire Model.

(a) Decision to Fire. The decision to fire mortars is made if the potential firing unit has organic mortars (area fire weapons organic to a unit engaged in ground combat are assumed to be mortars) and ammunition and has detected at least five personnel targets during the GCM assessment interval. Further, target range must be within the mortar's maximum and minimum range bracket. Firing, or target, range is calculated as the range from the rear edge of the firing unit's front band to the center of the target unit's front band, when units are in their GCM engagement orientation.

(b) Weapon Selection. If the potential firing unit has more than one type organic area fire weapon or munition, a munitions - range workload factor is computed for each and the weapon with the greatest factor is used. For a given munition, the workload factor is computed as:

$$F = \left(\frac{A_u}{A\ auth}\right) \cdot \left(\frac{Rmax - Rtgt}{Rmax - Rmin}\right) \qquad \text{(IV-7-157)}$$

with A_u = rounds on hand in unit

A auth = rounds authorized the unit

Rmax, Rmin = weapon max and min ranges

Rtgt = target range

(c) Volume of Fire. For one mortar firing event, the number of mortars and rounds available for firing is taken as

$$Ma = M_u \cdot F/W \qquad \text{(IV-7-158a)}$$

$$Aa = A_u \cdot F/W \qquad \text{(IV-7-158b)}$$

where: Ma, Aa = mortars, rounds available to fire

Mu, Au = mortars, rounds in firing unit

F = GCM engagement front for the unit pair

W = firing unit front

Each available tube fires the number of rounds that can be fired at maximum firing rate in 3 minutes (from the Area Fire model data base) with that expenditure limited to the rounds available for firing.

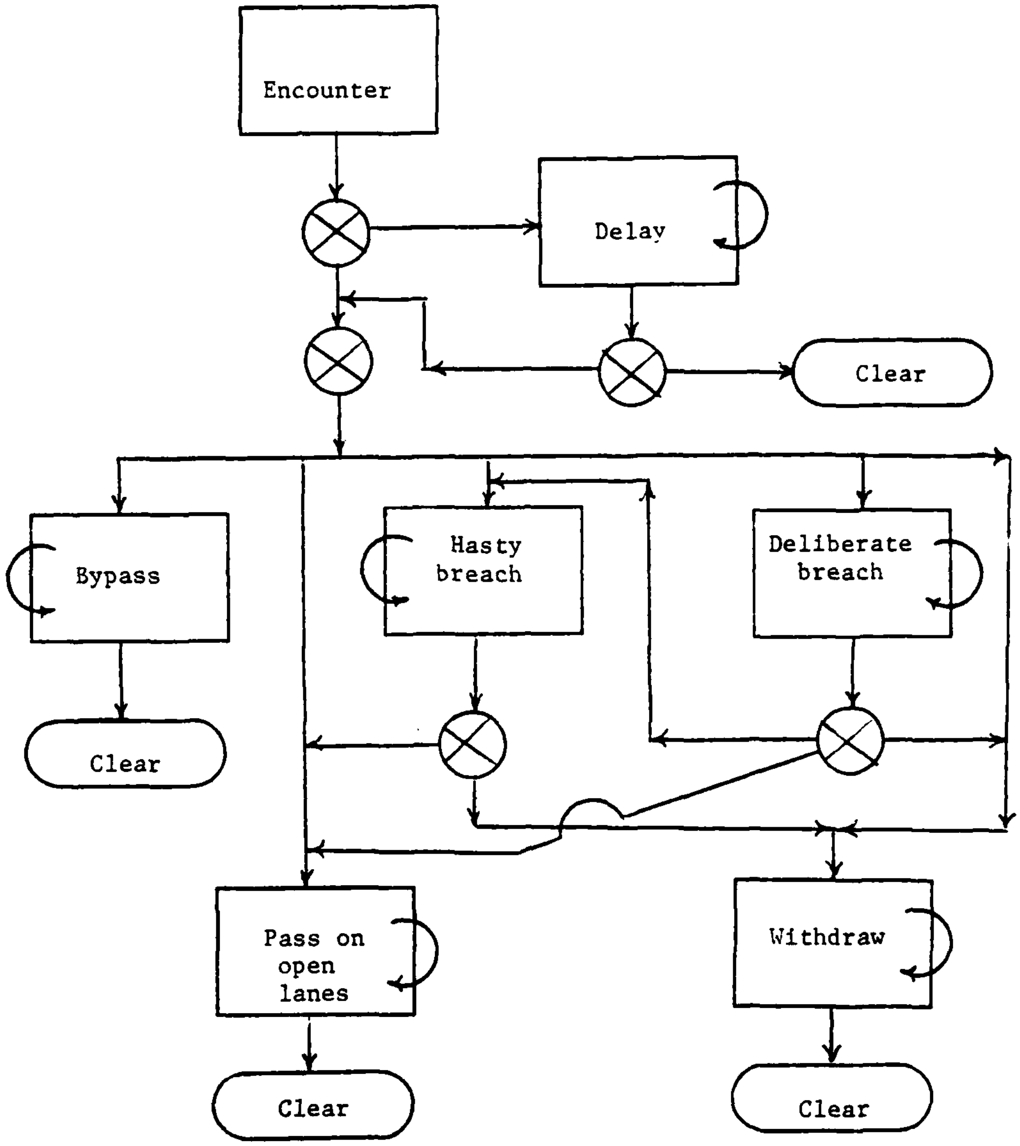
5. BARRIER INTERACTIONS. Logic within the Ground Combat Model for the interaction of a unit with a barrier is intended to represent an attacking unit's encounter of and reaction to a minefield which a defending unit is covering by direct fire. Encounter of a barrier by defending units is not portrayed. Other type barriers may be represented, in which case explicit simulation is limited to a time delay imposed upon the encountering unit. During this time unit motion is halted and the unit may be under fire.

a. Modes of Interaction. Model design is based on the definition of seven modes of barrier interaction. A unit involved with a barrier is placed in one of the modes, with possible transition among modes, until the unit clears the barrier. Figure IV-7-16 illustrates the possible transitions among modes. Modes other than encounter are incremental and thus re-entrant.

(1) Encounter Mode. The encounter mode is the initial mode of interaction. Within this mode encounter losses are assessed, the appropriate reaction to the barrier is selected and amount of any delay associated with countermeasure decision and initiation is determined.

(2) Delay Mode. In the delay mode, the encountering unit's movement is halted. The exchange of direct fire continues, with the attack unit stationary, in this mode. This is the only mode selected for a "pure delay" barrier, which is the only non-minefield type barrier dealt with within the Ground Combat Model. Once scheduled delay is accounted for, the unit transitions to an appropriate countermeasure mode, except in the case of a pure delay barrier wherein the unit is clear of the barrier upon completion of the delay.

(3) Bypass Mode. In the bypass mode, attacking unit motion is directed along the barrier until it is cleared. Direct fire exchanges continues apace.




= OR gate. Upon entry, logical flow will take one of the exit paths, depending on current conditions.

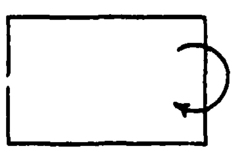

= Re-entrant state. Logical flow may remain in this state for some number of increments.

Figure IV-7-16. Barrier Interaction Transitions.

(4) Withdraw Mode. The withdraw mode is the default condition into which a unit enters if it has no feasible alternative counter to the barrier. In this mode the attacking unit disengages from any defender covering the barrier.

(5) Hasty Breach Mode. The hasty breach mode is used to represent a unit attempting to open lanes in a field by actually passing a vehicle, with or without some special equipment as plows or rollers, through the field. Exchange of direct fire continues, with unit motion of the encountering unit halted and vehicles actually working on the field disallowed from firing. If the unit can open sufficient lanes, it will pass through the field on these lanes, in the passage mode. If the unit loses the required clearing equipment, default to the withdraw mode is made.

(6) Deliberate Breach Mode. This mode is similar to the hasty breach mode but here the unit is using other mechanical or explosive devices to clear the field. Upon clearance of required lanes, transition is made to the passage mode. Upon exhaustion of required material without opening lanes, transition may be made to the hasty breach mode or withdraw mode, depending on countermeasure decision and feasibility.

(7) Passage Mode. This mode represents a unit clearing the field on open lanes.

b. Barrier Encounter. Within the DIVWAG System, each barrier segment is defined for location purposes by a straight line. A barrier encounter is sensed in the GCM mode when the center of an attack unit's leading edge crosses an appropriate barrier line.

(1) Each time an attacking unit is assessed in the basic GCM operational cycle, discussed in paragraph 3, a check is made as to whether the unit will encounter a barrier during the time increment about to be assessed for the exchange of direct fires. The computational procedure follows:

(a) Compute (XA, YA) the coordinates of the unit's leading edge center at the beginning of the time increment to be assessed.

(b) Compute (XF, YF) the coordinates of the unit's leading edge center at the end of the time increment to be assessed.

(c) Determine if the line segment from (XA, YA) to (XF, YF) intersects any barrier segment lines. The check is only made for existing minefields or "pure delay" barriers. A minefield is distinguished as a barrier type 1, 2, 3, or 4 and a pure delay barrier as type 25. (A definition of barrier types is found at Chapter 14, Engineer Model.)

(d) If more than one barrier segment line is intersected, the intersection point closest to (XA, YA) is saved. This point is called the "encounter point" and the associated barrier is the barrier encountered, if any.

(2) The barrier encounter will occur when the encountering unit is located with its leading edge center between (XA, YA) and (XF, YF) both in space and in time. Recalling that the assessment is made post facto, to cover the time interval from last assessment to current game time, the time of encounter must be within that time interval. Exchange of direct fires will, at this time, be simulated only from last assessment time to encounter time. Thus on next entry to the model, for the encountering unit, the encounter time will be last assessment time.

(3) If in the period from last assessment time to encounter time the attacking unit would enter inside of the minimum GCM separation distance of any defense unit, as discussed under the unit geometry considerations in paragraph 4, the encounter will be cancelled and, within the model, will not occur.

c. Barrier Intelligence and Discovery Losses.

(1) DIVWAG barrier intelligence is on a force-wide basis. Either a given barrier segment is known or unknown to a given force. If in the Ground Combat Model a unit encounters a minefield not previously known to its force, discovery losses are assessed against the encountering unit. Once a barrier has been encountered by any element of a force, the barrier becomes known to all elements of the force. Thus a given barrier segment can cause discovery losses only to the first element of a force which encounters the segment.

(2) Discovery losses in GCM are assessed against only one type vehicle, the nominally typical formation lead vehicle, specified in the constant data load. The essential process is to calculate V, the number of potential losses based on unit and field geometry; P_k, a normalized kill probability for the specified type vehicle and the composition of the field encountered; and assessing a loss of $L = V \cdot P_k$ against the unit.

(a) Potential loss definition is based on a subjective review of the situation with a maneuver unit, viewed as a whole, encountering a previously unknown or poorly known minefield while in an attacking posture. It is assumed that a maneuver company and battalion would generally be operating in a "two up" formation giving two lead vehicles on a company front and four lead vehicles on a battalion front. Based on the fraction of the unit front covered by the field, F, and assuming that following vehicles will sense any detonation caused by lead vehicles and will not progress into the field, the number of potential losses, V, for an encountering battalion is:

<u>V</u> = if <u>Fraction covered</u>

$$V = 1 \text{ if } F \leq 0.25 \quad \text{(IV-7-159a)}$$

$$V = 2 \text{ if } 0.25 < F \leq 0.50 \quad \text{(IV-7-159b)}$$

$$V = 3 \text{ if } 0.50 < F \leq 0.75 \quad \text{(IV-7-159c)}$$

$$V = 4 \text{ if } 0.75 < F \quad \text{(IV-7-159d)}$$

For a company-sized unit encountering the field, V would be set at 1 or 2 depending upon whether less or more than half of the unit front were covered by the field.

(b) The normalized kill probability for the first mine detonated by a given vehicle is calculated as

$$P_k = \sum_j G_j V_j \quad \text{(IV-7-160)}$$

where G_j is the probability that the first mine detonated by the vehicle is of type j and V_j is the probability of a vehicle kill given detonation for the type mine.

1. Given a vehicle's track width, W_t and belly width, W_b, let T be the ratio of track width to overall width. That is

$$T = 2 \cdot W_t / (2 \cdot W_t + W_b) \quad \text{(IV-7-161)}$$

Then if, for a given mine type j and vehicle, probability of a kill given detonation at the track is P_{kt} and given detonation at the belly is P_{kb}, probability of a kill given detonation is

$$V_j = P_{kt} \qquad \text{(IV-7-162a)}$$

if the mine is only pressure fuzed and

$$V_j = T \cdot P_{kt} + (1 - T) \cdot P_{kb} \qquad \text{(IV-7-162b)}$$

if the mine has other than pressure fuzing. The implicit assumption is that a pressure fuze mine detonates only at the track.

2. The probability that the first mine to be detonated by a given vehicle is of type j is approximated as follows:

a. Let n_j be the number of mines in the field of type j. Then

$$f_j = n_j \,/\, \sum_j n_j \qquad \text{(IV-7-163)}$$

is the proportion of mines of type j in the field and is an estimate of the probability of a vehicle encountering mine type j, given an encounter does occur.

b. Given the track to total width ratio [illegible], as computed above, and the probability of mine type j failing to detonate properly, d_j let

$$F_j = f_j \,.\, (1 - d_j) \qquad \text{(IV-7-164a)}$$

if mine type j is other than pressure fuzed and

$$F_j = f_j \cdot T \cdot (1 - d_j) \qquad \text{(IV-7-164b)}$$

if mine type j is pressure fuzed. The value F_j represents the probability a mine that detonates is of type j, given that a mine detonates.

c. The probability that the first mine to detonate is of type j is approximated by

$$G_j = F_j \,/\, \sum_j F_j \qquad \text{(IV-7-165)}$$

The greatest assumption made in using this approximation is that the lead vehicle does, indeed, detonate a mine.

d. Countermeasure Decisions and Delays. Upon encounter of a barrier, reaction of the encountering unit is based on current situational parameters. The model defines countermeasures to a field in generic terms as bypass, deliberate breach and hasty breach. The DIVWAG user provides elaboration on these techniques and specification of which techniques to use under various battle conditions through input data. Based on this data, model logic selects a feasible countermeasure or, lacking feasibility, causes the unit to withdraw from the field and covering fires.

(1) Battle Conditions. The Ground Combat Model selects barrier countermeasures from a priority list of up to ten options. Eight such option lists are provided by the model user for each of eight battle conditions. The model establishes the battle condition at the time of barrier encounter and uses this condition to select the proper list of countermeasure options. The eight conditions are based on all combinations of two variables describing intensity of fire experienced by the unit.

(a) Indirect fire conditions are defined at two levels. If the encountering unit was assessed by indirect fires within ten minutes of encounter time, indirect fires are considered present. Otherwise, indirect fires are considered absent.

(b) Direct fire conditions are nominally identified on four levels as: none, ineffective, effective or devastating. The model uses the simulated exchange of direct fires for the time increment from last assessment time to encounter time to establish the direct fire condition based on the following rules:

1. If no direct fire rounds were fired at the en. untering unit during the test increment, there was no direct fire.

2. If direct fire was received by the unit, an hourly loss rate is computed for each weapon system involved in the direct fire calculations. The loss rate, R, for a given item is calculated as:

$$R = (L/E) \cdot (6000/T) \qquad \text{(IV-7-166)}$$

where R = loss rate, (percent per hour)

L = losses in the test increment

E - item strength at beginning of the test increment

T = duration of the test increment (centiminutes)

If the hourly loss rate is less than ten percent per hour, for each involved weapon system, direct fires are termed "ineffective."

3. If hourly loss rate exceeds ten percent per hour for any system but is less than twenty percent per hour for all systems and less than ten percent for at least one system, direct fires are termed "effective."

4. If the hourly loss rate exceeds 20 percent per hour for any system or exceeds ten percent per hour for all involved systems the direct fires are termed devastating.

(2) Countermeasure Selection. Once the prioritized list of countermeasure options is accessed, the list is queried in order until either an option is found feasible or the list is exhausted. Feasibility depends on the nature of the option and conditions of the encountering unit and the field.

(a) A bypass option is defined in terms of a zone of action and a compression factor. If the field is passable and the encountering unit can maneuver around the field without exceeding the boundaries of its zone of action, a bypass is considered feasible. The unit is allowed to reduce its unit front up to the stated compression factor in this maneuver. Geometric calculations involved in establishing this feasibility are presented in paragraph 5e with the discussion of bypass logic.

(b) A hasty breach option is defined in terms of the vehicle and associated equipment to be used in breaching lanes and a desired and sufficient number of lanes.

1. If the unit's force had knowledge of the field prior to encounter, the number of open lanes known to the force is compared to the number of lanes specified in the decision table as sufficient. If sufficient open lanes are known to the unit, it will pass over the field on open lanes since it is not necessary to breach any new lanes.

2. If the unit does not have prior knowledge of sufficient open lanes, feasibility of the hasty breach option is checked. The option is considered feasible if the unit has on hand sufficient equipment to initiate work on at least the number of lanes

indicated as sufficient less any lanes known to the unit. If, for this countermeasure, only a vehicle is specified in the data load then a "bulling" tactic is implied and is considered feasible if one vehicle per lane is available. If other major items are specified for the countermeasure, these items will also be required on a one per lane basis. The additional items will be treated as a plow or roller-type device used in conjunction with the specified vehicle.

(c) A deliberate breach type option is defined in terms of personnel, consumable items, and major items as well as a desired and sufficient number of lanes. If sufficient open lanes are known, the unit will pass on these lanes, as with the hasty breach option. Otherwise, feasibility is checked in terms of personnel and material to initiate work on the number of sufficient lanes, less any previously known lanes.

1. The personnel requirement for a deliberate breach is stated, in the data base, in terms of persons per lane worked. To meet the requirement, the encountering unit must have the required number of troops within subordinate engineer-type units.

2. To initiate work on the specified number of lanes the unit must have on hand sufficient consumables to clear the lanes the entire depth of the field, if the unit has prior knowledge of the field, or to an assumed depth loaded in the countermeasure data base if the unit does not have prior knowledge of the field. Consumption rates of each consumable are a part of the data. Calculations used for consumption are discussed with the deliberate breach option at paragraph 5h.

3. Number of major items per lane, if any, may be specified for up to three items in the data definition of a deliberate breach option. The required items must be present for a unit to initiate this option. Otherwise, the option is considered infeasible.

(d) If the countermeasure option list for the encountering unit is exhausted and no feasible countermeasure is found, the unit will default to a withdrawal from contact. This mode of operation is described in paragraph 5f.

(3) Delay Assessment. On the encounter of a barrier, delay times may be assessed against the encountering unit depending on battle conditions and the nature of the barrier. These are simple delays, in that during the time of the delay no countermeasure action on the part of the encountering unit is explicitly simulated. The encountering unit will, during this delay time, participate in the exchange of direct fires but will not move. Once the simple delay is

completed the unit will pass into one of the countermeasure modes as illustrated in Figure IV-7-16, or will be treated as clear of the barrier if it is a simple delay barrier.

(a) Simple delay for a pure delay barrier is loaded in the GCM data base for encountering units of greater than company size, company size or less than company size. The appropriate value for the encountering unit is assessed in the case of a pure delay barrier.

(b) Simple delay in the case of a minefield encounter is the sum of a decision time and a countermeasure initiation time. The data base contains a decision time for each of the eight battle conditions identified in paragraph 5d(1) above. An initiation time is also loaded for each countermeasure for each of three unit sizes; greater than company, company, and less than company. The appropriate values are accessed and assessed against a unit which encounters a minefield with no prior intelligence of the field. If the unit had intelligence of the field prior to encounter, it is assumed that sufficient preparations were made and no simple delay is assessed.

e. Minefield Bypass. The elementary problem of a minefield bypass is represented within the model as passing a unit, represented by a rectangle, around a linear barrier, represented by a line segment or connected segments. Restrictions are placed on the lateral movement of the unit rectangle and the end of any barrier line may, as a control function, be specified as non-passable. The problems of determining feasibility of the bypass and actually moving the unit around the barrier are treated independently in the model.

(1) Bypass Feasibility. The situation treated in testing for bypass feasibility is illustrated in Figure IV-7-17. Given a potential bypass point (end of a barrier line) within the unit's zone of action, will the unit fit in the open space between the point and the zone of action boundary? The unit is permitted some reduction in front, the extent of which is provided as part of the countermeasure option, as is the width of the zone of action.

(a) Width of the zone of action is supplied in the countermeasure option as a multiplicative factor, ZA, no smaller than one, to be applied to the unit's width at time of encounter. Thus, if the unit width is W, the width of the zone of action is $ZA \cdot W$. The zone is represented as the area within parallel zone boundaries, each half the zone width from the unit center and parallel to the unit's orientation. The boundaries are straight lines represented in point-slope form with a slope ϕ equal to the encountering unit's orientation and point (Z1X, Z1Y) and (Z2X, Z2Y) defined as:

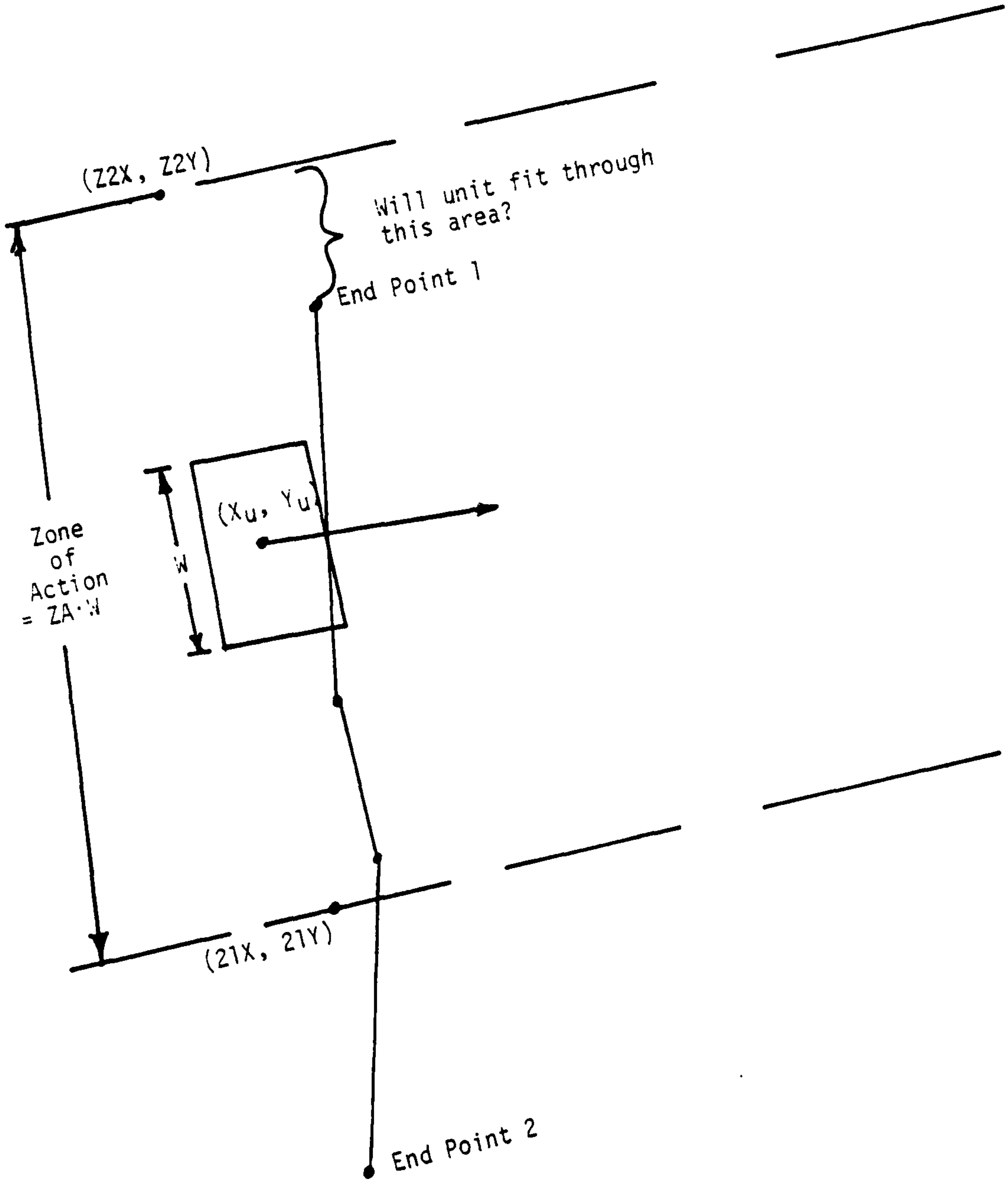


Figure IV-7-17. Bypass Feasibility Determination

AD-A112 652 ARMY COMBINED ARMS COMBAT DEVELOPMENTS ACTIVITY FORT--ETC F/G 15/7
DIVWAG MODEL DOCUMENTATION. VOLUME II. PROGRAMMER/ANALYST MANUA--ETC(U)
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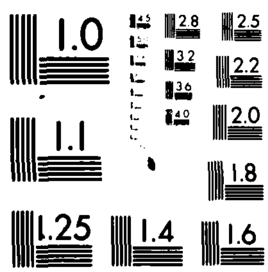


MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

$$Z1X = XU + W1 \cdot \sin \phi \qquad \text{(IV-7-167a)}$$

$$Z1Y = YU - W1 \cdot \cos \phi \qquad \text{(IV-7-167b)}$$

$$Z2X = XU - W1 \cdot \sin \phi \qquad \text{(IV-7-167c)}$$

$$Z2Y = YU + W1 \cdot \cos \phi \qquad \text{(IV-7-167d)}$$

where the unit center is at (XU, YU) and half the zone of action is:

$$W1 = (ZA \cdot W) /2 \qquad \text{(IV-7-168)}$$

(b) Potential bypass points are identified at time of barrier encounter. This depends on the definition of a barrier line as a series of connected barrier segments as discussed in Chapter 14. The identification of potential bypass points is a logical decision process rather than mathematical. Both ends of the encountered barrier segment are queried in turn, the same logic being used for each.

1. If the encountered segment is at the end of a line, then the end point of this segment is a potential bypass point.

2. If the encountered segment is not at the end of the barrier line, the next segment in line is queried.

a. If the next segment is a "pure delay" segment or has barrier type = 0, the line is considered non-bypassable in that direction. Use of the type = 0 barrier to flag a non-bypassable area is a gamer technique to facilitate game control.

b. If the next segment is a minefield, the same process is repeated for that segment, extending the search for a potential bypass point.

c. If the next segment is not a minefield and not a non-bypassable type, the potential bypass point is the point where the encountered segment links to the segment being queried.

3. The process is continued along a barrier line until a potential bypass point is identified or the line is deemed non-bypassable in that direction.

4. Within the model, two potential bypass points are always identified, one for each end of the barrier line. Where

an end of the line is deemed non-bypassable, the potential point is defined by a point on an extension of the segment being queried and 50 kilometers distant from the segment. This insures that the bypass feasibility logic will treat a bypass on this end of the line as infeasible.

(c) To be feasible, a potential bypass point must fall within the unit's zone of action. To check this condition, the dot product $\bar{A} \cdot \bar{B}$ of the vector $\bar{B}$ from (Z1X, Z1Y) to (Z2X, Z2Y) and the vector $\bar{A}$ from (Z1X, Z1Y) to the point being checked (BPX, BPY) is formed. This scalar product has the value:

$$\bar{A} \cdot \bar{B} = (Z2X - Z1X) \cdot (BPX - Z1X) + (Z2Y - Z1Y) \cdot (BPY - Z1Y) \quad \text{(IV-7-169)}$$

which is, by definition:

$$\bar{A} \cdot \bar{B} = \left| A \right| \cdot \left| B \right| \cos \theta \quad \text{(IV-7-170)}$$

where θ is the angle between $\bar{A}$ and $\bar{B}$. The three cases of interest are illustrated in Figure IV-7-18.

1. When the angle between $\bar{A}$ and $\bar{B}$ is greater than 90°, the potential point is clearly outside of the zone of action. In this case cos θ is negative and the scalar product must be negative. Thus if $\bar{A} \cdot \bar{B}$ is negative the point is disallowed.

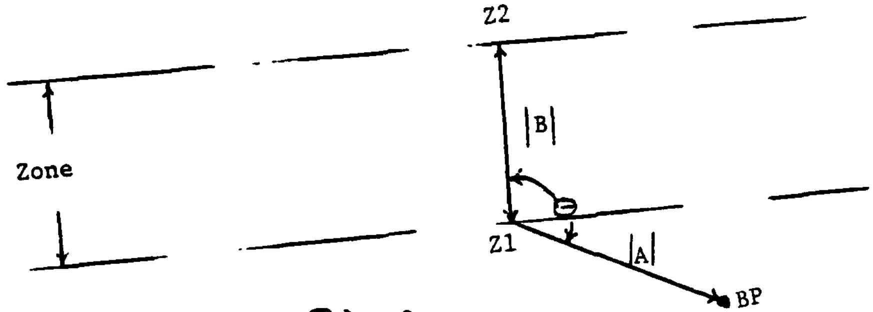
2. If the projection of $\bar{A}$ onto $\bar{B}$ is formed by dropping the perpendicular from $\bar{A}$ to $\bar{B}$, it is clear by inspection that cos θ = b/ $|A|$ and thus

$$A \cdot B = A \cdot B \cdot b/ A = B \; b \quad \text{(IV-7-171)}$$

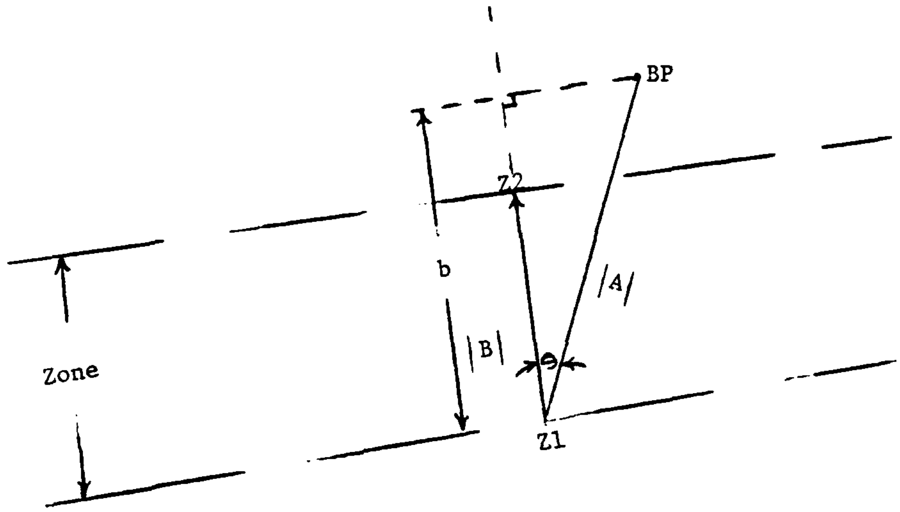
b = distance between the intersection point, formed by the projection of $\bar{A}$ onto $\bar{B}$, and the farthest point on $\bar{B}$.

it is also clear by inspection that if the point in question lies in the zone of action then b $<|B|$. Thus, the point is rejected if $\bar{A} \cdot \bar{B} \geq |B|^2$ that is to say if the value of the dot product is not less than the distance across the zone of action squared.

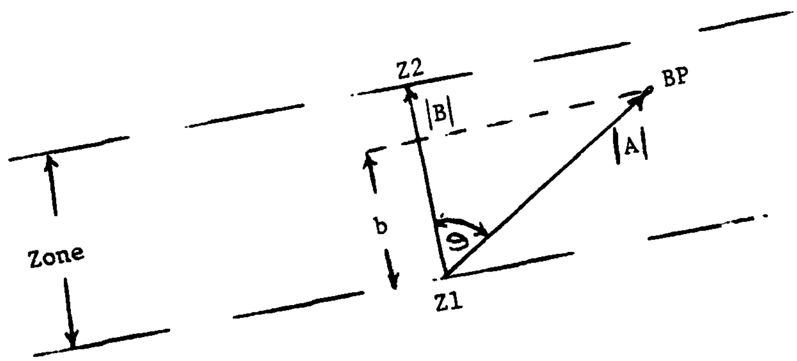
(d) Given a potential bypass point within the zone of action, the unit must be able to bypass without violating the zone boundary. This check is made by comparing the perpendicular distance from a potential bypass point to the closest zone boundary with the



Case 1. $\theta > 90^\circ$. BP out of zone.



Case 2. $b > |B|$. BP out of zone.



Case 3. $b \leq |B|$. Point BP in zone

Figure IV-7-18. Determination if bypass point is within a zone.

minimum allowable unit front. If the distance is no less than allowable front a bypass is considered feasible. If a bypass is feasible at both ends of the barrier the point closest to the unit, or equivalently, the point allowing the greatest space within the zone, is chosen. Minimum allowable unit front is defined in terms of a multiplicative factor, no greater than one, to be applied to the unit's width. This compression factor is supplied as part of the option.

(2) Bypass Execution. Given a desired bypass point (BPX, BPY) the unit moves in a generally lateral direction until clear of the barrier and thence continues toward its initial objective.

(a) Lateral movement is accomplished by moving the unit center from its location at the time of barrier counter to a new location such that the unit is clear of the barrier with leading corner of the unit rectangle at (BPX, BPY) and with the unit oriented on its original objective.

1. Calculation of the unit center position at the bypass point is based on the situation shown in Figure IV-7-19. Given the bypass point (BPX, BPY) and objective (OBJX, OBJY):

$$DX = OBJX - BPX \qquad \text{(IV-7-172a)}$$

$$DY = OBJY - BPY \qquad \text{(IV-7-172b)}$$

$$D1 = \sqrt{DX^2 + DY^2} \qquad \text{(IV-7-172c)}$$

$$\theta = \arctan (DY/DX) \qquad \text{(IV-7-173)}$$

Since the unit is to be oriented on the objective, the line from the unit center to objective will be normal to the unit front. Thus, if the unit half-width at the bypass point is W, the right triangle can be solved for the third leg and internal angle:

$$D2 = \sqrt{D1^2 - W^2} \qquad \text{(IV-7-174)}$$

$$\gamma = \arctan (W/D2) \qquad \text{(IV-7-175)}$$

and, adding half-depth of the unit, d, distance from unit center to objective must be

$$D = d + D2 \qquad \text{(IV-7-176)}$$

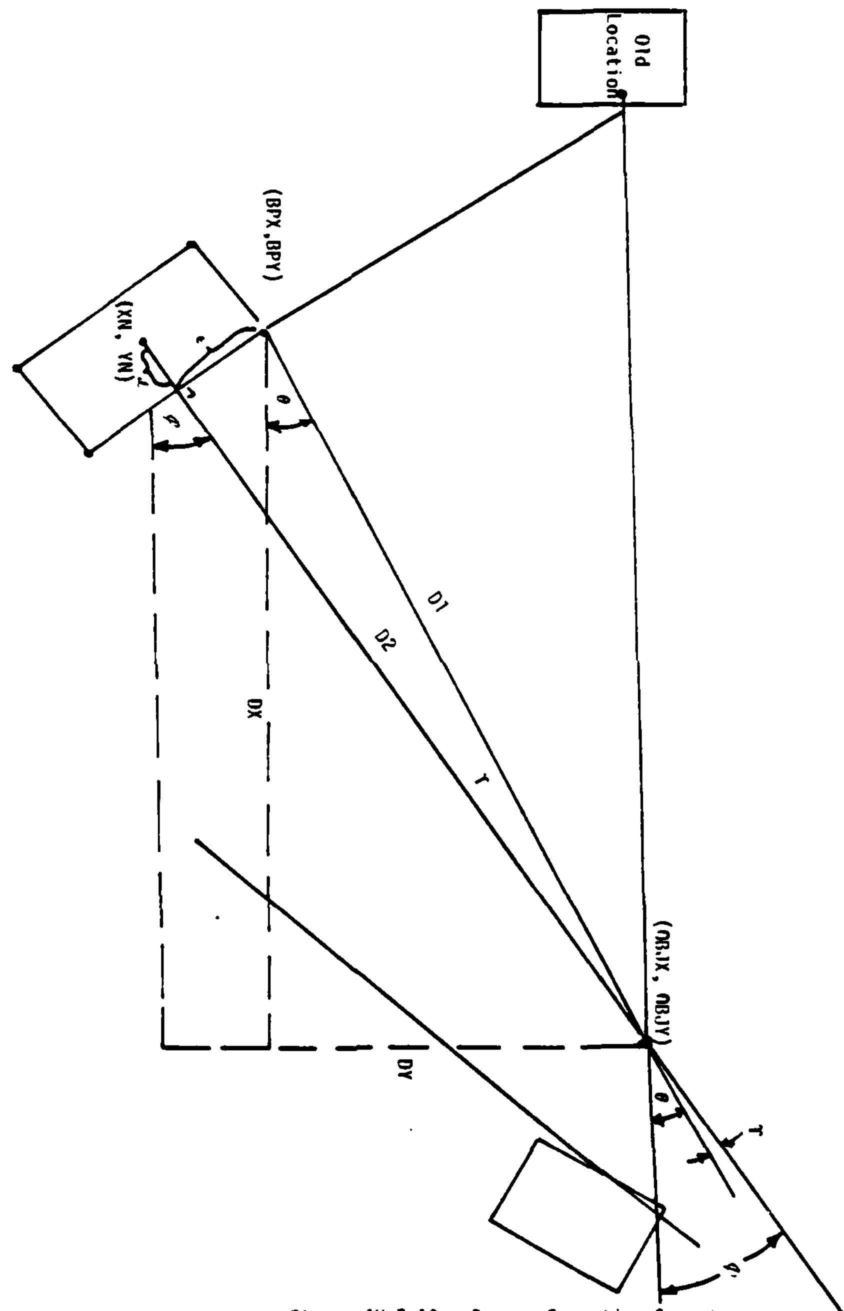


Figure IV-7-19. Bypass Execution Geometry.

In the case illustrated, it is obvious by inspection that at the bypass point the unit's orientation angle will be

$$\phi = \theta + \gamma \qquad \text{(IV-7-177)}$$

In general the angle θ must be between the unit's old orientation ϕ_o and its new orientation ϕ. Thus, if

$$0 > \phi_o \quad \text{then} \quad \phi = \theta + \gamma \quad \text{and if} \qquad \text{(IV-7-178a)}$$

$$0 < \phi_o \quad \text{then} \quad \phi = \theta - \gamma \qquad \text{(IV-7-178b)}$$

Finally, solving the last right triangle allows determination of the desired center point (XN, YN) by:

$$XN = OBJX - D \cos \phi \qquad \text{(IV-7-179a)}$$

$$YN = OBJY - D \sin \phi \qquad \text{(IV-7-179b)}$$

2. Calculation of the unit's center location at bypass depends on the unit half-width at the bypass point. Since some unit compaction is allowed in the bypass, this may differ from the unit's original size. The determination of feasibility has established that, at a maximum allowable reduction in unit front, sufficient space is available for a bypass within the unit's zone of action. The model assumes that, in a lateral motion, some compaction will generally occur and that the amount of compaction will tend to increase as the lateral distance to be moved increases. This is represented by reducing unit front in a direct ratio to the distance the farthest corner of the unit rectangle must move, subject to the allowable compaction and space limitations. The ratio used has been subjectively set to 1/2. Thus, given the values:

W = unit width at encounter

C = allowable compaction factor

S = available space for bypass (established in determining feasibility.)

D = distance from furthest unit front corner to bypass endpoint at encounter.

the test width for bypass is computed as:

$$W^1 = W - D/2 \qquad \text{(IV-7-180a)}$$

and the minimum allowable width as

$$W_{min} = C \cdot W \qquad \text{(IV-7-180b)}$$

Since it is already known that W_{min} does not exceed S, the unit will be allowed to attain, at the bypass point a width of:

$$W_{use} = \min\,[\max\,(W^1, W_{min}),\ S] \qquad \text{(IV-7-181)}$$

3. As with other portions of the Ground Combat Model, the bypass action is represented incrementally. For each increment, motion is treated as a barrier interaction while the exchange of direct fires is treated normally with adjustments to unit geometry calculations such that unit width and velocity, and location for ranging purposes, is that which would accrue midway through the increment. The total time length of the lateral movement is computed as the time required to move the units appropriate leading edge corner to the bypass point at the velocity the unit had on encounter. Increments are scheduled to use up this time in five minute increments, with the restriction of no less than two minutes left for the final increment. That is, given a time length T, increment length of the increment T_i is T if T is no more than seven minutes or T_i is five minutes if T is greater than seven minutes. T is decremented each increment until used up, at which time lateral movement is over. The velocity used in lateral movement is simply the rate of speed required to move the unit center to its desired location in the allowed time. This will generally be no greater than encounter velocity. It could be less because the unit center may not move as fast as the leading corner when compaction is considered. Unit location is the location of the unit center midway through the increment based on increment length and unit velocity. Unit width is width midway through the increment under the assumption of a common compaction rate in time over the duration of the entire move.

(b) Upon completion of the lateral motion, one last movement increment is conducted under control of the bypass logic, to clear the local area of the field. This movement is for a distance equal to the depth of the encountered field along the line from the unit center at bypass to the unit objective. This last increment is at the mean between speed at encounter and speed during lateral movement and at the mean between width at encounter and width at bypass point. Upon completion of this increment, the unit will continue in the basic ground combat cycle with unit velocity and speed as they were on encounter of the barrier line which has been bypassed.

f. Withdrawal from Contact. Should a unit decision process reach the default withdrawal option, the unit is forced to withdraw from contact. The unit is automatically given a WITHDRAW order and a new objective to the unit rear, on the extension of the line segment between the original objective and the unit location at encounter. The unit withdraws toward this objective, in five minute increments, at the same movement rate as at barrier encounter. At the end of each increment, firing status is checked and when no direct fire rounds were fired at the unit in question the unit's movement rate is set to zero and the unit will remain stationary, in this location, within the basic GCM cycle until termination of the named battle.

g. Hasty Breach Option. The hasty breach option is designed to represent the situation in which an encountering unit attempts to find or open lanes in an active minefield by actually driving vehicles through the field. The breaching vehicle may have specialized breaching equipment, such as rollers or plows, or may simply attempt to "bull" its way through the field.

(1) General. The logical basis of any representation of the hasty breach situation must be an in-field model which treats the interaction between vehicles and minefields. The basic in-field model used in DIVWAG represents one of a series of identical vehicles attempting to open one lane in a field by following in each other's tracks. The general approach used in this basic in-field model is taken from an unnumbered Ballistics Research Laboratory memorandum report ("An Analytical Approach for Some Air Scatterable Minefield Effectiveness Models," Barry H. Rodin, August 1971). Variations are introduced to the basic model to account for the effects of direct fires covering the field and the use of specialized equipment in the breach attempt. The results are then extended to the more general case of several lane sites being attempted by one unit in the field.

(2) Basic In-Field Model.

(a) General. The basic in-field model is a probabilistic procedure for combining the a priori probabilities of exactly J = 0, 1, 2...N mines in the path of a vehicle about to attempt a breach with the probability that the vehicle will survive an individual mine in its path. The model produces the probability of exactly L = 0, 1, 2...N mines remaining in the path after the single vehicle's breach attempt and the probability that the vehicle survives the attempt.

(b) Essential Calculations.

1. The basic model assumes that a vehicle either survives or fails to survive an encountered mine. There are no partial or differing kill categories nor is there progressive vehicle damage. Once encountered, that is once passed over by a vehicle, the mine is removed from consideration. Thus if the mine should fail to destroy the first vehicle over it, the mine is assumed to have been neutralized.

2. Given the values:

C_J = probability of exactly J mines in path prior to breach attempt

s = probability vehicle will survive a mine in its path

the model calculates the values

P_L = probability of exactly L mines remain in path after the breach attempt

S = probability the vehicle survives

3. The conditional probability of L mines after a breach attempt, if there were exactly J mines prior to the attempt is

$$P_{L1J} = s^{J-L-1} (1 - s) \text{ for } J > L > 0 \qquad \text{(IV-7-182)}$$

That is, to have exactly L mines left after an attempt given J prior to the attempt, the vehicle must survive J-L-1 mines and fail to survive the next mine. Combining this conditional with the probabilities of various numbers before the attempt leads to

$$P_L = (1 - s) \sum_J C_J s^{J-L-1} \text{ for } J > L > 1 \qquad \text{(IV-7-183)}$$

For the special case of no mines left in the path after the attempt, there may have been no mines before the attempt or the vehicle may survive the first J-1 mines, given J mines prior to the attempt. The last mine is removed regardless of whether the vehicle survives. Thus

$$P_o = C_o + \sum_J C_J s^{J-1} \text{ for } J > 0 \qquad \text{(IV-7-184)}$$

Finally, the vehicle survives in a lane with J mines if it survives all of the mines, each with probability s. Thus

$$S = \sum_J C_J s^J \text{ for } J > 0 \qquad \text{(IV-7-185)}$$

4. An elementary check on the probabilistic correctness of these calculations is the requirement that $\sum_L P_L = 1$ if $\sum_J C_J = 1$. We first note that $\sum_L P_L$ can be written as a linear combination of the C_J in the general form $\sum_L P_L = \sum_J a_J C_J$ with coefficients as a_J developed from:

$$\sum_L P_L = P_o + \sum_{L>0} P_L$$

$$= (C_o + \sum_{J>0} C_J s^{J-1}) + \sum_{L>0} (1 - s) \sum_{J>L} C_J s^{J-L-1} \qquad \text{(IV-7-186)}$$

It can be shown that if we solve for the a_J in the general form, $a_J = 1$ for all J. Thus $\sum_L P_L = \sum_J a_J C_J = \sum_J C_J$ which was desired. Briefly, we note by inspection that $a_o = 1$ and $a_1 = s^{1-1} = s^o = 1$. We also note for that $a_J = s^{J-1} + F_J (s)$ where the s^{J-1} contribution is from P_o and $F_J (s)$ from $\sum_{L>0} P_L$. To obtain $F_J (s)$ we note that for a given J there is a contribution to a_J for exactly J-1 terms, as L ranges from 1 to J-1. Further, each term, still for a given J, is $(1-s) s^{J-L-1}$ or, letting L assume its range of values the terms are $(1-s) s^{J-2}$, $(1-s) s^{J-3}$, ..., $(1-s) s^o$. Thus

$$F_J (s) = (1-s) \sum_{N=0}^{N=J-2} s^N \text{ and } \qquad \text{(IV-7-187)}$$

$$a_J = s^{J-1} + (1-s) \sum_{N=0}^{N=J-2} s^N \qquad \text{(IV-7-188)}$$

$$= s^{J-1} + \sum_{N=0}^{N=J-2} s^N - s \sum_{N=0}^{N=J-2} s^N$$

$$= s^{J-1} + \sum_{N=0}^{J-2} s^N - \sum_{N=1}^{J-1} s^N$$

$$= s^{J-1} + s^o - s^{J-1} = 1 \text{ for all J.}$$

(3) Variations to the In-Field Model. The basic in-field model is used to represent single vehicles in a field with no external influences. Three variations are made to allow consideration of direct fires covering the field, use of specialized equipment and the combination of these. Each variation maintains the basic approach in that it requires prior mine probabilities and individual survivability factors and combines these to develop mine distributions after a breach attempt and overall survival factors.

(a) Direct Fire. The inclusion of direct fire effects on the breaching action is made as an additional loss-producing potential for the vehicle in the field. No attempt is made to portray explicitly interactive or synergistic effects in that the effect of individual mines and the tactic of continuing on a path until damaged are not changed. In this case, of course, damage may be due to direct fires as well as the mines.

1. Simplifying Assumptions. Several simplifications of the situation are made to arrive at a tractable representation. The underlying assumption is that these simplifying assertions are not unreasonable.

a. It is possible to establish some probability of survival, R, for a vehicle within a given time and space. This probability represents the survivability a breaching vehicle would have if it carried out the breach maneuver on a path with no mines.

b. Given a value of R for a known time and space domain, if that time and space domain is broken into K equal increments then the probability of survival on each increment can be represented as $R^{1/K}$.

c. Given J mines randomly distributed along a path, the path can be represented as J+1 equal segments with a mine on each of the J interior borders.

d. Combining assertions b and c, given J mines over a path for which the survivability R holds, the probability of surviving between consecutive mines or between a border of the field and the first/last mine can be approximated by $r_J=R^{1/J+1}$.

2. Essential Calculations. The basic model says that, for J mines in its path, a vehicle encounters each mine individually and either survives or fails to survive the encounter. The direct fire variation simply adds prior to each encounter (and after the last) a period of space and time through which the vehicle must also pass and which passage the vehicle may survive or fail to survive. For computational tractability, all such spaces are assumed equivalent.

a. Given the same values C_J and s of the basic model, plus the probability R that the vehicle will survive effect other than mines on its passage of the field, the model calculates P_L and S defined as for the basic model.

b. Let $r_J=R^{1/J+1}$ be the probability of reaching one mine from the previous mine, or reaching the first mine in the field or reaching the far border of the field from the final encounter, for a path with J mines.

c. The probability of exactly L mines remaining after a breach attempt, given $J \geq L$ before the attempt is:

$$P_{L1J} = (1 - r_J) \quad J = L \qquad \text{(IV-8-189a)}$$

$$P_{L1J} = r_J^{J-L} [s^{J-L-1} (1-s) + s^{J-L} (1-r_J)] \quad J > L \qquad \text{(IV-8-189b)}$$

That is, to have L=J mines left, given J to begin, the vehicle must have failed to reach the first mine, $(1-r_J)$. To have $L < J$ mines left the vehicle must have reached J-L mines, (r_J^{J-L}), and must have either survived J-L-1 mines but not the next mine $[s^{J-L-1} (1-s)]$ or survived all J-L but failed to reach the next mine $[s^{J-L} (1-r_J)]$. Combining the conditionals with the probabilities of actually having various numbers in the field leads to, for $L > 0$:

$$P_L = C_L (1-r_L) + \sum_{J > L} C_J r_J^{J-1} s^{J-L-1} [(1-s) + S (1-r_J)] \qquad \text{(IV-7-190)}$$

d. For no mines to remain, given J to begin with, the vehicle must reach all J and survive J-1. Similarly to survive the field the vehicle must reach all J mines, survive all J mines and then reach the end of the field. Thus:

$$P_0 = C_0 + \sum_{J > 0} C_J r_J^J s^{J-1} \qquad \text{(IV-7-191)}$$

$$S = \sum_J C_J r_J^{J+1} s^J = R \sum C_J s^J \qquad \text{(IV-7-192)}$$

since r_J was defined as $R^{1/J+1}$.

e. Certain consistency checks on the variation are useful. First, if R=1, it should be noted that equations for P_L, P_0 and

S reduce to those for the basic case. Secondly, if there are no mines, the field survivability S reduces to S=R. Thirdly, it can be shown that $\sum_L P_L$ can be written as a linear combination of the C_J such that $\sum_L P_L = \sum_J a_J C_J$ and that $a_J = 1$ for all J. Thus, if $\Sigma C_J = 1$ then $\sum_L P_L = 1$.

$$\sum_L P_L = P_o + \sum_{L>1} P_L$$

$$= [C_o + \sum_{J>0} C_J \; r_J^J \; s^{J-1}]$$

$$+ \sum_{L>1} \left\{ C_L (1-r_L) + \sum_{J>L} C_J \; r_J^{J-L} \; s^{J-L-1} [(1-s)+s(1-r_J)] \right\} \quad \text{(IV-7-193)}$$

By inspection $a_o = 1$ and $a_1 = r_1^1 \; s^o + (1-r_1) = 1$.

Also each $a_J = r_J^J \; s^{J-1} + (1-r_J) + F_J (r, s)$

where $F_J (r, s)$ must be extracted from

$$\sum_{L=1} \sum_{J>L} C_J \; r_J^{J-L} \; s^{J-L-1} [(1-s) + s(1-r_J)]$$

Note for a given J, $F_J (r, s)$ must contain exactly J-1 terms as L ranges from 1 to J-1. Further, each term must be $r_J^{J-L} \; s^{J-L-1} [(1-s) + s (1-r_J)]$. Letting L assume its values gives rise to

$$F_J (r, s) = \sum_{N=1}^{J-1} (r_J^N s^{N-1} - r_J^N s^N + r_J^N s^N - r_J^{N-1} s^N)$$

$$= \sum_{N=1}^{J-1} r_J^N s^{N-1} - \sum_{N=1}^{J-1} r_J^{N+1} s^N = r_J^1 s^o - r_J^J s^{J-1} \quad \text{(IV-7-194)}$$

$$\therefore a_J = r_J^J s^{J-1} + (1 - r_J) + r_J - r_J^J s^{J-1} = 1. \qquad \text{q.e.d.}$$

(b) Special Equipment. A second variation of the basic in-field model allows the play of special mine-clearing equipment such as plows or rollers.

1. Approach. The special equipment version of the in-field model treats the special equipment as some device that sweeps out the breach path immediately ahead of the vehicle. An intact piece of equipment can, within the model, do one of three things to a mine in the breach path. It can negate the mine, such that the mine does no appreciable damage to the device and will not harm the using vehicle or trailing vehicles, with probability D. Secondly, the device could negate the mine with associated loss of the device itself. This happens if the mine explodes and does significant damage to the device. Since the mine has been exploded, it is negated as far as any future danger is involved. Negation with loss can happen with some probability E. Finally, with some probability F=1 - (D+E), the device will fail to negate a mine in the breach path. As with the basic model, the approach is to calculate mine distribution and survival probabilities after a trial, given prior distribution and survivability factors.

2. Essential Calculations.

a. The probability of surviving a mine encounter by either negation of the mine with no damage or by failing to negate the mine yet having the vehicle survive is $D+F \cdot s$. Thus, the probability of such a "safe" survival of N mines must be $(D + F \cdot s)^N$.

b. Once a mine is negated with loss of the special equipment, the vehicle continues without benefit of the equipment. The probability of surviving N mines by a "safe" survival of the first J mines, destructive negation of the J+1 'st mine and simple vehicular survival of the remaining N - (J+1) is:

$$(D + Fs)^J \cdot E \cdot s^{N-J-1} \qquad \text{(IV-7-195)}$$

c. It follows that the overall probability of surviving exactly N mines must be the probability of N "safe" survivals or of $J < N$ safe, destruct on J+1 and vehicle survival of the remaining, for all $J < N$. This is expressed as, the probability of surviving N mines, U_N:

$$U_N = (D + Fs)^N + E \cdot \sum_{J=0}^{N-1} (D + Fs)^J \, s^{N-J-1} \qquad \text{(IV-7-196)}$$

d. To be lost on encounter of the N 'th mine in its path, the vehicle must survive N-1 mines and fail to survive the next mine. If the first N-1 are survived "safely" (without loss of the special equipment), the vehicle must fail to counter and fail to survive the next mine. If the equipment has been lost on the first N-1 mines, simple vehicle failure in the N 'th mine suffices. Thus, the probability of being lost to mine N in the path is:

$$T_N = (D + Fs)^{N-1} \cdot F \cdot (1-s)$$

$$+ (1-s) \cdot E \cdot \sum_{J=0}^{N-2} (D + Fs)^J \, s^{N-J-1} \qquad \text{(IV-7-197)}$$

Note that T_1 reduces to F(1-s).

e. To have exactly L mines (L> 0) left after a breach attempt, given there were J mines (J >L) prior to the attempt, the system must have failed to survive on encounter of the J-L 'th mine in the path. Thus

$$P_L = \sum_{J > L+1} C_J \, T_{J-K} \quad \text{for} \quad L > 0 \qquad \text{(IV-7-198)}$$

f. To have no mines left after a breach attempt, either there were no mines originally or there was one mine (which could destroy the system but in any case could not persist) or there were J >1 mines and the vehicle survived J-1 of them. Survival of the last mine is not required for its removal. Thus

$$P_o = C_o + C_1 + \sum_{J > 1} C_J \, U_{J-1} \qquad \text{(IV-7-199)}$$

g. In this case, two levels of overall field survival are possible. The vehicle can survive the field with loss of the clearing equipment or the vehicle and equipment can survive intact.

To survive intact, a "safe" survival must be made for the total number of mines in the field. This will happen with probability S_T:

$$S_T = \sum_J C_J (D + Fs)^J \qquad \text{(IV-7-200)}$$

The overall probability of the vehicle surviving is given by

$$S = C_o + \sum_{J>0} C_J \quad U_J \qquad \text{(IV-7-201)}$$

and thus, if desired, the probability of the vehicle surviving with loss of the equipment must be $S_T - S$.

h. Certain logical checks on the formulation are of interest.

1. The sum of resultant mine probabilities is unity. That is $\Sigma P = 1$ if $\Sigma C = 1$. As in the other cases, this is accomplished by looking at the resultant sum as a linear combination of the input probabilities, $\Sigma P = \sum_J a_J C_J$. By inspection the coefficients a_o and a_1 are equal to unity. Again, by inspection

$$a_{J+1} = U_J + \sum_{N=1}^{J} T_N \quad \text{for } J \geq 1 \qquad \text{(IV-7-202)}$$

But this is simply the sum of the probabilities of either surviving the J 'th mine or being lost on some mine up to and including the J 'th mine for a given value J. By the logical definition of U and T this must be unity. Thus ΣP must be equal ΣC.

2. If D and E are set to zero, such that there is no effect of special equipment, the entire system of equations reduces to the basic in-field model.

3. If D=1, the perfect countermeasure, $U_N=1$ and $T_N=0$ for all N. Thus $\bar{P}_L=0$ for L = 0, $P_o=1$ and $S=S_T=1$ as should be expected. Likewise if E=1, the countermeasure that is lost on the first

mine, the system reduces to the basic model with one less mine, as should be expected.

(c) Special Equipment and Direct Fire. The third extension of the in-field model is the logical combination of the others. In this application direct fire effects are considered only on the vehicle, not on the breaching equipment. The basic values C_J and s are used, as are the R and r_J of the direct fire variant and the D, E, U_N and T_N of the special equipment variation. The basic calculations are:

1. To have L (L> 0) mines left in a path after a breach attempt, given some J $\geq$L mines prior to the attempt, the vehicle must have failed to reach the first mine (J=L) or failed to survive its encounter of the J-L 'th mine or, having survived its encounter of J-L mines failed to reach the next mine. Combining appropriate conditional probabilities with likelihood of realizing the various mine distributions we obtain, for L greater than zero:

$$P_L = C_L\,(1 - r_L)$$

$$+ \sum_{J>L} C_J\; r_J^{J-L}\; T_{J-L}$$

$$+ \sum_{J>L} C_J\; r_J^{J-L}\; U_{J-L}\;(1-r_J) \quad \text{for } L>0 \qquad \text{(IV-7-203)}$$

2. To have no mines left after an attempt, the vehicle must have reached all mines in the field and have survived its encounter of all but the last. Outcome of the last encounter does not affect this probability which is:

$$P_o = C_o + C_1\,r_1 + \sum_{J>1} C_J\,r_J^{J}\;U_{J-1} \qquad \text{(IV-7-204)}$$

3. To survive intact, the vehicle must reach all mines in the field and have a "safe" encounter of all mines, and finally reach the end of the field:

$$S_T = \sum_{J} C_J\;r_J^{J+1}\,(D + Fs)^J \qquad \text{(IV-7-205a)}$$

or, noting the definition of $r_J = R^{1/J+1}$

$$S_T = R \cdot \sum_J C_J \ (D + Fs)^J \qquad \text{(IV-7-205b)}$$

Similarly, the probability of the vehicle surviving the field (with or without the equipment) is

$$S = R \ (C_0 + \sum_{J>0} C_J \ U_J) \qquad \text{(IV-7-206)}$$

(4) Generalization. The basic in-field model and its extensions, presented in the previous paragraph, treat cases of the situation in which a single vehicle attempts to open one lane. This is generalized to treat a unit making successive attempts on multiple potential lane sites. To accomplish this, the appropriate in-field model calculations are iterated, with the resultant distribution of mines from one pass serving as the input distribution on the next pass. The initial pass is made using the Poisson distribution to estimate the distribution of mines on a path, based on the assumed random placement of mines over the entire field. While iteration gives successive attempts, extension to several lane sites is made through an expected value treatment which is based on the assumption that lane sites are sufficiently separated that the activity at one site will progress independently of other sites. The logic to represent one vehicle's attempt at opening a lane, on each lane site under operation, is treated in one pass of the hasty breach model. A pass through the model logic includes four phases: initialization, in-field calculation, assessment, and scheduling the next pass.

(a) Initialization. There are four types of initialization involved in the hasty breach model. These are the pre-entry initiations made within the countermeasure decision logic, initialization made on the first pass through the model, initiation on successive passes under repeated conditions and initiation on successive passes under changed conditions. These are discussed below.

<u>1</u>. Upon selection of the hasty breach mode as a countermeasure, certain factors are determined from the countermeasure decision data. The data itself consists of desired number of lanes, sufficient number of lanes, vehicle to use, special breach equipment item to use (if any), vehicle speed in the field and an avoidance flag. Feasibility establishes ability to start work on at least the sufficient number of lanes less any known to be open to the unit. The

unit will initiate work on the number of lanes it has equipment for up to the desired number, less any known open lanes. Thus, given lanes desired, sufficient and open (L_S, L_D and L_O) the task is feasible if the unit can work on $L_S - L_O$ and the unit will work on as many as it can up to $L_D - L_O$. Recall that L_O was less than L_S, or the unit would have immediately started to cross on the open lanes. If the number of lanes to work is L_W, this is passed on to the hasty breach model with the other decision data. The first pass is scheduled for assessment at time t_c after any required delay time. The value of t_c is simply the time to cross the field based on field depth and the input vehicle speed in the field.

2. The first pass through the hasty breach model comes at the time of assessment of the direct fire exchange for a period t_c required by a breaching vehicle to cross the field. Initialization on the first pass includes setting the initial distribution of mines in a path, calculating the vehicle and, if necessary, special equipment survivability factors and possibly adjusting the number of lanes the unit is to work on.

a. Within the DIVWAG system, mines are treated as being randomly distributed within a field with a density ρ :

$$\rho = N / L \cdot W \qquad \text{(IV-7-207)}$$

where ρ = mine density, mines /m^2

N = total number of mines in the field

L = field depth, meters

W = field width, meters

The model treats a vehicle as sweeping out a path directly through the field, where the area swept out is $L \cdot w$, with w the overall width of the vehicle. Then the average, or expected number of mines in the path can be calculated as:

$$m = \rho \cdot L \cdot w \qquad \text{(IV-7-208)}$$

Using the assumption of random placement in the field and, under the condition that the path area is small compared to the total field area, and the total number of mines in the field is large, the distribution of mines in a path prior to a breach attempt may be approximated by the Poisson density function. Thus, the probability of exactly J mines being in a path, prior to breaching, is taken as

$$C_J = \frac{e^{-m} m^J}{J!} \qquad J = 0, 1, 2, \ldots N \qquad \text{(IV-7-209)}$$

While the density function, in theory, continues for an indefinite value of J, it is for applications generally cut off when C_J becomes negligible. This happens quite rapidly. For example, if m=10, which is toward the upper range of values expected in this application, C_{20} is approximately 0.00187. Calculations are actually cut off when C_J becomes less than 10^{-6} which, in the case of m=10, will happen when J=29. If the hasty breach attempt is made after a deliberate breach has been initiated but halted, the value m is adjusted to reflect progress made in the deliberate breach attempt. In this case the new value:

$$m^1 = m\,[f + (1 - f)\, c_f] \qquad \text{(IV-7-210)}$$

where m^1 = adjusted expected number of mines in path

m = original expected number of mines in path

f = fraction of path not cleared by the deliberate breach

C_f = fraction of mines missed by deliberate breach on portion of path cleared.

The values of f and C_f are passed by the deliberate breach model when needed.

b. All variations of the in-field model require the value s, the probability that the breaching vehicle will survive a mine in its path. For a given type vehicle, v, and a given minefield this is calculated as:

$$s = \sum_j \frac{n_j}{N} \cdot V_{sj} \qquad \text{(IV-7-211)}$$

where n_j = number of mines of type j in the field

N = total number of mines in the field

V_{sj} = vehicle survival against mine type j.

The values of V_{sj} are based on characteristics of the vehicle and of the mine type j. The input data required for the calculation of V_{sj} includes:

P_T-V_j = probability that, if a mine of type j explodes at the track of a vehicle type v, the vehicle is disabled.

P_B-V_j = probability that, if a mine of type j explodes at the belly of a vehicle type v, the vehicle is disabled.

P_{DUDj} = probability a mine type j will fail to detonate, given proper conditions for detonation.

P_{SEEj} = probability a mine type j is seen and avoided. The countermeasure decision data may contain a flag to disallow avoidance under selected tactical conditions. If the flag is set, P_{SEEj} will, for those conditions, be given a value of zero.

T_R = for the given vehicle the ratio of total track width to total vehicle width.

The combination of these variables represents the situation of the vehicle encountering a single mine in its path in which:

- The mine will be either at the vehicle's track or belly with respective likelihoods of T_R and $(1 - T_R)$.
- A mine that is not a dud and that is, in the data, credited with a track (belly) kill capability will detonate when passed over by the vehicle's track (belly).
- To disable a vehicle the mine must not be seen and avoided and must not be a dud.

Then

$$V_{sj} = 1 - \left\{ (1-P_{SEEj})(1-P_{DUDj})[T_R \cdot P_{T-Vj} + (1-T_R) P_{B-Vj}] \right\} \quad \text{(IV-7-212)}$$

c. If the use of special breaching equipment is to be played, the appropriate survivability factors for this equipment must be computed. These are based on the characteristics of the equipment and mines to be played. The basic data required for an item of breaching equipment include the track and belly width typically protected for a vehicle using the equipment and, for each mine type j:

d_j = probability the equipment will counter a mine of type j, with no serious damage to the equipment, given mine in the equipment's path.

e_j = probability the mine will significantly damage the equipment, given mine in the equipment's path.

If the full path to be swept out by the vehicle is not protected by the breaching equipment, an adjustment is made to account for mines that lie in the path of the vehicle but not the breaching equipment. This is made under the assumption that if partial protection is being provided, it will be provided at least in the vehicle's track area. Since any protection provided is against track lethality, the adjustment factor applied is the ratio of track lethality to overall lethality for the given mine type j,

$$f_j = \frac{T_R \cdot P_{T-Vj}}{T_R \cdot P_{T-Vj} + (1-T_R)\, P_{B-Vj}} \qquad \text{(IV-7-213)}$$

where T_R, P_{T-Vj}, P_{B-Vj} are values used to calculate the vehicle's survivability factor V_{sj}. Finally, the factors for each mine are combined over the totality of mines in the field to provide:

$$D = \sum_j \frac{n_j}{N} \cdot f_j\, d_j \qquad \text{(IV-7-214)}$$

$$E = \sum_j \frac{n_j}{N} \cdot f_j\, e_j \qquad \text{(IV-7-215)}$$

Where n_j = number of mines of type j, N = total number of mines and f_j = 1 if no adjustment was required.

d. For each pass of the hasty breach model, losses to direct fires of the breaching vehicle are calculated for a direct fire exchange of duration t_c, time needed to cross the field. Based on these losses, L_v, and the number of vehicles of the breach type involved in the front band as targets within the direct fire geometry calculation, O_v, a survival factor, $R = 1 - L_v / O_v$, is calculated. This is used as appropriate for the direct fire variations of the in-field model. If R = 1, these variations are not needed.

e. A unit could encounter a field and, in attempting to breach lanes through the field, select paths beyond the fields lateral boundaries. A breach attempt on such a path would be successful on the first trial, although the crew of the breaching vehicle would not know if the path were inside the field or a "free path" beyond the field's border. Such free paths, external to the field, are credited only on the first trial, if the fraction of the unit front covered by the field is $f_{cov} < 1$. Then, if the unit had started work on L_w lanes it would be given

$$FP = L_w - I\,[f_{cov}\,(L_w + 1)] \qquad \text{(IV-7-216)}$$

where the functional I [x] is the integer part of a real number x. The operation of this function is such that a free path is given if a fraction of the unit front at least $1/(L_w+1)$ is open and, for each additional increment of size at least $1/(L_w+1)$ open an additional free path will be found and the number of lanes worked for successive passes, L_w, will be reduced accordingly.

3. On successive passes through the hasty breach model, distribution of mines in the paths and vehicle and special equipment survivabilities must again be established. In this case, the distribution of mines in a path will be the residual probabilities of the previous pass, which are simply stored and passed forward for each pass of the model. The survivability of the fire effects other than mines, R, is computed as discussed in paragraph g(4)(a)2.d. above for each pass. Minefield vulnerability factors s, D and E do not change unless the vehicle or breach equipment changes. These values are stored and passed forward from the initial pass until an equipment change necessitates recalculation. In that case, all three values are recalculated, as for the initial pass, and the new values are passed forward for any following passes.

(b) In-Field Calculations. After initialization, the appropriate in-field model variant is called, depending on whether special breach equipment is used and whether direct fire losses to the breach vehicle were experienced in the time of the breach attempt, tc. This will represent one trial, or one vehicle attempting to breach on each of the lanes being worked. The in-field routine is exercised iteratively on each pass through the model. The first iteration provides the residual mine distribution, which will be saved and passed on for the next pass through the model if required. The first iteration also provides the probability of the vehicle surviving S_1 and, if appropriate, the vehicle and special equipment surviving S_T, on this pass. The model is then exercised iteratively to obtain estimates of the survival probabilities on following passes, S_j and S_{Tj}.

(c) Assessment. Three assessments are made by the hasty breach model. First, losses to the breaching unit due to the field are assessed. Secondly, the status of the breaching operation is assessed to determine if the field has been breached. Thirdly, if the breaching operation is to continue, ability of the unit to continue the operation is assessed.

1. Losses. During a breach operation, the model maintains a record for the breaching vehicle and the special equipment item, if any, the number of items currently in the unit and the number of those items which have successfully crossed the field. After each pass of the model, these must be updated to account for items across the field as well as losses. For the following, let:

T_O, T_L, T_C = number of breaching vehicles in the unit lost in the field due to mines on this pass and across the field

C_O, C_L, C_C = number of special equipment items in the unit, lost in the field on this pass and across the field

R = probability of breach vehicle surviving direct fire

S = probability of vehicle surviving breach attempt

S_T = probability of vehicle and special breach equipment surviving breach attempt

L_W = lanes worked, after reduction for free paths, if any, on first pass of the model

L_{ST} = L_W + free paths on first pass of the model, $L_{ST} = L_W$ on other than the first pass

The essential bookkeeping problem is straightforward. After a pass of the model, losses must be calculated and deleted from the strengths in the unit and items which reach the other side of the field must be tallied. Losses attributable to direct fires are assessed as direct fires are assessed against the breaching vehicle, but not against any other breaching equipment, so this must be accounted for. Vehicle losses, in the field, on lanes other than free paths are calculated as:

$$\text{losses} = L_W \cdot (1-S) \tag{IV-7-217}$$

This figure, however, combines losses to direct fires with losses directly due to the field. To separate these, we note that losses due to direct fires must be $L_W \cdot (1-R)$ and so, losses due to mines must be:

$$\begin{aligned} T_L &= L_W\ (1-S) - L_W\ (1-R) \\ &= L_W\ (R-S) \end{aligned} \tag{IV-7-218}$$

These are deleted from the unit, giving a new quantity on hand, T_o^1, as $T_o^1 = T_o - T_L$. Vehicles crossing the field must be those starting across less any lost to direct fires less any lost to mines. Those lost to mines are available as T_2 and those lost to direct fires are simply L_{ST} (1-R). In this case, all lanes are considered, including any "free paths" in the first pass of the model. The new value of vehicles across the field T_C^1, is then simply the number across on previous passes plus the number that survive this pass

$$\begin{aligned} T_C^1 &= T_C + L_{ST} - L_{ST}\ (1-R) - T_L \\ &= T_C + R\ L_{ST} - T_L \end{aligned} \tag{IV-7-219}$$

For special breaching equipment, losses to direct fires are not dealt with in the direct fire assessment. The assumptions is made, in the hasty breach model, that if the vehicle is lost to direct fires, the special equipment may be considered lost to the breaching unit. The algorithm used to compute losses to this equipment is:

$$C_L = L_W\ (R-S_T) + L_{ST}\ (1-R) \tag{IV-7-220}$$

Note that the first term represents losses due to mines, on lanes that are not free paths, and the second term represents losses due to direct fires suffered by all elements making this pass. On other than the first pass, when, $L_W = L_{ST}$, this reduced to $C_L = L_W \cdot (1-S_T)$. Since these are total losses they can be immediately applied to the numbers in the unit and across the field:

$$C_o{}^1 = C_o - C_L \tag{IV-7-221a}$$

$$C_c{}^1 = C_c + L_{ST} - C_L \tag{IV-7-221b}$$

2. Completion of Breach. A breach action is completed if the unit has sufficient open lanes to cross the field. The minimum sufficient number of lanes for passage of the field, under conditions at time of encounter, was provided in the countermeasure decision data. To complete the breach attempt, the unit must open at least this number less any known open lanes less any free paths found in the first pass of the model. Thus if

L_N = lanes the unit must open

L_S = sufficient lanes for passage

L_O = known open lanes

FP = free paths

$L_N = L_S - L_O - FP.$

The criterion for completion is having completed sufficient trials, or passes through the model, to equal or exceed the expected number of trials required to open at least L_N lanes. (Actually, since the number of passes is an integer and expected number of trials a rational, the breach is considered complete when the number of passes carried out is at least within 0.1 of the expected value. Thus, for example, the first pass will complete the action if expected number of trials is less than 1.1.) The expected number of trials is:

$$E_T = \sum_{J > 0} J \cdot PL_J \tag{IV-7-222}$$

where PL_J is the probability of having sufficient lanes on trial J and not on any previous trial. PL_J is calculated as

$$PL_J = PM_J \left(1 - \sum_{K=0}^{J-1} PL_K\right) \qquad \text{(IV-7-223)}$$

where PL_0 is defined as zero and PM_J is the probability of having at least the desired number, L_N, of survivors on trial J. The values of PM_J, in turn, come from the assumption that, in an expected value sense the same trial is being conducted on each of L_W independent sites and, at each site, the probability of the vehicle surviving trial J, S_J, applies. Under these assumptions, the binomial distribution applies. That is, given L_W independent attempts of trial J, all with probability S_J of success (survival), the probability of exactly I successes is:

$$P\ (I:\ S_J,\ L_W) = {L_W \atop I}\ S_J^I\ (1-S_J)^{L_W - I} \qquad \text{(IV-7-224)}$$

Then the probability of L_N or more successes is simply unity less the probability of fewer than L_N successes or

$$PM_J = 1 - \sum_{I=0}^{L_N - 1} \binom{L_W}{I} S_J^I\ (1-S_J)^{L_W - I} \qquad \text{(IV-7-225)}$$

Thus, for any given trial ITRIAL in a sequence of trials, the probability of having succeeded on previous trials PL_J (J less than ITRIAL) is saved and the probability of succeeding on trial ITRIAL, or later trials, is predicted by obtaining the appropriate values of S from the in-field model and solving for PL_K ($K \geq$ ITRIAL). If the resultant expected number of trials has been satisfied, the breach action is complete. The expected number of lanes opened in the action is computed as $L_W \cdot$ S ITRIAL and is added to the number of open lanes, if any, on this minefield's barrier file. Thus, once opened, a lane is accessible to all units of the opening unit's force. The unit is scheduled to pass through the field on the number of lanes now open. If the breach attempt is not completed, the unit will attempt to continue the attempt.

<u>3</u>. Breach Continuation. If a unit does not complete a breach action, its ability to continue the action with another pass through the model is assessed. To schedule another pass, the unit must

have sufficient vehicles and, if appropriate, special equipment not yet across the field to again attempt the effort on L_W lanes. If possible, the next attempt on L_W lanes is scheduled for time tc after the current attempt. Otherwise, L_W is decremented, by one, and the unit's ability to work on the reduced number of lanes is assessed. This continues until the unit is able to work on a reduced number of lanes or L_W becomes less than L_N. If this fails, the original decision table used to select this breach option is re-called and re-queried, starting with the current option's position on the table. Decision table options are again referenced, in turn. If an option calls for lanes and the unit has L_O + FP paths at least equal to the minimum sufficient number of lanes, a passage on lanes is scheduled. If an option calls for another hasty breach and the action is feasible, that is, the unit can work on the specified (sufficient less open less free path) number of lanes, this action is scheduled. Otherwise the next option is queried until the table is exhausted at which point a withdraw action is scheduled.

h. Deliberate Breach Option. The deliberate breach option is designed to represent a unit opening lanes in a field by the use of explosive means. By the use of appropriate input data, it may also be used to represent other mechanical or manual clearing techniques. The unit is subject to direct fire assessments throughout the breach action.

(1) General Approach. An incremental approach is used to represent the deliberate breach option. For a given lane clearing technique, the countermeasure option constant data base contains the parameterization of a standard clearing increment in terms of the depth of field cleared, amount of time required and quantity of consumable items used for one increment. The model is, essentially, a set of bookkeeping logic to schedule sufficient increments to clear a lane through the depth of the field and to remove expenditures from the units status file as they are made.

(2) Calculations. Upon each entry to the model, at least one standard clearing increment is simulated. The calculations involved are those required to assess the results of the last pass through the model and to schedule the next pass through the model. The basic logical flow is shown in Figure IV-7-20.

(a) First Entry to Model. The first entry to the deliberate breach model is made at the time the action is scheduled to begin. Thus no assessments are to be made and the only action required is scheduling the first pass, or first breach action on the field. The first pass is scheduled to include the minimum number of increments that will clear at least 25 meters into the field. Sched-

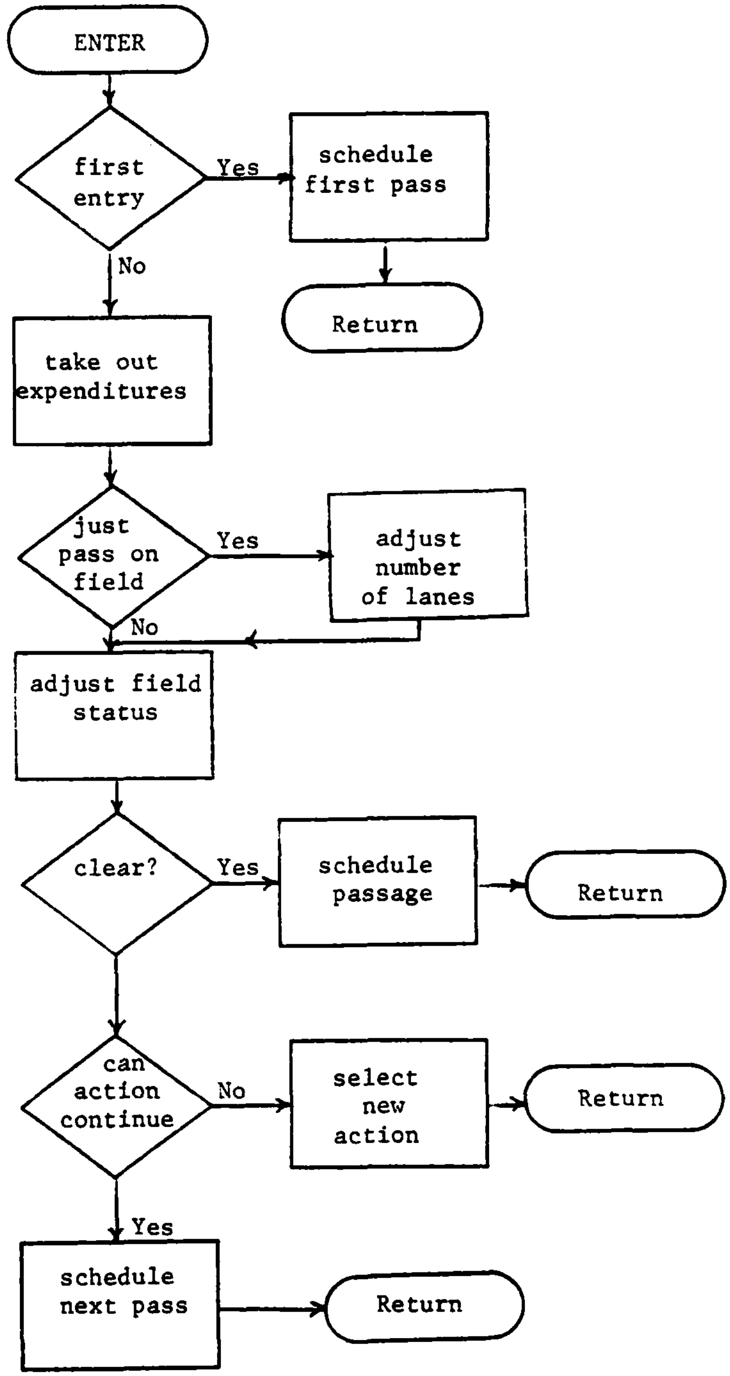


Figure IV-7-20. Logical Flow of Deliberate Breach Model.

uling, in this case, is simply a matter of setting the number of increments N and the time for assessment of these increments,

$T^1 = T + N \cdot T_I$

where T^1 = scheduled assessment time

T = current time of first entry

N = number of increments to be assessed

T_I = time to accomplish one increment

(b) Equipment Expenditure. Each entry, other than the first, into the model is at a time scheduled for assessment of some N standard increments, scheduled in the previous pass through the model. Assessment of expenditures is accomplished by subtracting from the unit's status file those items used in the increments thus completed. Thus, for a unit working on LW lanes, the amount of item J to be subtracted is $S_J = N \cdot LW \cdot X_J$ where X_J is the expenditure per standard increment as loaded within the countermeasure data.

(c) Lane Adjustment. As discussed for the hasty breach option, at paragraph 5.g.(4)(a)2.e., above, a unit could select potential lane sites beyond the lateral boundaries of an encountered field. Discovery of such "free paths" is also allowed in the deliberate breach model after the first pass, that is, after the assessment of at least 25 meters depth into the field. As with the hasty breach model, if free paths are discovered, the number of lanes the unit is working on, LW, is adjusted accordingly.

(d) Field Status. Throughout the course of a deliberate breach action the depth of the field currently open and remaining to be opened is maintained. As each pass of N increments is completed, the depth $N \cdot D_I$, where D_I is the depth cleared by a standard increment is added to the depth currently open and subtracted from the depth remaining to be opened. Once the depth remaining to be open is zero, the lanes are considered clear and the number of lanes being cleared are added to the number of open lanes on the barrier file record for this barrier. Both forces are given intelligence of lanes opened under this option. When the lanes are established as being clear, passage through the field is scheduled as described in paragraph 5.i. below.

(e) Continuation of Action. If the lanes under work are not clear, the unit's ability to continue the action is determined based on equipment requirements. For major end items, a go/no go determination is made whereby the action may continue if the unit has LW · Y_J of item J where LW is the number of lanes under work and Y_J is the number of items required per lane as contained in the countermeasure data base. For expendables, the number of increments the unit will be able to sustain is computed for each item called for in the countermeasure data base and the minimum of these is taken as the number the unit is capable of carrying out. If this number M_{INC} is non-zero, then the unit may continue its action.

(f) The number of increments scheduled for the next pass is based upon the amount the unit is capable of, M_{INC}, the duration of an increment, T_I, the depth of field cleared by an increment, D_I, and the depth of the field left to be cleared, D_L.

1. If increment duration T_I is five minutes or more, one increment is scheduled for the next pass.

2. If increment duration is less than five minutes, the number of increments and time to clear the field are computed as

$$M_{CLEAR} = D_L \,/\, D_I \text{ (rounded up to the next integer) and}$$

$$T_{CLEAR} = M_{CLEAR} \cdot T_I$$

Then, if T_{CLEAR} is greater than seven minutes, the number tentatively scheduled is the number that can be completed in five minutes N = 5 minutes / T_I (rounded up to the next integer). If T_{CLEAR} is not greater than seven minutes, the number tentatively scheduled is N = M_{CLEAR}.

3. The number actually scheduled is then limited by M_{INC}, the number the unit is capable of. Time of assessment is then calculated as current time plus the duration of the increments being scheduled.

(g) If the current action cannot be continued, due to a lack of resources, an attempt is made to find an alternate breaching mode by referencing the countermeasure decision table that originally called for this option. Decision table options are queried, starting with the current option's position in the table, in an attempt to find a feasible alternative. If an option calls for lanes and the unit has open lanes plus "free paths" at least equal the minimum sufficient number of lanes, a passage on lanes is scheduled. If an option calls for work on no more lanes than those currently under work, and is a feasible hasty or deliberate breach option, it is scheduled to work on the depth remaining to be opened. Otherwise the next option in the table is queried. Once the decision table has been exhausted, a withdraw action is scheduled.

i. Passage on Open Lanes.

(1) General. The simulation of a unit passing through a field on open lanes is designed to represent the delay associated with a maneuver unit passing its combat vehicles through a field when under direct fire. The assumption is made that the unit will strive to maintain unit integrity to the extent that unit motion will be curtailed by the field until the major combat vehicles actively engaged in the battle have cleared the field. Once this has been accomplished, it is assumed that any additional unit vehicles will be able to cross the field essentially unimpeded, behind the area of actual combat, and will not restrict the forward motion of the unit's combat mass being represented within the ground combat model. While the passage of combat vehicles is in progress, fire of vehicles in the lanes is curtailed but those vehicles already over the field or waiting to cross will provide covering fires.

(2) Passage Delay Time. Passage delay time is computed as a function of the number of combat vehicles which will cross the field, depth of the field, number of lanes upon which the action is to take place, and movement rates of the crossing vehicles.

(a) Combat vehicles whose passage of the field will affect the crossing time are those vehicles, within the front band of the unit, which are active in the Ground Combat Model exchange of direct fires and which are identified as either tanks or APCs in the GCM data base. Since there are at most eight weapon systems defined in this data base, let the number of such vehicles of each type J be VFB_J, J = 1, 2, ... 8 and let SVFB be the sum of VFB_J over J. (Note for some J, VFB_J may be zero.) If the unit had knowledge of the field prior to the encounter, some fraction of the unit front, F_{COV}, was established as being covered by a barrier within the encounter logic. A proportionate fraction of the vehicles is, in this case, treated as covered by the field and the remaining vehicles do not affect the crossing delay if the unit initiates passage upon encounter. Thus:

$$VC_J = F_{COV} \cdot VFB_J \qquad J = 1, 2, \ldots 8 \qquad \text{(IV-7-226)}$$

$$VU_J = VFB_J - VC_J \qquad J = 1, 2, \ldots 8 \qquad \text{(IV-7-227)}$$

Note that, if the unit does not initiate passage on encounter but rather selects a breaching action, F_{COV} is set to 1.0 and $VC_J = VFB_J$ and $VU_J = \phi$. If a hasty breach has been accomplished, some breaching vehicles, VO_J, may already be over the field and the number to cross, VC_J, is reduced accordingly. Ultimately, we develop, for J = 1, 2, ... 8:

VFB_J = number of front band weapon system J

SVFB = total of front band systems $\sum_J VFB_J$

VC_J = number of weapon system J which will cross field in lanes

SVC = total of systems to cross, $\sum_J VC_J$

VU_J = number of weapon system J "uncovered" by the field

SVU = total of systems uncovered, $\sum_J VU_J$

VO_J = number of systems of type J already over field

SVO = total systems over field, $\sum_J VO_J$

$$VFB_J = VC_J + VU_J + VO_J \qquad \text{(IV-7-228a)}$$

$$SVFB = SVC + SVU + SVO \qquad \text{(IV-7-228b)}$$

(b) The crossing rate used for vehicles to pass over a lane is taken as the average GCM limiting speed of the vehicles which must actually cross the field. Thus, if the limiting speed for weapon system J in the GCM data base is V_J, then the crossing rate is:

$$R = \sum_J VC_J \cdot V_J \,/\, SVC \qquad \text{(IV-7-229)}$$

(c) The number of lanes used for passage is, if the passage is initiated immediately on encounter of a known field, the number of open lanes previously known to the encountering unit limited by the maximum desirable number of lanes from the countermeasure decision table. The number of lanes used for passage after a breach action is the number of open lanes known prior to the action (if any) plus lanes opened by the action plus any "free paths" found in the course of the action. This total is, by the logic of the breaching models, limited to the maximum desirable number of lanes in the countermeasure decision table.

(d) If L lanes are available, then

$$P = SVC / L \qquad \text{(IV-7-230)}$$

passes of a vehicle on each lane must be made to cross the field. The value of P is rounded up to an integer to account for the possible movement of fewer than L vehicles on the final pass over the lanes. If R is taken as the average movement rate within a lane, and passage over a lane covers the field depth D_F plus some adjustment factor D_A for maneuver prior to entry and upon exit from a lane (an adjustment factor of 50 meters is currently used), then the amount of time required to cross the field is estimated as:

$$T_C = P \cdot (D_F + D_A) / R \qquad \text{(IV-7-231)}$$

(3) Interface with Direct Fires. The assessment of direct fires continues while the unit is crossing the field. To account for the relative inability of L vehicles to fire, at any one time, while actually on a lane, a total of L vehicles is excluded from firing but continues to be treated as targets for direct fires for the duration of the action. The number of each system actually excluded from firing $VEXC_J$, is a pro-rata portion of the total L:

$$VEXC_J = VC_J \cdot L / SVC \qquad \text{(IV-7-232)}$$

Remaining vehicles are generally treated as providing covering fire from stationary positions. In the case where some portion of the vehicles are not covered by the field ($F_{COV} < 1.$), a pseudo-unit velocity is used in the direct fire assessment to account for the limit on the firing rates of these vehicles, which must maintain some motion to attain unit integrity when crossing vehicles have cleared the field. This pseudo-velocity is the weighted average of the movement rate required for these vehicles to cover a distance equal to the field depth and the zero movement rate of those vehicles covering by fire but not moving. Thus

$$V_{FIRE} = (D_F / T_C) \cdot SVU / (SVU + SC + SC - L) \qquad \text{(IV-7-233)}$$

(4) Scheduling and Completion of Action. The action is actually scheduled, for purposes of direct fire assessment, in five minute increments with the restriction that a final increment of less than 2 minutes is to be avoided. Thus, if T_C is less than seven minutes, and then the remaining time is scheduled for the last increment. Once the required time has elapsed the unit location is updated to a position on its original line of movement a distance equal to the depth of the field ahead of its position at field encounter and the unit resumes Ground Combat activity in the basic (no barrier) cycle of operation.

j. Premature Termination of Barrier Interactions. A given battle may terminate, due to a termination condition in the DSL Battle Paragraph being satisfied on the expiration of a DIVWAG game period, while a unit is involved with a barrier under control of the Ground Combat Model. The DIVWAG System does not currently allow such an interaction to be carried forward to another model or to be re-established within another named battle. Thus the interaction must be terminated upon battle termination. The procedures used depend upon the nature and status of the unit/barrier interaction at time of the battle termination.

(1) Encounter Mode. If the battle is interrupted as the unit is encountering a barrier, the unit will suffer discovery losses and be given intelligence of the field. No countermeasure selection will be made. Any time remaining for direct fire assessment will be assessed as in a delay mode.

(2) Delay Mode. If the battle is interrupted while a unit is in the delay mode, any scheduled countermeasures are lost and the unit may re-encounter the barrier, in another model or on re-entry to GCM.

(3) Bypass Mode. If interrupted while in a bypass mode, the unit will be given the location it has attained in any bypass motion. Any remaining bypass action is lost and the barrier may be re-encountered in a new model or on re-entry to GCM.

(4) Withdraw Mode. If interrupted while in a withdraw mode, the unit is moved to its next scheduled withdraw point. The barrier may be re-encountered.

(5) Hasty Breach Mode. If a unit is interrupted while in the process of a hasty breach operation, post-assessment of the action will be made and the barrier file will be set to reflect the currently expected number of lanes now opened by the breach action. The unit may re-encounter the field.

(6) Deliberate Breach Mode. An interrupted deliberate breach action is post-assessed for the current scheduled increment. If this completes the action, the barrier file is adjusted to show the open lanes. If not, partial credit for the action may be reflected by considering L lanes open where:

$$L = LW\ (1 - P_{MISS})\ D_{OPEN} / D_F \qquad \text{(IV-7-234)}$$

LW = number of lanes being worked

P_{MISS} = fraction of mines missed in open area

D_{OPEN} = depth of field now opened

D_F = field depth

In any case, the unit may re-encounter the field.

(7) Passage. If a unit is interrupted while passing through an open field, the unit is treated as though the passage were complete if no more than five minutes of crossing time remains after post-assessment of the currently scheduled increment. Otherwise progress through the field is lost and the field may be re-encountered.

APPENDIX A

GROUND COMBAT MODEL INPUT REQUIREMENTS

1. INTRODUCTION. This appendix addresses the entry of data into the DIVWAG data base to permit simulation of ground combat operations. Illustrations of card formats, explanations of information to be entered in the various card columns of these formats, the names of program variables, and other reference information are provided to expedite the process of loading constant data into the model prior to game play. The data entered in this segment of the data base are constant, as are data treated in the previous chapters of this section. This model is concerned with five major activities: (1) unit geometry, (2) target acquisition, (3) firepower potential, (4) firepower effectiveness, and (5) assessment of losses. Each of these activities is explained in detail in this chapter.

a. Data Requirements. A commonality of data requirements exists between the Ground Combat Model and the other models of DIVWAG involving firepower and movement. The constant data are entered only once into DIVWAG; thereafter, they are used by all models requiring common type information.

b. Chapter Format. The initial paragraph of this appendix provides an insight into contents of the appendix, its relationship with other chapters, a broad description of the data base used by the Ground Combat Model, and a description of the data deck structure. The later paragraphs describe how the card formats are organized and explain the details of data entry. In addition, an illustration and an explanation are given for the data deck structure for the Ground Combat Model.

c. Data Base. The Ground Combat Model accesses common and unique data files. Files of unit status, secondary weapons, terrain, and weather are examples of common data files shared with several DIVWAG models. Details on these files are included in the DIVWAG documentation. The unique file is data file 39, Force Element Description, containing data on weapon systems, threats to friendly forces, and environmental factors. Detailed information on data file 39 is covered in this chapter.

d. Data Deck:

(1) Essentially, two complete data decks are required to load data file 39 with unique data required for the Ground Combat Model. Data deck 1 is a complete deck of the six card formats with as many cards of each as necessary. In data deck 1, Blue is the attacker and Red is the defender. A control card signals the end of deck 1, and deck 2 follows. In deck 2 Blue is the defender and Red is the attacker. The data entered in deck 2 will be only that which is changed from attacker to defender for Blue and defender to attacker for Red. Each card in data deck 2 must be completed insofar as it is necessary to do so. That which pertains to Blue for both attack a

defend will be utilized for both purposes and will be in data deck 1. That which pertains to Red for defend and attack will be used for both purposes and will be in data deck 1. If there are no changes from deck 1 to deck 2, cards need not be prepared, only one data deck is entered; and the loading program automatically loads **identical** data for the Red attacker, Blue defender case.

(2) Each element (e.g., personnel, weapon, sensor) to be considered by the Ground Combat Model must be assigned to a transport system such as a tank, armored personnel carrier, or other type system. The equipment item code is the unique method used to designate a specific type of transport system. When personnel are the transport system (men transporting portable weapons systems), then the item code of the weapon system is used.

(3) The four types of card formats concerned with the combat threat and friendly forces are: (1) Weapon/Transport Systems Specification, (2) Weapon System Specifications, (3) Sensor Specifications, and (4) Weapon/Transport System Targets and Priorities. Each of these cards is discussed in detail in the following paragraphs, and instructions are given for data entries to apply to each.

2. WEAPON/TRANSPORT SYSTEM. The first of the card formats dealing with the combat units of both friendly and hostile forces is the weapon/transport system. The purpose of this card is to capture all the characteristics about the transport system that will provide mobility for the firepower. Its capability of being detected as a target by opposing forces and similar related facts are called for in this card format.

a. Card Format. The format for this card is illustrated in Figure IV-7-A-1, Transport System Specifications. The card format is divided into three major sections. The first is the card type, force indicator, and its posture in combat. The second segment is for the first transport system description. The third segment describes the second transport system.

b. Card Type, Force, and Posture (Columns 1-3). The number 1 has been preprinted in column 1. Do not make any changes. Either an "R" for Red forces or a "B" for Blue forces is to be entered in column 2. Any other designator will cause the processor to reject this card. Column 3 will have either "A" for attacker or "D" for defender. Any other data entry will cause the card to be rejected. In preparing data deck 1 it must be recalled that "A" is for Blue attacking. When Red data are prepared for data deck 1 it must always be for Red defending. Any other combination in data deck 1 will cause these cards to be rejected by the processor. Data deck 2 will always have the "B," Blue force, in "D," defense, and the "R," Red force, will be in "A," attack. Data deck 2, as a rule, will be smaller than data deck 1 because only cards that contain changed data from attacker to defender for Blue and defender to attacker for Red will be entered.

CARD TYPE	RED OR BLUE	ATTACK-DEFEND	TRANSPORT SYSTEM SPECIFICATIONS																							CARD ID	CARD SEQ. NR
			TRANSPORT SYSTEM 1											TRANSPORT SYSTEM 2													
					DIMENSIONS IN FEET											DIMENSIONS IN FEET											
					LOWER BOX			UPPER BOX								LOWER BOX			UPPER BOX								
			ITEM CODE	TRANSPORT	LGTH	WDTH	HGTH	LGTH	WDTH	HGTH	REFL FACT	NR PERS	PIN POINT PROB	ITEM CODE	TRANSPORT	LGTH	WDTH	HGTH	LGTH	WDTH	HGTH	REFL FACT	NR PERS	PIN POINT PROB			
1																										3001	

Figure IV-7-A-1. Transport System Specifications

c. Item Code of Transport (Columns 4-7). The transport item code and its type are to be entered in these columns. Figure IV-7-A-2, Transport Types, will be used to assist in preparing the type of transport. Eight transport systems are authorized for the submodel data base. The transport systems are the actual targets at which opposing fires will be directed within the Ground Combat Model. When personnel are the transport system then the item code of the weapon system is used.

Type	Transport System
T	Tank type vehicle
A	Armored personnel carrier
V	Wheeled vehicle and any other type vehicle used to transport a weapon system
P	Personnel

Figure IV-7-A-2. Transport Types

(1) Item Code (Columns 4-6). Enter the item code of the transport system in these card columns. The item code is used so that this particular type of transportation may be uniquely identified. If there is no item code for a particular type of transport system, then its characteristics cannot be entered in the data base; therefore, there must be an item code for each transport system to be entered in these card formats.

(2) Transport Type (Column 7). Select the code from Figure IV-7-A-2 and enter it in this column.

d. Dimensions of the Transport System (Columns 8-25). The dimensions of the transport system form the area of target presentation to hostile forces (see Figure IV-7-A-3, Target Dimensions). In describing this area, the area of the lower box (Figure IV-7-A-3) is considered as though it were a tank, including the hull and track; and the area of the upper box is considered as the turret and its weapons. The following card columns ask for width, length, and height of the lower box and upper box of the transport system. If the transport system has no upper box--the cab and body of a truck would be considered as all being in the lower box--these entries will be left blank, or zeros may be entered. In any event these dimensions are to assist in determining the area that the transport system presents as a target to hostile forces.

These entries will be in feet. If the dimension is given as a fraction such as 12-1/4 feet, change to decimals (12.25) and round off, in this case to 12 feet. Only whole numbers are to be entered in these card columns, and all numbers are right justified.

(1) Length of Lower Box in Feet (Columns 8-10). Enter the length in feet of the lower box of the transport system. If this is a truck, then consider overall dimensions as the lower box.

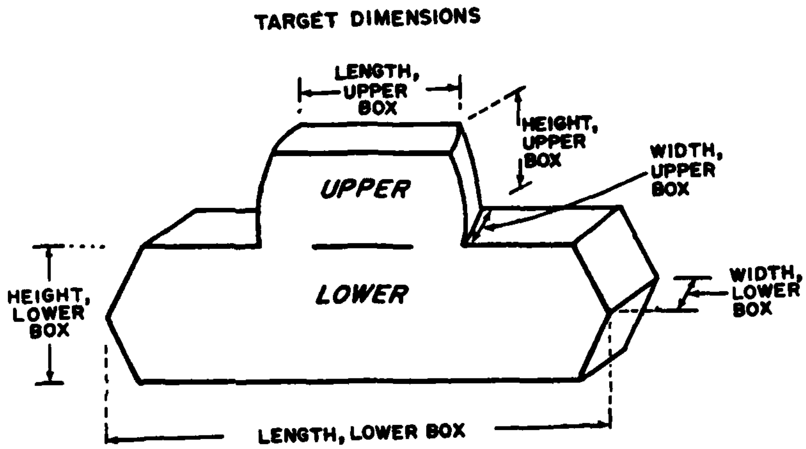


Figure IV-7-A-3. Target Dimensions

(2) Width of Lower Box in Feet (Columns 11-13). Enter the width in feet of the lower box.

(3) Height of Lower Box in Feet (Columns 14-16). Enter the height of the lower box in feet.

(4) Length of Upper Box in Feet (Columns 17-19). Enter the length in feet of the upper box, or turret in case of tank. If there is no upper box or turret, then leave blank or fill with zeros.

(5) Width of Upper Box in Feet (Columns 20-22). Enter the width of the upper box in feet in these card columns. If there is no upper box, such as for a truck, then leave blank or enter zeros.

(6) Height of Upper Box in Feet (Columns 23-25). Enter the height of the upper box in feet. If there is no upper box, then leave blank or fill with zeros.

e. Reflectance, Personnel, Pinpoint Probability, and Mobility Class Rate (Columns 26-37). The values entered in these columns are related to the amount of light reflected by the transport system, the probability that it can be pinpointed the first time that its primary weapon is fired, the number of personnel associated with the system, and the mobility characteristics of the transport. The personnel figure is used in part of the calculations for casualties. If a transport item is assessed as a kill in the model, the personnel associated with the system become casualties. The mobility class rate figure is used to determine the number of transports which must be moving in order to sustain the ordered unit velocity. No transport is ever allowed to move faster than its mobility class rate.

(1) Reflectance (Columns 26-28). Enter the reflectance factor for this type of transport system. For example, (see Table A-2, page A-9, Volume II, CRESS User's Handbook). This is a decimal fraction, left justified. For example, if the reflectance factor is 0.12 enter 120 in columns 26-28.

(2) Personnel Numbers (Columns 29-31). Enter the number of personnel associated with this vehicle.

(3) Probability of Pinpointing (Columns 32-34). The probability of being pinpointed is to be entered here to three decimal places. If this probability is expressed as four decimal places, such as 0.2321, the data will be rounded off to three digits and entered without the decimal; thus, it would appear as 232 with the right figure 2 being entered in column 34. If the figure for probability were 0.23, this would be entered as 230 with the trailing zero.

(4) Mobility Class Rate (Columns 35-37). Enter the combat mobility class rate of the transport in kilometers per hour. The entry should be right justified and cannot be zero.

3. SPECIFICATIONS FOR THE WEAPON SYSTEM:

a. General:

(1) The weapon system is to be described and its performance characteristics recorded in the card columns of this format. The weapons are transported about the battlefield on the transport system described in card format 1 with the identifier of 3901. Reference will be made to that transport system so that it may be referenced in the data base. Further, when the transport system has been destroyed, the weapon systems mounted on it also are destroyed. In addition, the personnel associated with that transport system are casualties, and the number of rounds of ammunition aboard the transport system are also lost.

(2) As in the case of the transport system there are to be two decks of cards; the first deck has the Blue force attacking and the Red force defending, and the second deck has the Blue force defending while the Red force is attacking. This procedure is established so that those preparing the card entries will be aware of all data that must be entered and can take into consideration all the factors that are dependent upon the combat posture of the force they are describing (attack or defend). This procedure also eliminates redundant work in that only essential differences between attack and defend postures need be entered. For example, in attack or defend, there will be no difference in the dimensions of the upper or lower boxes of the transport system. Once these data are entered for Blue attacking with Red defending, there is no need to enter identical data the second time for Red attacking and Blue defending. Also the reflectance and probability of being pinpointed the first time that the primary weapon fires is the same whether Blue is attacking or defending. If, however, a single data entry is changed for an item code, all data must be repeated for that item code.

(3) It was mentioned in paragraph 2c that a maximum of eight transport systems could be entered in the data base. These same constraints place an upper limit of 16 different weapon and transport system combinations. Combinations may include an arrangement of weapons, ammunition, and transport system; therefore, a maximum of 16 card types 2 may be prepared. Any greater number will cause all after number 16 to be rejected.

b. Card Format. Figure IV-7-A-4 Weapon System Specifications, illustrates the format of this card type. The card has four major sections: (1) the card type, force indicator, and combat posture (attack or defend), (2) system identification through a series of codes, (3) aim and fire time with rounds per minute, and (4) ammunition weapon system range and accuracy. The code for the transport system must have already been entered in card type 1 and the system completely described. If this is not done, then the processor will reject the data.

c. Card Type, Force, and Posture (Columns 1-3). The preprinted figure 2 is entered in column 1. Make no change in this number. In column 2 the letter "R" for Red force or "B" for Blue force is to be entered, and no other. If this entry is not made the data will be rejected by the processor. "A" for attack or "D" for defend is to be entered in column 3. If this is data deck 1 and for Blue forces, then "A" must be entered and none other. If this is data deck 1 and for Red, then "D" must be entered in column 3 and none other. For data deck 2 the Blue force will have the letter "D" entered in column 3 and Red will be "A." Failure to follow this procedure will cause the deck to be rejected by the processor.

d. System Identification (Columns 4-12). The item code of the combined ammunition system, weapon system, and transport system are to be entered here.

			WEAPON SYSTEM SPECIFICATIONS																								
			SYSTEM IDENTIFICATION																								
CARD TYPE	RED OR BLUE	ATTACK-DEFEND	WEAP ITEM CODE	AMMO ITEM CODE	TRANS ITEM CODE	SECS AIM & FIRE	ROUNDS PER HOUR	RANGE METERS	PROB HIT	TIME OF FLIGHT	RANGE METERS	PROB HIT	TIME OF FLIGHT	RANGE METERS	PROB HIT	TIME OF FLIGHT	RANGE METERS	PROB HIT	TIME OF FLIGHT	RANGE METERS	PROB HIT	TIME OF FLIGHT	RANGE METERS	PROB HIT	TIME OF FLIGHT	CARD ID	CARD SEQ. NR
2																										3901	

Figure IV-7-A-4. Weapon System Specifications

It is essential that the transport item code be entered and completely described in card type 1 of the 3901 series.

(1) Weapon System Code (Columns 4-6). Enter the item code of the weapon system carried about the battlefield by the transport system described in format 1.

(2) Ammunition Code (Columns 7-9). Enter the item code of the ammunition that is designed to operate with this weapon.

(3) Transport System Code (Columns 10-12). Enter the item code of the transport system as it was entered in card format 1.

e. Weapons Characteristics (Columns 13-18). The average time to aim and fire a round and the sustained rate of fire in rounds per minute are desired in these card columns.

(1) Average Time in Seconds (Columns 13-15). Enter the average time in seconds to aim and fire a round from this weapon. If the time is expressed as seconds and fractions, convert fractions to decimals and round off to one decimal place. Thus, if the time were 2-1/8 seconds the decimal equivalent would be 2.125 rounded to 2.1 and entered beginning in column 14 with no decimal point. If the time were 2 seconds, then the trailing zero would be entered, with 20 being the figures to be entered in columns 14 and 15.

(2) Rounds per Hour (Columns 16-18). Enter the number of rounds per hour that can be fired from this weapon at a sustained rate considering the actions of the crew and the mechanical capabilities of the hardware.

f. Range and Probabilities of Hits (Columns 19-72). The range in meters, probabilities of a hit at that range, and the time of flight at that range are the entries to be made in these columns. These data should be fixed in relation to maximum and minimum range of the weapon; thus, the shortest range will be minimum and longest range will be maximum. It is desired to have six sets of data; that is, select six ranges for which data have been provided in terms of probability of a hit and the time of flight. The hit probability is based on a stationary NATO target of 7-1/2 x 7-1/2 feet. If information is not available on six sets of range data, then five, four, or three sets will suffice. A minimum of two sets of data is required. For those sets of data that are not completed the card column may be left blank, or zeros may be entered.

(1) Meters in Range 1 (Columns 19-23). Enter the meters for range value 1 in these card columns. All figures are to be whole numbers and right justified.

(2) Probability of a Hit (Columns 24-25). Enter the percent probability of a hit at this range. Whole numbers are to be used; and if the probability is expressed in three digits, it is to be reduced to two by rounding off; thus, a percent probability 98-1/4 would be converted to 98.25, rounded to 98, and entered in column 24-25.

(3) Time of Flight (Columns 26-27). Enter the time of flight expressed in seconds. Only whole numbers are to be entered, and the rule expressed in subparagraph (2) above will be followed.

(4) Additional Data Sets (Columns 28-72). Five additional sets of data defined exactly as that for items (1) through (3) above may be entered in these card columns.

4. SPECIFICATIONS FOR SENSORS. A means of detecting targets must be provided for each weapon system and its transport. These means may be the unaided eye of an observer or more complex sensor systems. The sensor systems may be employed on more than one weapon and its transport means; therefore, after the performance characteristics of the sensor are described, entries must also be made indicating the percentage of these sensors that are associated with each of the weapon systems. The transport system is the key in that if the sensor is aboard that transport it is used as a means for detecting targets for all weapons. The sensor is the target detecting capability of the friendly force. It is one of the combat items of equipment that will be lost should the transport system be destroyed. The data decks for sensors are also divided into two sets. One is the situation of Blue attacking while Red is defending. The second data deck is Red attacking with Blue the defender. In the second data deck only the changes that may occur when Red attacks or when Blue defends need be entered.

a. Card Contents. The four segments of this card format are illustrated in Figure IV-7-A-5, Sensor Specifications. The first segment is the card type with force designator. Second is the combat posture of the force described (attack or defend) and the item code of the sensor. The third segment contains the essential performance characteristics of the sensor, and the fourth is the means of transport about the battlefield. A constraint should be placed on the number of sensors that are to be carried about by one transport system. The rule should be that there will be no more sensors aboard a transport system than there are personnel to man them. The crew must continue to serve the crew type weapons; however, one individual may be taken from this category while the driver and assistant driver, if they are not assigned crew duties, may assist in the manning of sensors.

b. Card Type and Force (Columns 1-2). The number 3 has been preprinted in column 1. Make no changes in this entry. In column 2 enter only "R" for Red or "B" for Blue. Any other entry will cause card rejection.

			SENSOR SPECIFICATIONS																								
CARD TYPE	RED OR BLUE	ATTACK-DEFEND	SENS ITEM CODE	DAY-NIGHT	RANGE METERS	PROB DET TARGET	RANGE METERS	PROB DET TARGET	DET & RPT TIME SECS	TRAN ITEM CODE	SENS UTIL	TRAN ITEM CODE	SENS UTIL	TRAN ITEM CODE	SENS UTIL	TRAN ITEM CODE	SENS UTIL	TRAN ITEM CODE	SENS UTIL	TRAN ITEM CODE	SENS UTIL	TRAN ITEM CODE	SENS UTIL	TRAN ITEM CODE	SENS UTIL	CARD ID	CARD SEQ. NR
3																										3,9,0,1	

Figure IV-7-A-5. Sensor Specifications

c. Sensor Code and Combat Posture (Columns 3-6):

(1) Combat Posture (Column 3). Only the following alphabetic characters will be entered: "A" for attacker or "D" for defender. Any other character or character omission will cause the card to be rejected. "A" is entered in data deck 1 for Blue only and in data deck 2 for Red only. "D" is entered in data deck 1 for Red only and in data deck 2 for Blue only.

(2) Sensor Code (Columns 4-6). Enter the item code of the sensor selected.

d. Sensor Characteristics (Columns 7-24). A separate card must be prepared for each type sensor to be entered in the data base. For each type sensor there are six items of performance information that are to be obtained: time of day for sensor employment, range in meters for two different ranges (preferably minimum and maximum, but not necessarily so), the probability of detecting the hostile target at each range, and the mean time to detect and report.

(1) Time of Day for Sensor (Column 7). The time of day for the sensor to be employed is listed in Figure IV-7-A-6, Sensor Employment. Select the period of best performance for the sensor, look up its code in Figure IV-7-A-6, and enter that letter in this card column.

Code	Time of Day for Sensor Performance
D	Daylight operations are optimum for this sensor. Night performance degrades capability to unacceptable level.
N	Night operations are optimum for this sensor. Daytime performance degrades capability to unacceptable level.
B	Both day and night are optimum times for operation of this sensor. It is used around the clock.

Figure IV-7-A-6. Sensor Employment

(2) Range in Meters (Columns 8-12). Enter in meters the range of detection for this sensor. This entry will determine the distance from the transport system for detecting hostile units.

(3) Probability of Detection (Columns 13-14). Enter percent probability of detecting a target at the stated range. If the percent probability is expressed with a decimal, such as 98.2, round off to an integer number and enter in these card columns; thus, the 98.2 would be 98 entered in columns 13-14.

(4) Range in Meters (Columns 15-19). Enter the range for the second point selected for sensor target detection and recognition. Only whole numbers are to be used, and fractions or decimals will be rounded off.

(5) Probability of Detection (Columns 20-21). Enter the percent probability of detecting a target at this range using the technique explained in paragraph d(3) above.

(6) Seconds of Elapsed Time to Detect and Report (Columns 22-24). Enter the time in seconds to detect, recognize, and report a target. If this time is reported as fractions of seconds it should be converted to decimals and rounded to the nearest whole number; thus, the time elapsed may be 12-1/4 seconds. This would be converted to 12.25 and, when rounded, would be 12. The data entry appears as 12 with the decimal point omitted. If the entry were 12.5 seconds the entry would appear as 13 with no decimal entry.

e. *Weapons System* Sensor Utilization (Columns 25-72):

(1) General:

(a) Three factors are to be considered in preparing these data items. First, the number of sensors assigned to a unit may not provide for each transport to have a particular sensor type; thus, the sensor-to-transport ratio is required. Second, the doctrine of employment may not call for the sensor to be employed more than a certain fraction of the time as a countermeasure, due to battery drain, or for other reasons. Finally, the number of personnel required to operate the sensor may be such that it cannot be operated continuously but must be turned off to allow the personnel to operate other items of equipment. In order to prepare these data a simple work sheet is suggested for each transport. This work sheet is shown in Figure IV-7-A-7.

(b) There can be up to nine types of sensors, exclusive of visual, per transport; thus, one row of the work sheet should be prepared for each sensor assigned to a particular transport. Data for visual detection should not be included. The next column should contain the basis of issue reduced to the ratio of sensors to transports; e.g., if the basis of issue is two sensors per platoon of five tanks, the ratio would be 0.40 sensors per tank. The next column should contain the fraction of usable time that

WEAPONS SYSTEMS SENSOR UTILIZATION WORK SHEET				
Weapons System Transport Item Code__________________				
Number of observers per transport __________________				
	Sensor Item Code 1	Sensors per Transport 2	Fraction of Usable Time Turned On 3	Sensor Utilization 4
1				
2				
3				
4				
5				
6				
7				
8				
9				
TOTAL SENSOR UTILIZATION				
Total Sensor Utilization cannot exceed number of observers per transport				

Figure IV-7-A-7. Weapons Systems Sensor Utilization Work Sheet the sensor is turned on. Usable time is defined by the entry in column 3 of Figure IV-7-A-5. On the work sheet multiply column 2 by column 3 and place the result in column 4. After all sensors assigned to this transport are filled out, the total of column 4 is computed. If this total exceeds the number of observers, the fraction of usable time that some of the devices are turned on must be reduced until the total sensor utilization does not exceed the number of observers.

(2) Transport System (Columns 25-27). Enter transport system item code. This number must have been included among those filled in on card type 1 for transport system.

(3) Sensor Utilization (Columns 28-30). Enter the sensor utilization from column 4 of the Weapons System Sensor Utilization Work Sheet for the transport.

f. Additional Transport Systems (Columns 31-72). The remaining card columns in this segment of the format are to be completed using the instructions as given in paragraph e above. Make certain that all known transport systems that have this sensor are included. If there are not enough transport systems to fill in all card columns on this card, then they may be left blank or zeros filled in.

5. TARGETS AND THEIR PRIORITIES:

a. General:

(1) Weapons and their ammunition are effective against specific hostile targets. The identification of the weapon and its ammunition in card type 2 was the first step in specifying the weapon, ammunition, and target. The weapon and ammunition characteristics are now identified for each target.

(2) Target priorities are assigned numerically as 0 through 8, with 1 being the highest. The assignment of target priorities to a specific weapon must be such that there is no gap in priority assignment; that is, target priorities 1, 2, and 4 may not be assigned for a particular weapon, with the idea that priority 3 would be awarded later to another target to be played later in the game. This procedure is unacceptable; the weapon would only fire at its first and second priority targets, and the fourth would never be fired on even though it might be the only one in view for a considerable time. A zero priority target is never fired on.

(3) Priority assignment is made only to distinguish between two or more targets that may appear at the same time. As a rule the highest priority is assigned to the target for which the combination of weapon and ammunition has the greatest probability of kill. Lower priority targets are those for which the combination weapon and ammunition has a lesser probability of kill.

(4) As rounds of ammunition are expended, the commander of the force must take steps to drop the lower priority targets from the firing order. Those that have the greatest threat to the friendly forces, or for which this weapon has greatest kill probability, must be the last to be dropped. This same logic must be provided in the model; therefore, in this card format the data preparer enters the percentage of remaining ammunition that would cause the commander to issue orders to drop certain targets from the firing order. The largest percentage must be associated with the lowest priority. As soon as one target is dropped from the weapon's firing list all other targets of the same priority or lower priority are also dropped. Percentages may be specified for a maximum of four priority levels.

b. Format of Card. The four segments of this card are illustrated in Figure IV-7-A-8, Target Priority and Vulnerability. The four segments are: card type and force indicator, combat posture and system, target identification and priority, and accuracy of weapon system. This card is designed to contain the data for only one weapon system and one target type. If a weapon system has more than one assigned target, additional cards must be prepared. The data must be available for two or more ranges (two is the lower limit). The remaining columns may be left blank, or zero fills may be made.

c. Card Type and Force Designator (Columns 1-2). The number 4 has been preprinted in column 1 as shown in Figure IV-7-A-8. Make no changes. For column 2 enter either "R" for Red force or "B" for Blue force and no other type entry. Failure to do so will result in rejection of the data from the system.

d. Weapon System Identification (Columns 3-12). The complete identification of the system requires the code of the transport, weapon, and ammunition. These are asked for in the data set bounded by columns 3-12.

(1) Combat Posture (Column 3). Enter an "A" for attacker if this is the Blue force for data deck 1. Enter "D" for the Red force for data deck 1. For data deck 2 enter "A" for Red, and enter "D" for defender for Blue.

(2) Transport Code (Columns 4-6). Enter the item code of the transport system for a maximum of eight transport systems.

(3) Weapon System Code (Columns 7-9). Enter the item code of the weapon here. This must be one of the weapon systems recorded in card format 2.

(4) Ammunition Code (Columns 10-12). Enter the item code of the ammunition associated with this weapon system.

e. Target Priority (Columns 13-20). Data in this segment of the card deal with the equipment of the hostile force that presents a target to friendly forces.

CARD TYPE	RED OR BLUE	ATTACK-DEFEND	TARGET PRIORITY AND VULNERABILITY																			CARD ID	CARD SEQ. NR
			SYSTEM ID ITEM CODE TRAN	WEAP	AMMO	ENEMY TRAN ITEM CODE	PRIORITY	PCT AMMO ON HAND TO DROP	RANGE METERS	KILL PROB	RANGE METERS	KILL PROB	RANGE METERS	KILL PROB	RANGE METERS	KILL PROB	RANGE METERS	KILL PROB	RANGE METERS	KILL PROB			
1	2	3	4–6	7–9	10–12	13–15	16	17–20	21–25	26–27	28–32	33–34	35–39	40–41	42–46	47–48	49–53	54–55	56–60	61–62	63–72	73–76	77–80
4																						3901	

Figure IV-7-A-8. Target Priority and Vulnerability

(1) Target Code (Columns 13-15). Enter the item code for the hostile force target. A maximum of eight targets can be identified. Bear in mind that the target is really the transport system. The other items of equipment carried on board that transport system are lost when the transport system is lost, but all are considered operational as long as the transport system is operational.

(2) Priority of Target (Column 16). Enter the priority assigned this target, ranging from 1 (highest) through 8 (lowest). These priorities must be made in numerical sequence, and there can be no gap in priority number assignments. This column may be left blank for zero priority targets.

(3) Percent of Ammunition on Hand to Drop Target (Columns 17-20). Enter the percent of total authorized rounds that would cause the commander to drop this target. If the target were the highest priority target for the weapon system, then zeros could be entered; the weapon would be fired at that target until all ammunition was expended. Enter only a whole number. If the data are in decimals, round off to the nearest whole number. All entries are to be right justified.

f. Target Vulnerability (Columns 21-62). A series of range values is asked for in relation to this target, weapon, and ammunition. At least two of the ranges must be given, and as many as six are desirable. If data are not available, columns may be left blank, or zeros may be entered.

(1) Range in Meters (Columns 21-25). Enter the range in meters for this target.

(2) Probability of Kill (Columns 26-27). Enter the probability of a kill given a hit on this target at the range indicated.

(3) Additional Ranges and Probabilities (Columns 28-62). Each of the additional data sets calls for information similar to that of items (1) and (2) above.

6. LINE OF SIGHT. The visibility between two points on the battlefield during day or night and under a variety of environmental conditions is of utmost importance to direct fire weapons in combat operations. This card format is illustrated in Figure IV-7-A-9, Line of Sight. During this discussion frequent reference is made to posture 1 and posture 2. Posture 1 assumes that the target is advancing at its maximum velocity. To do so usually means that the target is exposed, presents some contrast with its background, and is more readily detectable. In posture 2 the target is assumed to be stationary and partially concealed. Naturally, the latter is a more difficult target to detect than is a target in posture 1. In each instance the terrain specification factors are desired for personnel and for vehicles, both of which will be defined in posture 1 and posture 2. All line of sight conditions are expressed in meters. Only one card is required.

LINE OF SIGHT																					
CARD TYPE	CONDITION	TERRAIN SPECIFICATIONS NO FOREST				TERRAIN SPECIFICATIONS WITH FOREST				CONDITION	TERRAIN SPECIFICATIONS NO FOREST				TERRAIN SPECIFICATIONS WITH FOREST					CARD ID	CARD SEQ. NR
		POSTURE 1		POSTURE 2		POSTURE 1		POSTURE 2			POSTURE 1		POSTURE 2		POSTURE 1		POSTURE 2				
		PRSNL	VEH	PRSNL	VEH	PRSNL	VEH	PRSNL	VEH		PRSNL	VEH	PRSNL	VEH	PRSNL	VEH	PRSNL	VEH			
5																				3901	

Figure IV-7-A-9. Line of Sight

a. General. In good terrain with no forestation to obstruct the view, there is a higher probability of line of sight at long ranges than would be the case were forestation present. Similarly, if the terrain is considered bad and has a number of possible defilading features, the probability of line of sight is considerably reduced. The following methodology may be used to generate terrain dependent line of sight data.

(1) Select a terrain cell of arbitrary size of each type (i.e., good or bad). Through this cell construct an arbitrary line and record the location and elevation of all contour lines at the points where they intersect the line.

(2) The resulting measurements provide a map profile along the line being considered. In the case of forested terrain the tree tops may be assumed to form another profile at a constant distance above the first. Line of sight in this representation is said to exist if the line between the observer and the target does not intersect either the earth profile or the elevated profile corresponding to the tree tops.

(3) The resulting profile(s) may be computer analyzed to find the frequency of line of sight as a function of observer-target separation. The analysis considers a fixed observer height and different target heights for personnel and vehicles. For a large number of random sets of observer and target locations along the map profile a record is maintained of the fraction of the times the line from the top of the observer to the top of the target does not intersect the profile(s) for several intervals of observer-target separation.

(4) The probability of line of sight is computed by the Ground Combat Model by the following equation:

$$P_{LOS} = (1 + 2r/\bar{r}) \; e^{-2r/\bar{r}}$$

where r is the observer-target range and $\bar{r}$ is an empirical value derived by considering the best fit of the equation to the map analysis output. An example of the empirical fitting process for the case of a vehicle in good forested terrain is depicted in Figure IV-7-A-10. The resulting value of $\bar{r}$ for this analysis was found to be 650 meters.

b. Card Type (Column 1). Figure IV-7-A-9 portrays the number 5 in column 1. Make no change in this number as it distinguishes the data entered into this card from that of other cards.

c. Condition (Column 2). The condition refers to good or bad type of terrain. For good terrain enter the number 1. For bad type terrain enter the number 2.

d. Terrain Specifications (Columns 3-34). The specifications for terrain are predicated on the entry of the number 1 or 2 in column 2. These data are

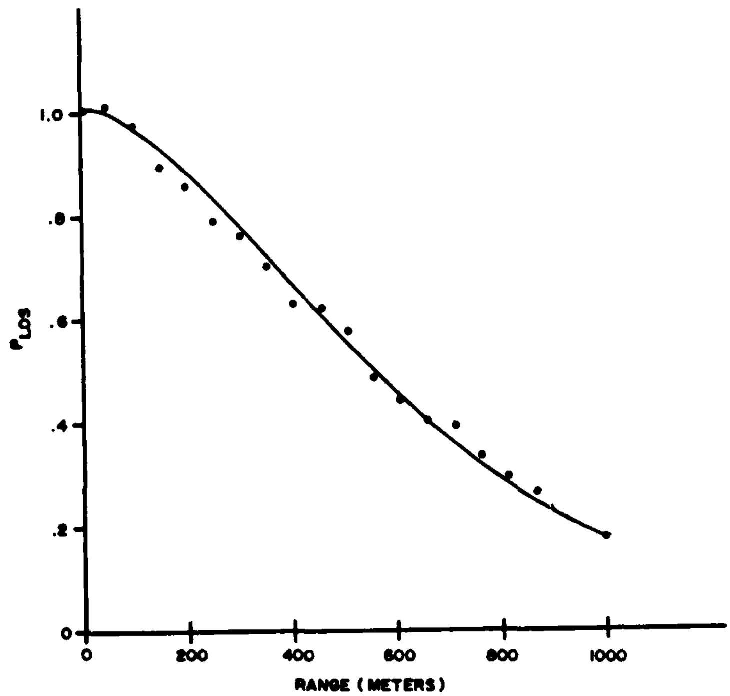


Figure IV-7-A-10. Probability of Line of Sight versus Range used as part of an equation that solves for the probability that an observer will detect a priority target in his area of responsibility.

(1) Posture 1 Personnel (Columns 3-6). For nonforested area with personnel moving at maximum velocity toward the observer, enter $\bar{r}$ that represents this situation expressed in meters.

(2) Posture 1 Vehicles (Columns 7-10). For nonforested area with vehicles moving at maximum velocity directly toward the observer, enter $\bar{r}$ that represents this situation stated in meters.

(3) Posture 2 Personnel (Columns 11-14). For a nonforested area with personnel stationary and partially concealed enter $\bar{r}$ for the line of sight calculation in meters.

(4) Posture 2 Vehicles (Columns 15-18). Enter $\bar{r}$ in meters for a nonforested area with vehicles stationary and partially concealed.

(5) Forestation Posture 1 Personnel (Columns 19-22). For personnel moving at maximum velocity directly toward the observer in forested terrain, enter $\bar{r}$ that equates to this line of sight condition in meters.

(6) Forestation Posture 1 Vehicles (Columns 23-26). For vehicles moving at maximum velocity directly toward the observer in forested terrain, enter $\bar{r}$ that equates to this line of sight condition in meters.

(7) Forestation Posture 2 Personnel (Columns 27-30). For a forested area with personnel stationary and partially concealed enter $\bar{r}$ equated to this condition expressed in meters.

(8) Forestation Posture 2 Vehicles (Columns 31-34). For forested area with vehicles stationary and partially concealed enter $\bar{r}$ equated to this condition expressed in meters.

e. Second Terrain Condition (Columns 35-67). The second terrain conditio to be specified in these card columns is to be different from that specified in the first segment of the card. The figures 1 and 2 indicate the different terrain situations that contrast between the first and second segment of the card. The definition of terms and intent of labels are identical with that used for the data entry instructions for columns 2 through 34 in this format.

7. HORIZON AND BACKGROUND. As part of the information needed in solving for the probability of detecting a target, the factors for illumination and background reflectance for three seasonal conditions must be taken into consideration. Figure IV-7-A-11, Horizon and Background, illustrates the card format used for this purpose. The card is divided into four major segments. Each of the first three segments has identical columnar heading titles. The instructions for entering data in the first set of card columns, 2 through 12, are identical for entries in columns 14 through 23 and 25 through 34. Normally a war game

HORIZON AND BACKGROUND

CARD TYPE	SEASON	BACKGROUND REFLECTANCE				BACKGROUND REFLECTANCE				BACKGROUND REFLECTANCE				SKY-GROUND RATIO				CARD ID	CARD SEQ. NR
		BARE	SPRSE	THICK		BARE	SPRSE	THICK		BARE	SPRSE	THICK		1	2	3			
6																		5901	

Figure IV-7-A-11. Horizon and Background will span a brief period of time within a single season; therefore, it is expected that a single set of data pertaining to that season will be entered.

a. Type of Card (Column 1). The number 6 has been preprinted in this card column. Make no change as this number distinguishes all data in this card.

b. Background Reflectance (Columns 3-12). Each set of data in this card has data entered to provide contrast in summer, autumn, and snow conditions.

(1) Season (Column 3). Enter the code for the season of the year in this card column. Consult Figure IV-7-A-12, Table of Seasons and Codes, and insert the appropriate code number in this column. Only one of the three numbers may be entered in this column. Failure to enter a number will cause rejection of the card and its data. All succeeding entries in columns 3 through 12 are dependent upon the number entered in this column.

Code	Season
1	Summer
2	Autumn
3	Snow

Figure IV-7-A-12. Table of Seasons and Codes

(2) Barren (Columns 4-6). Enter the factor developed for a barren countryside with the seasonal condition entered in column 3. This entry is all numeric and right justified.

(3) Sparse (Columns 7-9). Enter the factor that has been determined for sparsely covered countryside with the seasonal condition indicated in column 3.

(4) Thick (Columns 10-12). Enter the factor for thick vegetation with the given seasonal condition.

c. Sky-ground Ratio (Columns 37-45). Data in this segment of the card deal with the relative brightness of the horizon and background for three illumination conditions.

(1) Into the Sun (Columns 37-39). Enter the sky-ground ratio for an observer looking toward the sun. The decimal value should be rounded to

one decimal and entered right justified without the decimal. For example, if the sky-ground ratio is 3.27 enter 033 in columns 37-39.

(2) Sun Overhead (Columns 40-42). Enter the sky-ground ratio for an observer who has the sun overhead.

(3) Away From the Sun (Columns 43-45). Enter the sky-ground ratio for an observer looking away from the sun.

d. Minimum Front-to-Front Separation (Columns 47-51). Datum in this segment of the card defines the minimum front-to-front separation distance between units in ground combat. Enter the minimum front-to-front separation distance in meters. If no value is entered, a minimum front-to-front separation distance of 50 meters is assumed.

8. GROUND COMBAT DATA DECK STRUCTURE. This paragraph describes the data deck structure for constant data input used in the Ground Combat Model. The cards making up the deck and the order in which they must be read into the DIVWAG Model are discussed.

a. Ground Combat Constant Data Input Cards. These cards are listed in Figure IV-7-A-13. It may be recalled that each card format is initially prepared with the Blue forces attacking and the Red forces defending, followed by the Blue forces defending and the Red forces attacking. In the Blue defend and Red attack cards, only that information which changed from the previously entered information need be used. Thus, there are four sub-decks of the Ground Combat constant data input; in order of data processing entry, they are Blue attack, Red defend, Blue defend, and Red attack.

Card Type	Card Title	Card ID	Load Program Name
1	Transport Specifications	3901	GCMLD
2	Weapon System Specifications	3901	GCMLD
3	Sensor Specifications	3901	GCMLD
4	Target Priority and Vulnerability	3901	GCMLD
5	Line of Sight	3901	GCMLD
6	Horizon and Background	3901	GCMLD

Figure IV-7-A-13. Ground Combat Constant Data Card Input

b. Creating Ground Combat Constant Data File. The Ground Combat constant data file is created by reading in the data deck structure as shown in Figure IV-7-A-14. The input cards, the card type number, its identifier, and the name of the load program are listed in Figure IV-7-A-13.

(1) Structure of Ground Combat Overall Data Deck. The overall data deck of Ground Combat consists of four parts as illustrated in Figure IV-7-A-14 at the right hand side. Entered first is the data on Blue attack; then Red defend, Blue defend, and Red attack. Following Red attack is the 9 card, which indicates the end of file data for data file 39.

(a) Subdeck Structure. Each of the subdecks, such as shown at the right of Figure IV-7-A-14, is composed of card groupings as shown on the left of the figure. In each subdeck the first series of cards is the line of sight cards. They are followed by the horizon and background cards, and so on until the six sets of cards have been entered in each of the subdecks. The line of sight card, for example, is the first to be entered in any of the subdecks. The number 5 at the far left of this card deck is the card type number. The 3901 at the right of the line of sight card is the identification number, in which 39 is the file number and 01 is the card format. This same identification scheme is used throughout the subdeck structure.

(b) Grouping the Subdeck Cards. As the cards are punched and verified they are to be arranged in the subdecks but arranged by subdeck structure; thus, the last series of cards entered in a subdeck are those for target priority and vulnerability. All cards with the type number 5 in column 1 and the numbers 3901 punched in columns 73 to 76 would then be grouped together and would form the last section of each of the subdecks.

(2) Order of Subdecks. The subdecks of Ground Combat Model constant data input are ordered for entry as illustrated in Figure IV-7-A-14. The order in which the cards within each subdeck is arranged is the user's choice. The computer load program does not seek a fixed sequence of cards within the subdecks. It does, however, expect that the subdecks will be ordered as illustrated in Figure IV-7-A-14.

(3) Generation of Printouts. After the data decks are entered, a set of printouts is generated. These printouts are discussed in Appendix C to this chapter.

c. Updating the Ground Combat Model Constant Data Files. The Ground Combat Model constant data files may be updated prior to the start of game play. It is not recommended that the data base for the Ground Combat Model be changed after start of DIVWAG model operations.

(1) Errors, Omissions, or Deletions. The printouts from the input of constant data for the Ground Combat Model may indicate an error or need for insertion or deletion.

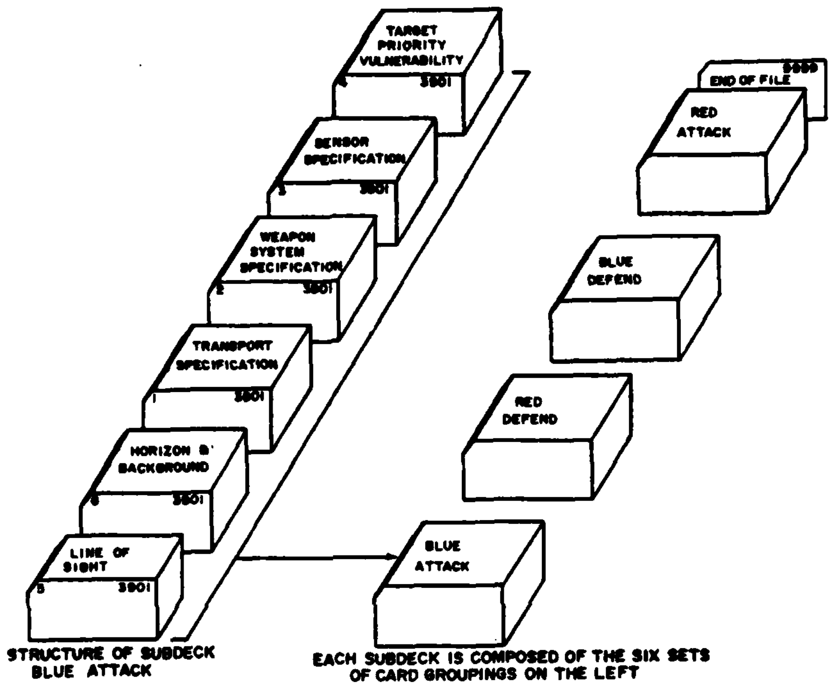


Figure IV-7-A-14. Ground Combat Data Deck Structure

(a) Error Correction. The card having the error should be identified and a new card punched with the correct data. The old card should then be removed from the deck and the new card inserted in its place.

(b) An Omission. An omission usually indicates that data have been left out and that new cards must be produced and read into data file 39. The data to be inserted are transcribed to punch card format, the data punched into cards, and the cards added to each of the subdecks as appropriate. The subdecks are then arranged in accordance with Figure IV-7-A-14 and resubmitted.

(c) Deletion of Data. The deletion of data is accomplished by the removal from the data deck of those cards whose information is no longer desired in data file 39. The data deck is again entered into the DIVWAG Model constant data base, and the files are recreated less that data on the cards which were removed.

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COUNTERMINE

APPENDIX A_1

1. INTRODUCTION. This appendix addresses the entry of data into the DIVWAG data base to allow the simulation of minefield encounters and the by-passing of Red or Blue forces involved in ground combat. Illustration of card formats, explanations of information to be entered in the various card columns, and other reference information are provided. The data entered in this segment of the ground combat data load are constant.

a. Data Requirements. The countermine constant data load plays a significant part in the delay and assessment of ground combat units within the DIVWAG Model. The constant data is entered only once into DIVWAG; thereafter, it is used specifically by the ground combat model (File 39).

b. Data Deck. Two complete decks are required if both Blue and Red forces are using countermine tactics. Data deck 1 will be the Blue force countermine data and data deck 2 will be the Red force countermine data (Chart 1).

2. INITIAL PREPARATION.

a. There are eight distinct card types required to complete the countermine data deck structure: 3901, Type 1 Explosive Type Breaching Options; 3901, Type 2 Mechanical Breaching; 3901, Type 3 Force-type Breaching (Bulling); 3901, Type 4 By-pass option; 3902, Type 5 Rank Order of Decision with Respect to Fire Conditions; 3903, Type 6 Implementation Times; 3904, Type 7 Decision Times; and 3905, Type 8 Encounter Vehicle.

b. It is important to recognize that the data required for the countermine load must be consistent with Red/Blue force doctrine and the game objectives. Before the necessary data can be entered on the appropriate card type a DECISION MATRIX must be developed to portray all the type of options available to a force and its order of preference, based on doctrine, in relation to a particular fire condition. An example of a type decision matrix is at Chart 2. Note the construction of the chart; the first portion of the matrix is condition. The condition segment has three subheadings: direct fire, which represents the amount and effectiveness of direct fire a unit is receiving; indirect fire, which is a simple indirect or no indirect fire; and the field type, which represents the type of possible mine kill. Note that the mine action is always considered a belly kill which is using the worst case possible. The second portion of the matrix is the order of choice of a particular option based on a particular fire condition. Note at the bottom of the matrix are example type options. It should be recognized that these are example options with their option mnemonic. With respect to the withdraw option (WD) a unit that is being simulated within the DIVWAG Model will always have this "default" option so that it does not get into a minefield, exhaust its mine clearing material, and then remain in the position until given a DSL order to withdraw. It is also realistic that a unit would withdraw if it could not accomplish the mission. The withdraw option need not be considered as an option. The model will automatically go to the WD option if all options are unavailable due to lack of equipment or expendables.

c. In conjunction with the preparation of a decision matrix, a work sheet must be prepared in advance to determine specifically, the items of equipment, quantities, and work rates. This information should be obtained from the most current and reliable sources. This may require a considerable amount of time and should be planned well in advance.

d. All numbers entered into the various columns will be right justified except where indicated. Further, column 1 in any card type is always entered the card type (number) and in column 2 is always B or R indicating a Blue force or Red force card.

3. DATA CARD FORMAT.

a. Explosive Type Breaching Options, 3901, Type 1 (Chart 3)

(1) This card type is used to describe a breach option in which the breaching unit clears lanes using explosive devices such as line charges, demolition blocks, or bangalore torpedoes. It could also be used to portray manual mine removal, although such an option would probably be considered impractical in most combat situations. Since most breaching techniques described with this type card are accomplished incrementally, the standard increment size is used to account for a unit's progress through a field. For example, in using a rocket propelled explosive, the unit would be expected to clear a field in increments equivalent to the length of the charge and this should be used as the standard increment. As a second example, in using bangalore torpedoes the unit would generally clear the field in a number of increments determined by the number of torpedoes that practically could be "linked," placed in the field and detonated at one time. The length of the field cleared by one such operation would then be used as the standard increment. Thus the standard increment is individual for each option based on considerations of the material and techniques of operation to be portrayed by that option.

(2) Columns 4-7 represent the designated four character mnemonic which is a particular breaching option. The four character mnemonic,

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in this case, would correspond to each of the explosive type options that have been indicated in the example decision matrix. Examples of these would be DBX5, DBX6, DBX7, HBX1, HBX2, HBX3 and HBX4.

(3) Column 9 represents the basic mode. The basic mode corresponds to the type of explosive breach. For a hasty breach option a 7 must be entered in this column. For a deliberate breach option a 6 must be entered in this column.

(4) Columns 11-13 represent the rate of progress, in minutes, per standard increment. The rate of progress is the time it takes to clear a standard increment distance.

(5) Columns 15-17 represent the item code of the consumable to be used. In most cases this would be the explosive. However, it could be expendable material other than explosives.

(6) Columns 19-22 represent the rate of consumption of the consumable per standard increment; in short, the amount of explosive used to clear one standard increment of a minefield.

(7) Columns 24-40 represent the same information required above, for each of the consumables required. If no additional consumables are required, these columns may be left blank (no zeros entered).

(8) Columns 42-44 represent the number of engineer troops required to breach one lane.

(9) Columns 46-48 represent the item code of the first vehicle required for a particular breach. For example, if a propelled charge is going to be used, the breach item code would probably be tank If the breach option is an explosive requiring engineers to emplace it, the item code would be a truck that would be used to carry the explosive.

(10) Columns 50-52 is the number of vehicles required per lane to be breached. This number could be in fractions of trucks.

(11) Columns 54-60 require the same information as columns 46-52, except that the data for the second vehicle, if required, is entered.

(12) Columns 62-64 represent the length of the standard increment, in meters. (Standard increment was previously explained.)

(13) Columns 66-68 represent the assumed depth of a minefield. The assumed depth is used if a unit has no previous intelligence of a particular field. This allows the unit to assess the units ability to support this option with material on hand (feasibility).

(14) Columns 70-71 represent the percent of mines missed. This data indicates the probability of mines not cleared from a minefield. If the percent missed is 5% the integer 05 is entered.

(15) In Columns 73-76 enter the card ID 3901.

b. Mechanical Type Breaching Option, 3901, Type 2 (Chart 4)

(1) This card type is used to describe a breach option in which the breaching unit clears lanes using mechanical devices such as the roller or plow.

(2) Columns 4-7 represent the option mnemonic for a type mechanical breach.

(3) Column 9 contains the basic mode (8) for a mechanical option (Plow, Roller).

(4) Column 11 represents the avoidance criteria. The avoidance criteria provides for the simulation of a tank crew exercising two choices, with and without an attempt to avoid mines which are discernible due to poor emplacement, ground signatures, air delivery, etc. The numeric value assigned is based on a minimum rate with avoidance and maximum rate without avoidance. Either a 1 or 0 is used - 1 being no avoidance and 0 being avoidance.

(5) Columns 13-15 represent the item code of the vehicle used to exercise the mechanical device. Usually this vehicle would be the tank.

(6) Columns 17-19 represent the number of personnel that would be killed if a belly kill occurred against the vehicle that was exercising the mechanical device. If the tank had a crew of 4, 3 personnel may be killed.

(7) Columns 21-23 is the item code of the mechanical device used, such as the roller or plow.

(8) Columns 25-27 represent the movement rate in meters per minute of the transport vehicle using the mechanical device. This rate would be consistent with the actual movement capability of the device.

(9) Columns 29-31 represent the item code of the second vehicle, if required. Normally, a mechanical device does not need a back up vehicle. However, this data allows a "second choice" for a mechanical device. If the unit does not have the first choice equipment the model will attempt to use second choice.

(10) Columns 33-35 represent the movement rate of the second vehicle.

(11) Columns 73-76 represent the card ID. In this column 3901 is entered.

c. Force Type Breach Option, 3901, Type 3 (Chart 5)

(1) This card represents the force type option or "bulling" technique. There are no mechanical or explosive type options listed on this card.

(2) Columns 4-7 represent the option mnemonic for a particular force option. This would normally be defined as a Hasty Force (HF1 is entered) or a Deliberate Force (DF1 is entered), a Hasty Force being a "bull" without regard for minefield signatures and the Deliberate Force for "bull" with regard to minefield signatures.

(3) Column 9 represents the basic mode. An 8 is entered in this column for the DF1 and HF1 option. This mode handles a movement through a minefield of a mechanized vehicle with no special devices for clearing a minefield.

(4) Column 11 represents the avoidance criteria for this option. For the Hasty Force the avoidance criteria would be 0 and for the Deliberate Force a one would be entered.

(5) Columns 13-15 represent the item code of the vehicle that will perform the "bull" action. Normally this would be the tank.

(6) Columns 17-19 represent the crew size of the vehicle that will perform the "bulling" action.

(7) Columns 25-27 represent the movement rate of the vehicle performing the forcing action. The rate will vary significantly as to whether the vehicle will be performing a HF or a DF, the HF being faster because of no delay in attempting to negotiate the minefield.

(8) Columns 73-76 represent the card ID; 3901 must be entered in these four columns.

d. By-Pass Option, 3901, Type 4 (Chart 6)

(1) The sole purpose of this card is to provide a "file" for the by-pass option. Model characteristics require such a file for each by-pass option even though the particular card may contain no other information than the option mnemonic.

(2) Columns 4-7 represent the option mnemonic for by-pass. Based on the zone of action and compaction factor which will be discussed with the next card, the by-pass options are listed on this card. The options will be listed as BP1, BP2, BP3, etc., left justified, depending on the number of by-pass options desired.

(3) Columns 73-76 represent the card type. 3901 is entered in these columns.

e. Rank Order of Decision With Respect to Fire Condition, 3902, Type 5 (Chart 7)

(1) This card should be considered the pivot point of the load. It brings the raw data (rates, equipment, characteristics) into cohesiveness. This card clearly establishes the rank order of decision with respect to various fire conditions.

(2) Columns 4-5 represent an example of particular fire conditions. It should be recognized that these are examples and can be changed to fit doctrine or game objectives. Further, it should be made clear that one card is required per condition, per choice. An example of the number of cards required can be found when a study of the decision matrix is made.

(a) 00 Condition: Represents No Direct Fire and No Indirect Fire. In this case a 0 is placed in column 4 and column 5. This particular condition simulates an encounter at the limits of GCM (3000 m) or under conditions where lack of line-of-sight precludes an exchange of fire. In this condition the unit first attempts to by-pass the minefield and is given a great deal of freedom of action in searching for and funneling through any gaps which might exist. Should this fail, it can use explosives in various combinations before being forced to use its limited assets (plow, roller, or a propelled charge).

(b) 01 Condition: Represents No Direct Fire, and Indirect Fire. This condition simulates an encounter outside the range or vision of direct fire weapons played in ground combat, but influenced by indirect fire. The unit is given the opportunity to by-pass the minefield but not with the same freedom of action as when no indirect fire was being received. If it cannot by-pass it must resort to the mechanical devices available since these require no exposure of personnel to the indirect fire. If these fail the unit can exercise its explosive options, using those which require the least exposure of personnel.

(c) 10 Condition: Represents Ineffective Direct Fire, and No Indirect Fire. This condition simulates an encounter within the range of the direct fire weapons played within the GCM but restricted by line-of-sight, visibility or extreme range. These same conditions affect the indirect fire.

(d) 11 Condition: Represents Ineffective Direct Fire, and Indirect Fire. This condition simulates an encounter similar with condition 10 with the exception that indirect fire is being received. This fire eliminated the use of options requiring exposure of personnel and necessitates both the expanded use of critical resources (propelled charge) and as in 10 condition above, the use of the "Bulling" options.

(e) 20 Condition: Represents Effective Direct Fire, and No Indirect Fire. This simulates an encounter well within the effective range of the enemy direct fire weapons system with few restrictions caused by line-of-sight or visibility but with no indirect fire. Only limited freedom of action with respect to "by-pass" is allowed and the range of options is considerably narrower than other conditions.

(f) 21 Condition: Represents Effective Direct Fire, and Indirect Fire. This simulates an encounter similar to 20 above with the additional pressure of indirect fire. Options are identical except that a "Deliberate Force" ("Bulling" with an attempt made to avoid mines) is eliminated.

(g) 30 Condition: Represents Devastating Direct Fire, and No Indirect Fire. This simulates an encounter under such conditions of range, line-of-sight and visibility that the maximum effect of the enemy direct fire weapons systems can be brought to bear but no indirect fire is encountered. Limited freedom of action with respect to "by-pass" is again allowed and the critical resources (propelled charge) and most vulnerable methods (Bulling) a.e quickly used.

(h) 31 Condition: Represents Devastating Direct Fire, Indirect Fire. This simulates an encounter similar to condition 30 above with the addition of indirect fire. Limited by-pass is allowed and the critical and vulnerable options are once again quickly used.

(3) Columns 7-8 contain the order of preference of each option, for each specific fire condition. A sequential list of numbers is entered, extending through every option. The order of preference would be obtained from the draft decision matrix.

(4) Columns 10-13 contain each option mnemonic corresponding to rank order of preference and each fire condition.

(5) Columns 15-18 contain the number of lanes desired for a battalion size force for each type option that requires lanes (a by-pass

does not need lanes). It should be made clear that the number of lanes is only for one choice under a particular fire condition.

(6) Columns 19-22 contain the number of lanes that are absolutely required for a battalion size force. This would be the minimum number of lanes required by a battalion for each particular option in conjunction with the fire condition.

(7) Columns 23-26 contain the number of lanes desired by a company. The same rationale used for a battalion applies.

(8) Columns 27-30 contain the number of lanes required by a company. The same rationale used for a battalion applies.

(9) Columns 31-34 contain the zone of action for a battalion. The zone of action (ZA) represents a single width of a unit from flank to flank. The various by-pass suboptions (1 thru 5 as an example) are expressed in terms of the number of zones of action left and right of the center of the leading edge of the unit that could be searched in order to find a way around a minefield. The search distance (ZA) will be entered in single digit numbers. An example (assumption: unit has a dimension of 2000 meters wide) of the zone of action would be if a unit was given a zone of action of two this means that from the center a unit can search a total of 4 Km (2 Km either side of the center of the unit).

(10) Columns 35-38 contain the maximum allowable compaction factor for a battalion. The compaction factor represents that width of a gap in an obstacle system to the left or right of the center of the leading edge of a unit which would allow N% of that unit (as dimensioned in width) to pass through. The factor must be less than 1. An example, .40 of a unit's front is unblocked, the unit will press the advance by funneling through the clear area. If more than .40 of the unit front is blocked, the unit will press the advance through the gap and also, breach the minefield. In short, the compaction factor represents a percent of the units front that can be compacted down to fit through a gap. If the by-pass opening is equal to or greater than the compaction factor the unit will pass.

(11) Columns 39-42 and 43-46 contain the zone of action and compaction factor for the company size element. NOTE: The compaction factor is represented by a percentage, i.e., 40% would be written .40 (right justified).

(12) Columns 73-76 contain the card ID which is a preprinted 3902.

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f. Implementation Times, 3903, Type 6 (Chart 8)

(1) The purpose of this card type is to provide for the time necessary to implement the use of a particular option. Implementation is defined as the time necessary to prepare an explosive or device to include movement, before execution. An example of this would be the time it takes an engineer squad to assemble explosives to be used for breaching.

(2) Columns 4-7 contain the option mnemonic. Each option mnemonic that will be used must be listed (left justified).

(3) Columns 9-11, 13-14, and 17-19 contain the implementation time in minutes (right justified) for a platoon, company, and battalion respectively for a particular option. There is one other option which must be entered on this card, if it is necessary to meet the objectives of a game. This option would be the Pure Delay (PDLA). This option is used when natural obstacles are being played. An example of this would be a river obstacle. An average delay time to cross this obstacle must be entered (right justified).

(4) Columns 73-76 contain the card ID. In these four columns enter 3903.

g. Decision Time, 3904, Type 7 (Chart 9)

(1) This card type represents the decision time necessary before implementation for each type fire condition listed in paragraph 3c(2) above. The decision times are generally based on gamer judgments.

(2) Columns 4-5, 11-12, 18-19, 25-26, 32-33, 39-40, 46-47, 53-54 will contain each of the eight fire conditions (example 00, 01 etc.).

(3) Columns 7-9, 14-16, 21-23, 28-30, 35-37, 42-44, 49-51, 56-58 will contain the decision time, in minutes, right justified.

(4) Columns 73-76 represent the card ID 3904.

h. Designated Encounter Vehicle, 3905, Type 8 (Chart 10)

(1) This card is used to identify the only vehicle that will make the initial encounter of a minefield.

(2) Columns 4-6 contain the item code of the encounter vehicle, right justified.

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(3) Columns 73-76 contain a preprinted 3905 to represent the card ID number.

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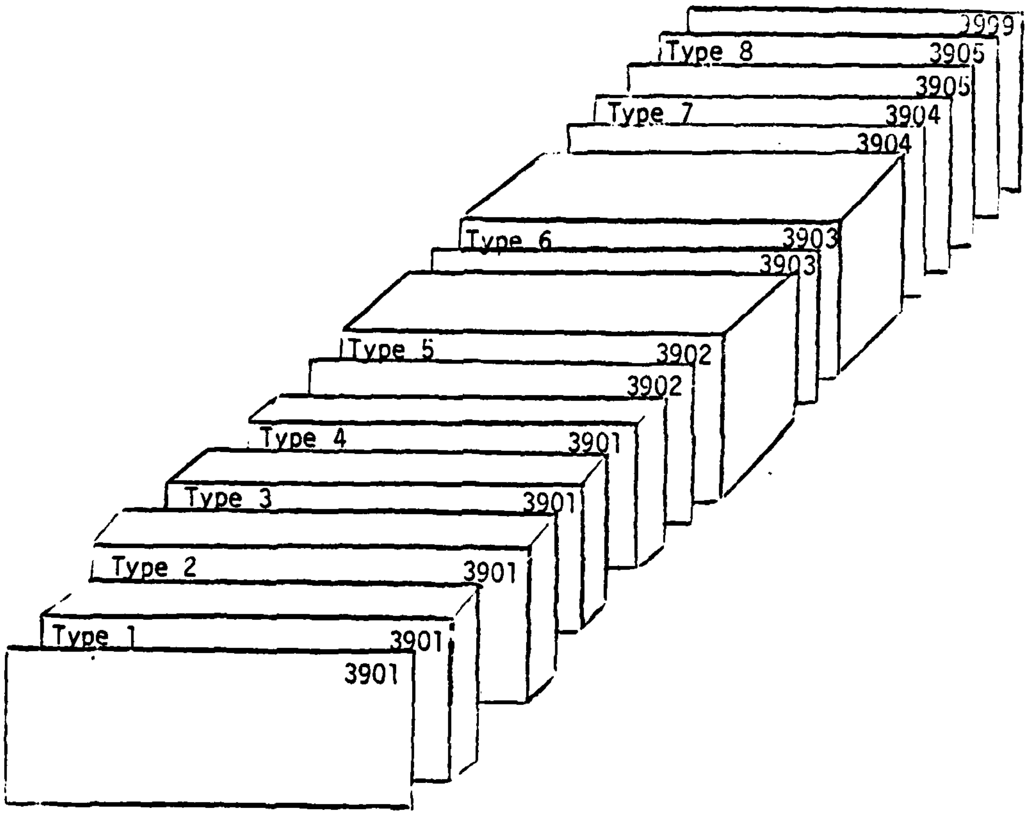
DATA DECK STRUCTURE

(EACH FORCE)



If both forces game countermine tactics each one would have a complete deck as shown above.

Chart 1

DRAFT DECISION MATRIX

CONDITION NO.	CONDITION			ORDER OF CHOICE									
	DIRECT FIRE	INDIRECT FIRE	FIELD TYPE	1	2	3	4	5	6	7	8	9	10
1	NDF	NIF	ASSUME WORST CASE: BELLY MINE OR MIX	BP1	BP2	BP3	DBX5	DBX8	HBM1	HBM2	HBX2	HBX1	HBX4
2	NDF	IF		BP4	BP5	HBM1	HBM2	HBX2	HBX1	HBX4	DF1	WD	
3	IDF	NIF		BP1	BP5	HBM1	HBM2	HBX2	HBX4	DF1	HF1	WD	
4	IDF	IF		BP1	BP5	HBM3	HBM4	HBX1	HBX3	DF1	HF1	WD	
5	EDF	NIF		BP1	HBM4	HBM3	HBX3	DF1	HF1	WD			
6	EDF	IF		BP1	HBM4	HBM3	HBX3	HF1	WD				
7	DDF	NIF		BP1	HBX3	HBM4	HBX3	HF1	WD				
8	DDF	IF		BP1	HBX3	HBM4	HBX3	HF1	WD				

NIF = NO INDIRECT FIRE
NDF = NO DIRECT FIRE
IDF = INEFFECTIVE DIRECT FIRE
IF = INDIRECT FIRE
EDF = EFFECTIVE DIRECT FIRE
DDF = DEVASTATING DIRECT FIRE

BP1,2,3,4,&5 = BY-PASS
DBX5,6,&7 = DELIBERATE BREACH USING ENGINEERS & EXPLOSIVES
HF1 = HASTY FORCE (WITHOUT DETECTION)
HBM1&3 = HASTY BREACH MECHANICAL (PLOW)
HBM2&4 = HASTY BREACH MECHANICAL (ROLLER)
HBX1&2 = HASTY BREACH EXPLOSIVE (BANGALORE TORPEDO)
HBX3&4 = HASTY BREACH EXPLOSIVE (PROPELLED CHARGE)
DF1 = DELIBERATE FORCE (BULL WITH DETECTION)
WD = WITHDRAW

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Chart 2

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EXPLOSIVE TYPE BREACHING OPTIONS

Card Type	R or B	Option Mnemonic (Left Justified)	Basic Mode	Rate of Progress in minutes per standard increment	Consumable # 1 (Item Code)	Rate of Consumption per standard increment	Consumable # 2 (Item Code)	Rate of Consumption per standard increment	Consumable # 3 (Item Code)	Rate of Consumption per standard increment	No. of Engineer Troops Required Per Lane	Item Code of First Vehicle Required	Number of Vehicles per lane required	Item Code of Second Vehicle Required	Number of Vehicles per lane required	Length of Standard Increment in meters	Assumed Depth of Minefield	Percent of Mines Missed	Card ID	Card Sequence No.
1																			3901	
1																			3901	
1																			3901	
1																			3901	

Chart 3

MECHANICAL TYPE BREACHING OPTIONS

Card Type	R or B	Option	Mnemonic (Left Justified)	Basic Mode	Avoidance Criteria	Tank Item Code	Number of crew lost due to belly kill mine	Item Code of Breach Item No. 1	Movement Rate in Meters per Minute	Item Code of Breach Item No. 2	Movement Rate In Meters per Minute	BLANK	Card ID	Card Sequence No.
2													3901	
2													3901	
2												BLANK	3901	
2													3901	

Chart 4

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FORCE TYPE BREACH OPTION

Card Type	R or B	Option Mnemonic (Left Justified)	Basic Mode	Avoidance Criteria	Item Code of Vehicle	Crew Size	BLANK	Movement Rate in Meters per Minute	BLANK	Card ID	Card Sequence No.
3										3901	
3										3901	
3										3901	
3										3901	
3										3901	
3										3901	
3										3901	
3											
3											
3											
3											

Chart 5

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BY-PASS OPTION

Card Type	R or B	Option Mnemonic (Left Justified)	Basic Mode	BLANK	Card ID	Card Sequence No.
4					3901	
4					3901	
4					3901	
4					3901	
4					3901	
4					3901	
4					3901	
4					3901	
4						

Chart 6

RANK ORDER OF DECISION W/RESPECT TO FIRE CONDITIONS

							LANE OPTIONS			BY-PASS OPTIONS						
Card Type	R or B	Direct Fire Code	Indirect Fire Code	Order of Preference	Option Mnemonic (Left Justified)	No. of Lanes Desired Bn	No. of Lanes Required Bn	No. of Lanes Desired Co	No. of Lanes Required Co	Zone of Action width Bn	Maximum Allowable Compaction Bn	Zone of Action width Co	Maximum Allowable Compaction Bn	BLANK	Card ID	Card Sequence No.
5															3902	
5															3902	
5															3902	
5															3902	
5															3902	
5															3902	
5															3902	
5															3902	

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Chart 7

IMPLEMENTATION TIME

Card Type	R or B	Option Mnemonic (Left Justified)	Time in Minutes To Implement the Desired Option: PLT	CO	BN	BLANK	Card ID	Card Sequence No.
6							3903	
6							3903	
6							3903	
6							3903	
6							3903	

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Chart 8

DECISION TIME

Enter the condition code number (defined in Columns 4-5 on Card Type 5) and the associated decision time (in minutes) for each condition.

Card Type R or B	Cond 1	Time	Cond 2	Time	Cond 3	Time	Cond 4	Time	Cond 5	Time	Cond 6	Time	Cond 7	Time	Cond 8	Time		Card ID	Card Sequence No.
7																		3904	
7																		3904	
7																		3904	
7																		3904	
7																		3904	
7																		3904	

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Chart 9

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DESIGNATED ENCOUNTER VEHICLE

Field
Card Type
R or B
Encounter Vehicle Item Code (Right Justified)
Card ID
Card Sequence No.

Chart 10

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APPENDIX A2

MINE DESCRIPTIVE DATA

1. INTRODUCTION. The representation of minefields within the Ground Combat Model requires parametric description of the individual mines being used. These data, loaded on the DIVWAG Data File 33, describe each mine both in terms of selected physical characteristics of the mine itself and in terms of the mine's effectiveness against encountering materiel.

2. PRELIMINARY DECISIONS. Prior to actual data preparation, some consideration should be given to the degree of specificity with which mine warfare must be portrayed in the gaming application at hand and the model's capability to discriminate meaningfully among different characteristics. For example, it is possible to define up to 20 distinctly different mines for each force within the data base. For most applications, however, it would be sufficient to define a limited number of "type" mines as representative of the diversity of hardware that could be used. Thus, an early decision on the mine or type mines to be used and the materiel that will be affected by these mines can reduce the complexity of the data collection problem.

3. DISCRETE MINE CHARACTERISTICS (CARD FORM 3301). Essential characteristics of each type mine to be played are coded on data form 3301. Up to 20 type mines may be defined for each force, and the data for each type mine and entered on one card form 3301.

a. Card Type (Column 1). The integer 1 should be entered in column 1 of Form 3301.

b. Force Indicator (Column 2). The letter B should be entered in column 2 of a card describing a Blue mine. R is to be entered for Red mines.

c. Mine Index (Columns 3-4). Each type mine being described for a force is identified by a unique mine index, an integer within the range 1-20. Enter the mine index for the mine being defined in columns 3 and 4.

d. Mine Type (Column 6). A mine type categorization, an integer code, is to be entered in column 6. Legal mine codes are:

1 = scatterable, antimateriel mines

2 = scatterable, antipersonnel mines

3 = conventional, antimateriel mines

4 = conventional, antipersonnel mines

It should be noted that, in the current version of the model, effects of antipersonnel mines are not portrayed.

e. Fuze Type (Columns 7-8). Mine fuzing is identified by an integer code, to be entered in columns 7-8 of Form 3301. The basic fuzing codes are:

1 = pressure

2 = influence/tiltrod

3 = pressure and influence/tiltrod

4 = tripwire

5 = long impulse

If the mine is also equipped with an antihandling device, add 10 to the fuzing code. For example, the fuzing code for a pressure fuzed mine with antihandling device would be 11. (The current version of the model does not treat tripwire fuzing.)

f. Item Code (Columns 11-13). Enter the equipment item code, an integer in the range 1-200, of the mine. Scatterable mines delivered by artillery are considered to be submunitions of the basic artillery round and, as such, a unique item code is not used for such mines. In this case no entry is to be made in columns 11-13.

g. Arming Time (Columns 16-20). If this is a scatterable mine with which a delay between mine placement and arming is associated, enter this arming delay to the nearest integer number of minutes. Otherwise, make no entry.

h. Self-Destruct Time (Columns 21-25). If this mine is designed to self-destruct, or otherwise become inactive, enter the time after arming at which self-destruct will occur. The entry should be a right justified integer number of minutes. If the mine has no self-destruct capability, make no entry.

i. Dud Probability (Columns 27-29). For the purpose of this model, dud probability is defined as the probability a mine will fail to detonate given that the necessary physical conditions for detonation have occurred. For example, with a simple pressure fuzed mine, enter

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probability the mine will fail to detonate given that a vehicle with sufficient ground pressure to cause detonation in normal circumstances has passed over the pressure plate. The entry should be made as a decimal fraction with the decimal point assumed in column 26. Thus, for example, a probability of .0 should be entered as 100 with the integer 1 in column 27.

j. Detection Probabilities (Columns 31-37). As detection probabilities enter the probability that a vehicle crew, in traversing an area where mines are known to be present, will be able both to see and to successfully avoid a single mine. Probabilities are required for both day and night conditions. The entries are to be made as three-digit decimal fractions, with the daytime probability in columns 31-33 (an assumed decimal point in column 30) and nighttime probability in columns 35-37 (an assumed decimal point in column 34).

k. Card Form Number (Columns 73-76). Enter the card form number 3301 in columns 73-76 of the coding sheet or punch card.

4. VEHICLE DIMENSIONS (CARD FORM 3303). The basic minefield-oriented dimensions of ground vehicles and ground mine clearing devices are to be entered on card form 3303. For vehicles, required data are track/wheel width and belly width. Track/wheel width should be the width of the path swept out by one track of a tracked vehicle or by the wheels on one side of a wheeled vehicle. Belly width should be the vehicle width inside the tracks or wheels. (Thus, belly width plus twice track width would be overall vehicle width between outer track wheel edges.) For a mine clearing device, desired data are the protected widths of the track/wheel or belly of the most typical using vehicle. For example, consider a type plow set which is composed of a plow in front of each track of the using vehicle. Suppose the most typical using vehicle is a tank with 50 cm track width and 200 cm belly width. Suppose, further, that each plow is 80 cm wide and is typically mounted to clear a path 10 cm beyond the outer edge of the track. Then each plow would protect the entire track width (50 cm) and additionally 20 cm of the vehicle's belly inside the tracks. The proper entries for such a plow set would be 50 cm track width and 40 cm (20 cm on each side) belly width. Instructions for filling out the data card follow:

(1) Card Type (Column 1). Enter the integer 1 in column 1.

(2) Force Indicator (Column 2). In column 2 enter the letter B if describing dimensions of Blue force vehicles and R if describing Red force vehicles.

(3) First Vehicle Entry (Columns 4-12). For each vehicle described, three data entries are required; the equipment item code of the materiel, track width (centimeters) of one track, and belly width (centimeters). All entries should be right justified integers with the item code in columns 4-6, track width in columns 7-9, and belly width in columns 10-12.

(4) Additional Vehicles. Each card form 3303 allows the definition of up to seven vehicles. Data for additional vehicles, entered as right justified integers, are entered as follows:

Vehicle	Item Code Columns	Track Width Columns	Belly Width Columns
2d	14-16	17-19	20-22
3d	24-26	27-29	30-32
4th	34-36	37-39	40-42
5th	44-46	47-49	50-52
6th	54-56	57-59	60-62
7th	64-66	67-69	70-72

(5) Card Form Number (Columns 73-76). Enter the card form number, 3303, in columns 73-76 of the coding form or punch card.

(6) Additional Cards. The data loading logic allows use of two cards form 3303 per force. Thus, with the data for seven items on each card, up to fourteen items may be defined per force.

5. VEHICLE VULNERABILITY (CARD FORM 3302). Data for the vulnerability of the vehicles identified on card form 3303 is required for each mine identified on card form 3301. Data are desired for vehicle vulnerability to both enemy and friendly mines; thus, four sets of cards form 3302 are to be used: Blue vehicle vulnerability to Blue mines, Blue vehicle vulnerability to Red mines, Red vehicle vulnerability to Blue mines, Red vehicle vulnerability to Red mines. For each vehicle/mine combination the required data are: P_K track - probability the vehicle will be disabled given a mine detonation at the track; P_K belly - probability the vehicle will be disabled given a detonation at the belly. One card form type 3302 allows for the provision of data for up to five vehicles of a given force against one type mine of either force. The coding format is as follows:

a. Card Interaction Code (Column 1). This code identifies the mines/vehicle force combination. Enter the appropriate integer code for:

Code	Mine force	Vehicle force
1	Blue	Red
2	Blue	Blue
3	Red	Red
4	Red	Blue

b. Mine Force Identifier (Column 2). Enter the letter B is this card contains vulnerability to Blue mines, R for vulnerability to Red mines.

c. Mine Index (Columns 3-4). Enter the mine index (an integer in the range 1-20) associated with the mine whose lethality is described on this card. The index for each type mine should have been established with card form 3301.

d. Vehicle Force Identification (Columns 5-8). If vulnerability of Blue vehicles is contained on this card enter BLUE in columns 5-8. For Red vehicles, leave column 5 blank and enter RED in columns 6-8.

e. Vulnerability, First Vehicle (Columns 12-20). For each vehicle described, the following entries are required: equipment item code of the vehicle, P_K track, and P_K belly. The item code is an integer in the range 1-201, to be entered for the first vehicle on a card in columns 12-14, right justified. P_K is to be entered as three-place decimals with the decimal point assumed to be at the left of the entry. Thus, for example, a P_K = .5 should be entered in its three-digit field as 500. (If P_K = 1 is desired, the entry 1.0 may be used.) For the first vehicle, data for P_K track should be in columns 15-17 and P_K belly in columns 18-20.

f. Vulnerability, Additional Vehicles. The vulnerability of up to five vehicles may be loaded on one data card. Proper locations for the data entries are:

Vehicle	Item Code Column	P_K track Column	P_K belly Column
2d	24-26	27-29	30-32

3d	36-38	39-41	42-44
4th	48-50	51-53	54-56
5th	60-62	63-65	66-68

g. Card Form Code (Columns 73-76). The card form number, 3302, must be entered in columns 73-76.

h. Additional Cards. For each type mine, the vulnerability of up to 10 vehicles on each force may be defined. Thus, for a given mine/vehicle force combination and a given mine index, two cards form 3302 may be provided.

6. MINE CLEARING EQUIPMENT VULNERABILITY (CARD FORM 3304). Vulnerability of mechanical clearing devices, such as plows or rollers, to individual mines are defined on card form 3304. Vulnerability for these devices is defined in terms of two probabilities: P_{SAFE} = probability that, if a given mine is encountered by the device, the effects of the mine are negated with no severe damage to the countering device; P_{LOSS} = probability that, if a given mine is encountered by the device, the mine causes such damage to the device that the device is no longer usable. As was the case with encountering vehicles, vulnerability of these devices to both enemy and friendly mines are desired.

a. Coding Instructions. Format of the 3304 form is identical to that of the card form 3302 with the following exceptions:

(1) Each card form 3304 contains data for the vulnerability of up to five items of equipment to one mine. Rather than P_K track, used for vehicles, P_{SAFE} should be entered for each device. Rather than P_K belly for vehicles, P_{LOSS} should be entered for each device.

(2) The card form number 3304 should be used in columns 73-76 for these cards.

b. Number of Cards. For each type mine, the vulnerability of up to five clearing items on each force may be loaded. Thus, for a given mine/vehicle force combination and mine index, only one card form 3304 is allowed.

7. DECK STRUCTURE. For proper functioning of the data loading logic, the input data deck should be structured as follows:

a. Form 3301 header card. This card should have 3301 in columns 73-76.

b. Form 3301 subdeck. All data cards form 3301 should be in this subdeck. Cards describing Blue mines should appear first followed by cards describing Red mines.

c. Form 3302 type 1 header card. This card should have 1 in column 1 and 3302 in columns 73-76.

d. Form 3302 type 1 subdeck. All data cards form 3302, type 1 (vulnerability of Red vehicles to Blue mines) should be in this subdeck.

e. Form 3302 type 2 header card. This card should have 2 in column 1, 3302 in columns 73-76.

f. Form 3302 type 2 subdeck. All data cards form 3302, type 2 (vulnerability of Blue vehicles to Blue mines) should be in this subdeck.

g. Form 3302 type 3 header card. This card should have 3 in column 1 and 3302 in columns 73-76.

h. Form 3302 type 3 subdeck. This subdeck is composed of all cards form 3302, type 3 (vulnerability of Red vehicles to Red mines).

i. Form 3302 type 4 header card. This card should have 4 in column 1 and 3302 in columns 73-76.

j. Form 3302 type 4 subdeck. This subdeck is composed of all cards 3302 type 4 (vulnerability of Blue vehicles to Red mines).

k. Form 3303 header card. This card should have 3303 in columns 73-76. Column 1 must be empty.

l. Form 3303 subdeck. This subdeck should contain all form 3303 cards.

m. Form 3304 header cards and subdecks. The form 3304 cards are similar to form 3302 cards, with up to four type cards. The card type is denoted by 1, 2, 3, or 4 in column 1; and header cards should have the type number as well as form number 3304 in columns 73-76. Structure should be similar to 3302 cards; i.e., form 3304 type 1 header and subdeck, form 3304 type 2 header and subdeck, form 3304 type 3 header and subdeck, and form 3304 type 4 header and subdeck.

n. The final card should be an end-of-data card. This card should have 9999 punched in columns 73-76.

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(Pages B-1 to B-330)

APPENDIX B

GROUND COMBAT MODEL PROGRAM DESCRIPTIONS

1. INTRODUCTION. The Ground Combat Model overlay (overlay II) is composed of a driver and ten segments. The segment structure, identifying the routines within each segment and the general purpose of each segment, is shown in Figure IV-7-B-1; the routines are described in this appendix.

Segment	Routines	Purpose
11.0	GCDVR, GCINIT, MODE1, MOD2, INRPT, DLOOP, CALOVR, MODE48, MODE9	GCM model driver
11.1	EXEC1, GONOGO, RANGER, WPNSET, VISSET, STRBAR, MODSET, DNUMBR	Geometry, environment
11.2	GCFIRE, GCKILL, GCKLL1, GCDET, GPKILL	Firepower
11.3	GBKEEP, MURFAC, GLEG	Assessment
11.4	EXEC4	GCM history
11.5	GCOBS, OBFIL, ISCAN, RCHECK, SET30, GRNG, FRACS, BPCHK	Barrier searching
11.6	EXEC6, CONGET, DSCVR, FESCUM, BPFES, ETRPS, PASS, CONSM, MJITM, SET6, LANES, DLA	Barrier reaction feasibility
11.7	EXEC7, ETRIAL, LOSTIT, FLD1, FLD2, FLD3, FLD4, VSET, TROUBL	"In minefield" calculation
11.8	EXEC8, STALL, STOPIT, FRSTRT, PSTHRU, BYPAS, WDRAW, DBRCH, NOWHAT	Barrier reaction implementation
11.9	GC9CON, USFUP, MORT, MOVDEF, OUTSET	DIVWAG interface
111.10	GEND, TRMCK	GCM termination

Figure IV-7-B-1

2. ROUTINE GCDVR

a. Purpose. GCDVR is the driving routine of the Ground Combat overlay and calls the processing segments.

b. Input Variables:

Name	Source	Contents
TCLOCK	ONE	Time since start of period.
LGTPER	ONE	Length of the period.
MODE	TWO	Ground Combat mode identification number, located at IDUM (4099).
IGO	TWO	Termination condition flag, located at IDUM (4101).
INRUPT	TWO	Interrupted actions flag, located at IDUM (4100).
ITBL (16, 4)	TWO	GCM control table, located at IDUM (4035).
IDXBAT	TWO	Record number of file 21 for ITBL, located at IDUM (4034).

c. Output Variables:

Name	Destination	Contents
MODE	TWO	Ground Combat mode identification number, located at IDUM (4099).
IGO	TWO	Termination condition flag, located at IDUM (4101).
IOVLY	TWO	GCM secondary overlay identification number, located at IDUM (4102).
ITBL (16, 4)	DF21	GCM control table, located at IDUM (4035).

d. Logical Flow (Figure IV-7-B-2).

(1) Block 1. Call routine GCINIT to set up GCM constant data, GCM control table, and to return mode of pending unit.

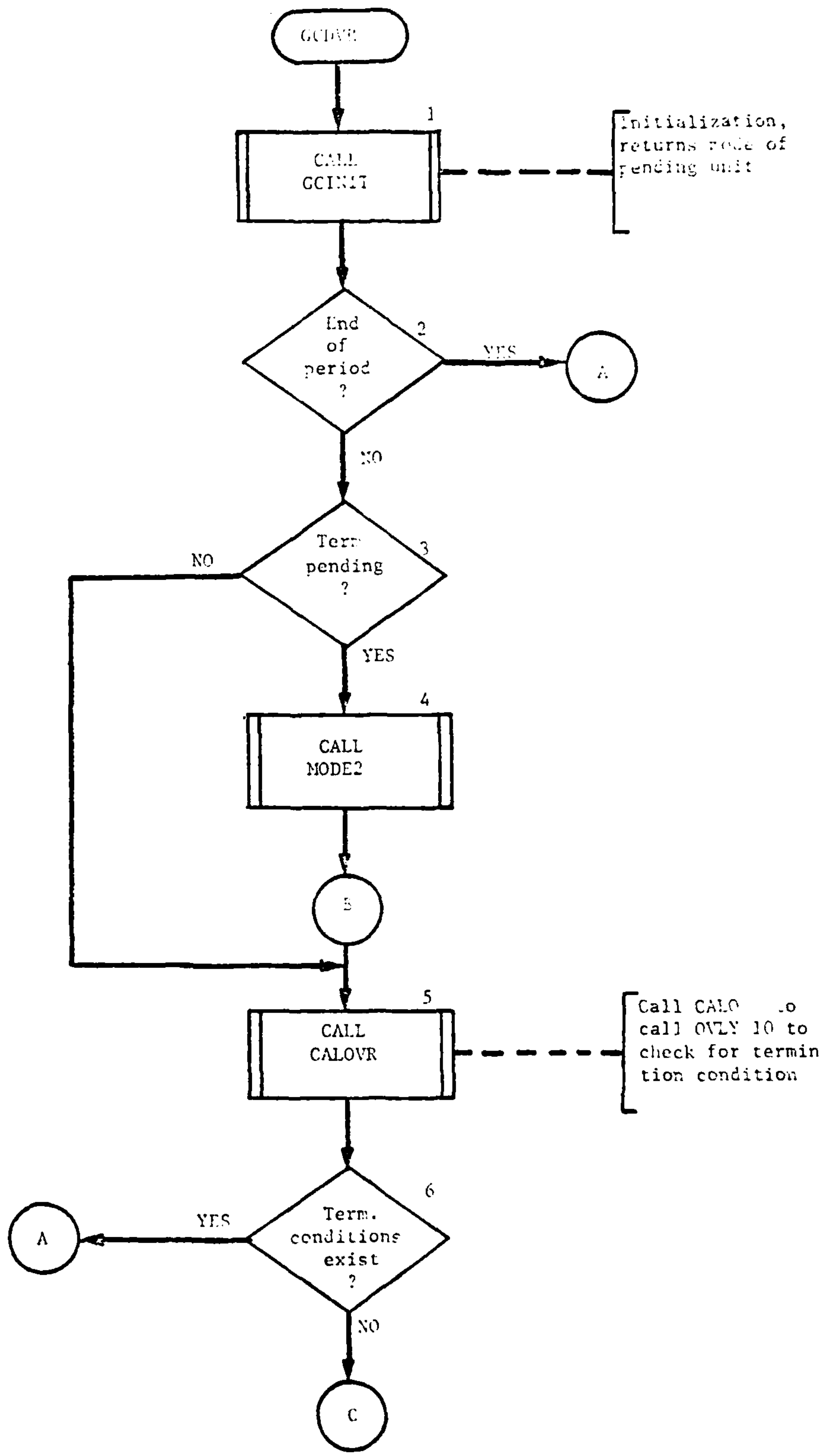

Figure IV-7-B-2. Routine GCDVR.

AD-A112 652 ARMY COMBINED ARMS COMBAT DEVELOPMENTS ACTIVITY FORT--ETC F/G 15/7
DIVWAG MODEL DOCUMENTATION. VOLUME II. PROGRAMMER/ANALYST MANUA--ETC(U)
JUL 76
UNCLASSIFIED CACDA-TR-8-76-VOL-2-PT-3 NL

3 OF 7
AD
A112652

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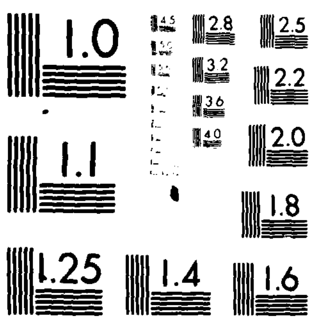
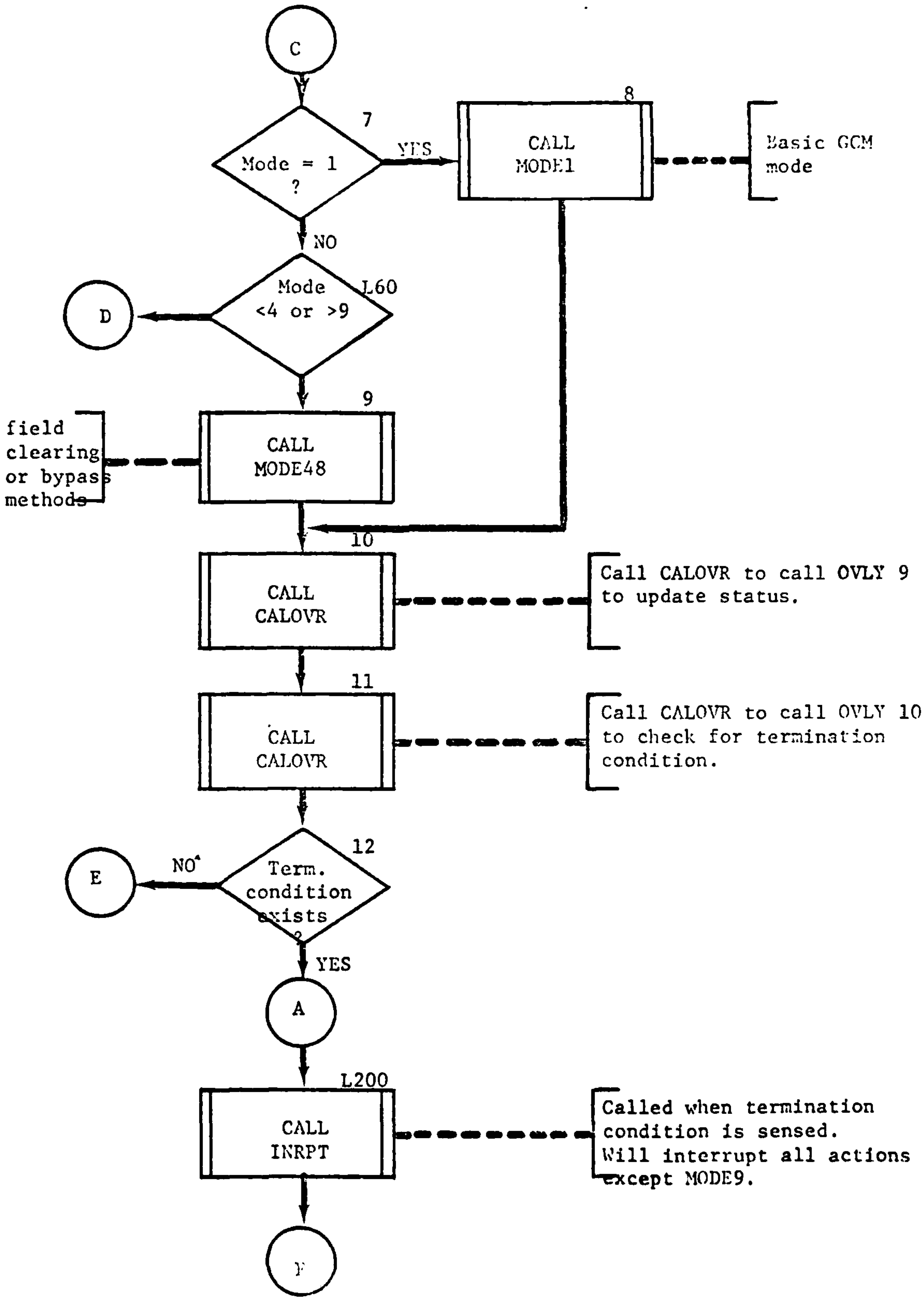
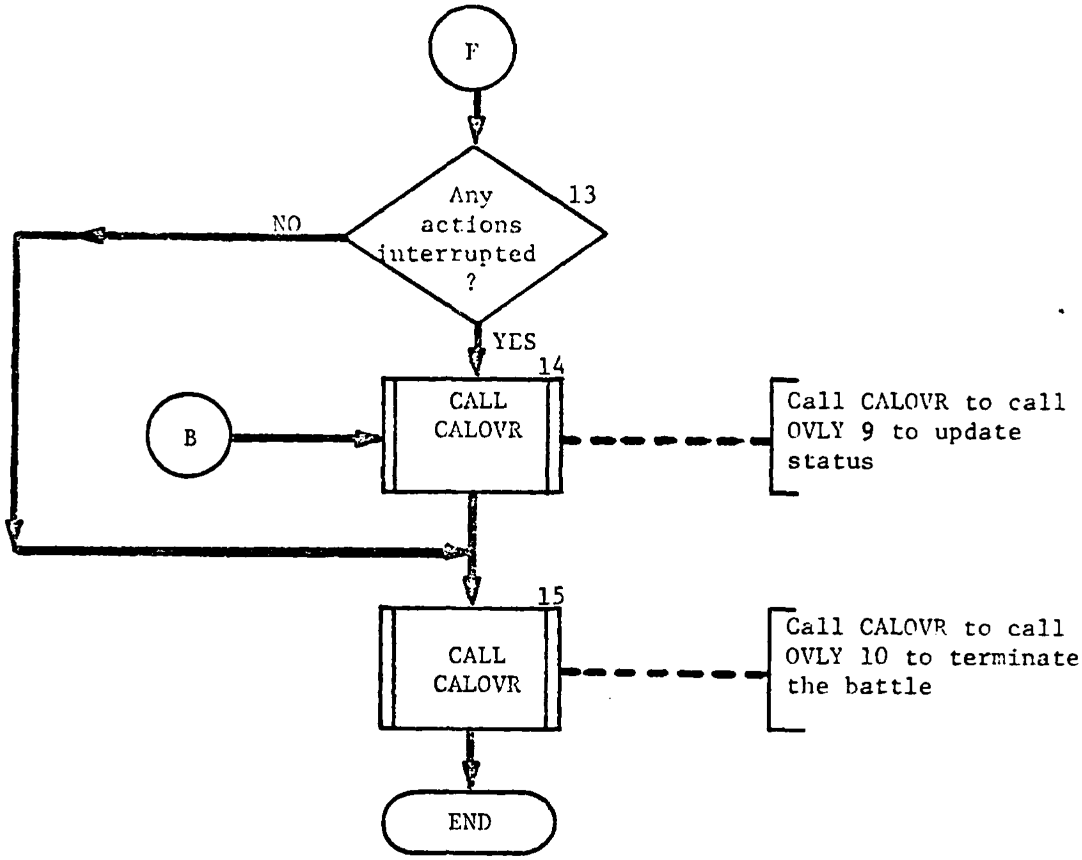
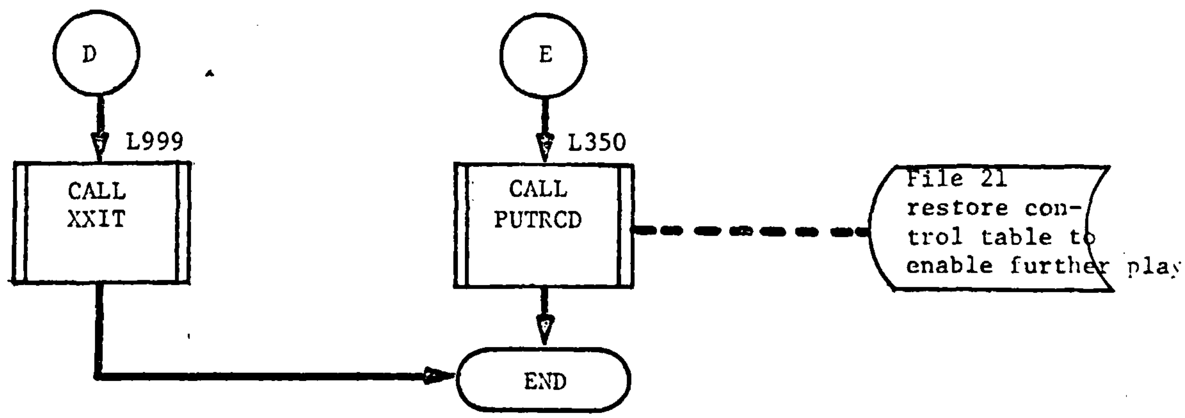


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A



C
7
Mode = 1 ?
YES
8
CALL MODE1
Basic GCM mode
NO
Mode <4 or >9
L60
D
9
CALL MODE48
field clearing or bypass methods
10
CALL CALOVR
Call CALOVR to call OVLY 9 to update status.
11
CALL CALOVR
Call CALOVR to call OVLY 10 to check for termination condition.
12
Term. condition exists ?
NO
E
YES
A
L200
CALL INRPT
Called when termination condition is sensed. Will interrupt all actions except MODE9.
F


F
Any actions interrupted ?
13
NO
YES
14
CALL CALOVR
B
Call CALOVR to call OVLY 9 to update status
15
CALL CALOVR
Call CALOVR to call OVLY 10 to terminate the battle
END


D
L999
CALL XXIT
E
L350
CALL PUTRCD
File 21 restore control table to enable further play
END

(2) Block 2. Compare the length of time since the start of period to determine if the period should be terminated. If yes, go to block L200.

(3) Block 3. Is there a termination pending (MODE=2)? If not, go to block 5.

(4) Block 4. Call routine MODE2 when termination is pending and then go to block 14.

(5) Block 5. Call routine CALOVR with IOVLY=10 to check for termination condition.

(6) Block 6. If a termination condition is sensed (IGO=1), go to block L200.

(7) Block 7. If not under basic GCM mode (MODE=1), go to block L60.

(8) Block 8. Call routine MODE1 (basic GCM mode), then go to block 10.

(9) Block L60. If not under GCM modes 4 through 9 (field clearing or bypass methods), go to block 999 (error condition exists).

(10) Block 9. Call routine MODE48 (field clearing or bypass methods).

(11) Block 10. Call routine CALOVR with IOVLY=9 to update status.

(12) Block 11. Call routine CALOVR with IOVLY=10 to check for termination condition.

(13) Block 12. If a termination condition does not exist (IGO=0), go to block L350.

(14) Block L200. Call routine INRPT to interrupt all ongoing actions except MODE=9.

(15) Block 13. If no ongoing actions were interrupted (INRUPT=2), go to block 15.

(16) Block 14. Call routine CALOVR with IOVLY=0 to update status.

(17) Block 15. Call routine CALOVR with IGO=1 to terminate the battle.

(18) Block L999. Call routine XXIT (error condition exists).

(19) Block L350. Call routine PUTRCD to restore GCM control table to enable further play.

3. ROUTINE GCINIT.

a. Purpose. GCINIT sets up the GCM constant data and determines the mode of combat.

b. Input Variables:

Name	Source	Contents
IUID	ONE	IUID of attacking unit.
BATID (2)	ONE	Battle ID.
NAMES (46)	DF21	Battle Name Table.
ITBL (16, 4)	DF21	GCM Control Table.
IDUM (4000)	DF39	GCM constant data.

c. Output Variables:

Name	Destination	Contents
IOUT (256)	DF21	GCM history records.
VATTV (8)	TWO	Attacker's weapon system transport velocities.
ITMAT (8)	TWO	Attacker's weapon system transport item codes.

d. Logical Flow (Figure IV-7-B-3).

(1) Block 1. Zero out IOUT array and the last 102 words of IDUM.

(2) Block 2. Get the Battle Name Table from DF21.

(3) Block 3. Using the Battle ID, locate its position on the Battle Name Table.

(4) Block 4. If the Battle ID was found on the Battle Name Table, go to block 6.

(5) Block 5. Call routine XXIT.

(6) Block 6. Get the GCM Control Table from DF21.

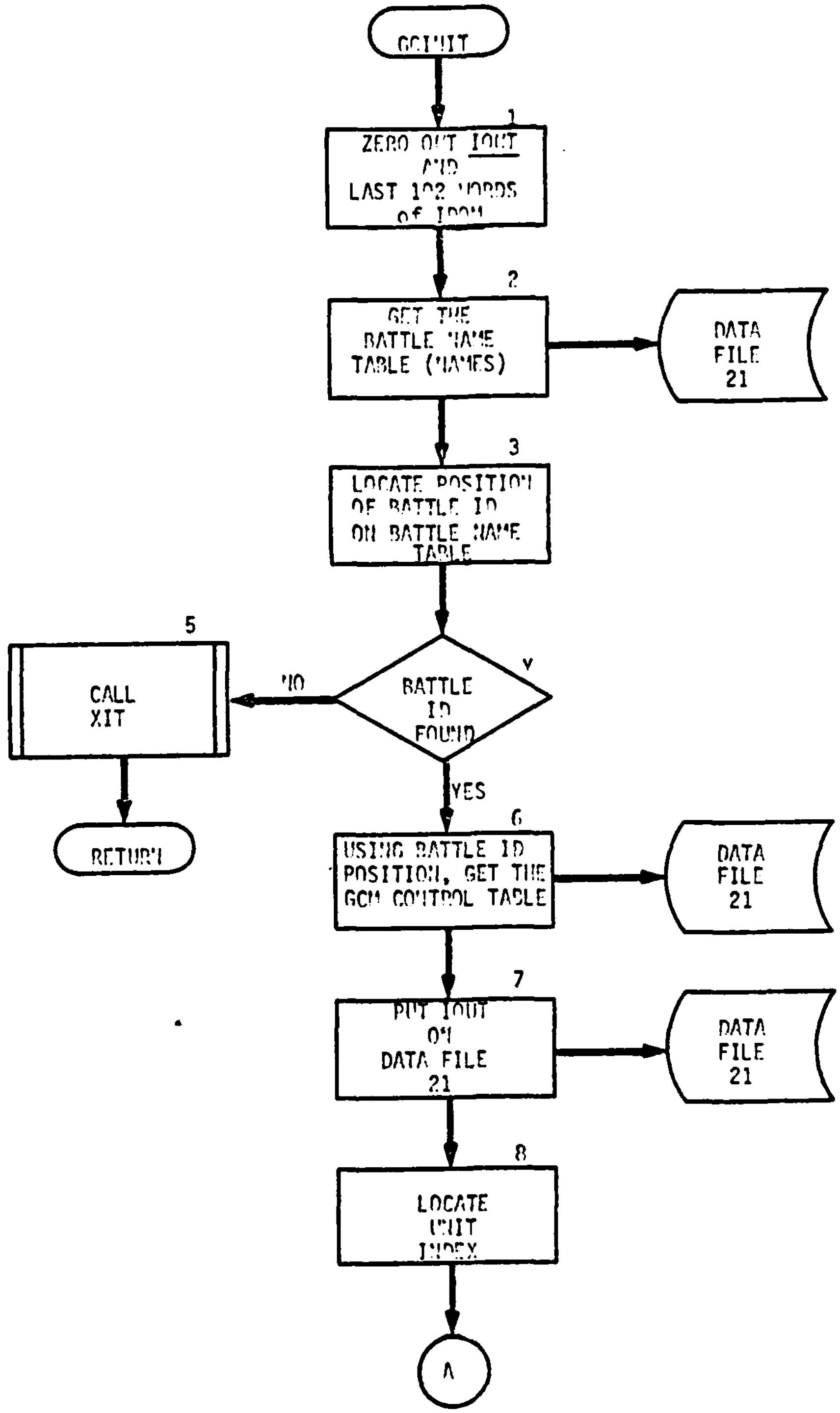
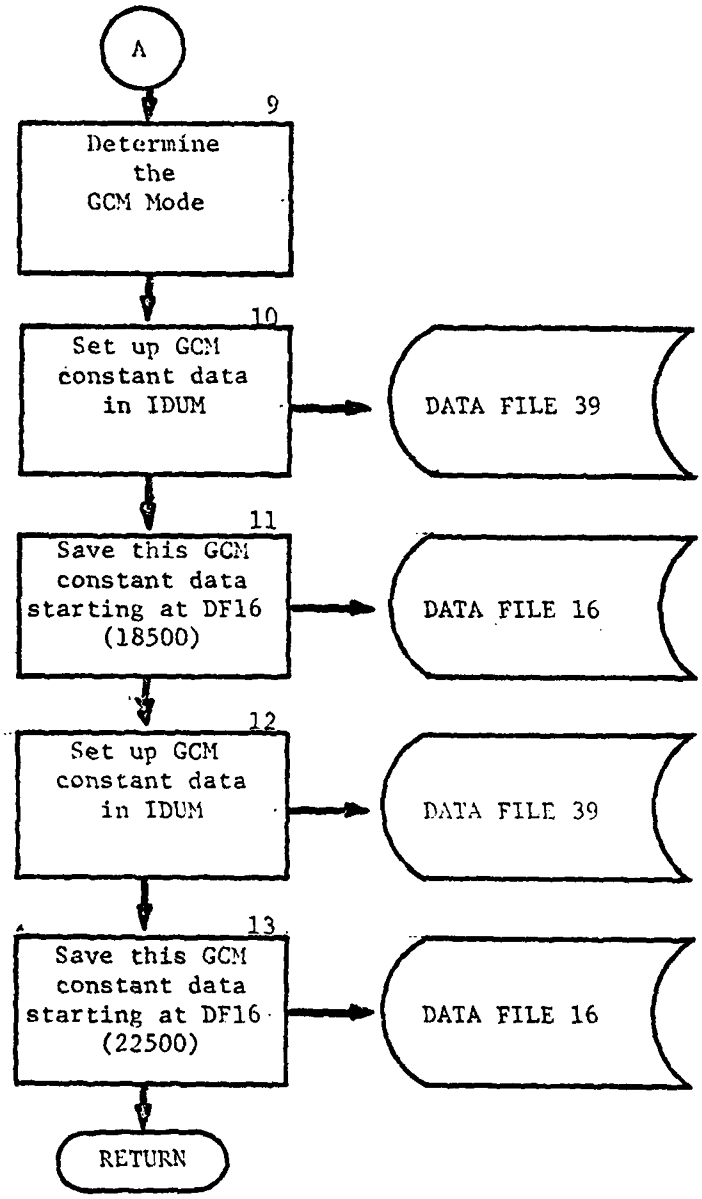


FIGURE IV-7-B-3 ROUTINE GCINIT


A
9
Determine the GCM Mode
10
Set up GCM constant data in IDUM
DATA FILE 39
11
Save this GCM constant data starting at DF16 (18500)
DATA FILE 16
12
Set up GCM constant data in IDUM
DATA FILE 39
13
Save this GCM constant data starting at DF16 (22500)
DATA FILE 16
RETURN

(7) Block 7. Put IOUT array on Data File 21.

(8) Block 8. Locate the unit index.

(9) Block 9. Determine GCM mode.

(10) Block 10. Get 4000 words of GCM constant data from DF39 and place in IDUM.

(11) Block 11. Put these 4000 words of GCM constant data on DF16 (18500).

(12) Block 12. Get 4000 more words of GCM constant data from DF39 and place in IDUM.

(13) Block 13. Put these 4000 words of GCM constant data on DF16 (22500).

4. ROUTINE MODE1.

a. Purpose. MODE1 is the driving routine of Ground Combat when MODE=1 which is the basic mode of Ground Combat.

b. Input Variables:

Name	Source	Contents
TCLOCK	ONE	Time since start of period.
LGTPER	ONE	Length of period.
MODE	TWO	Ground Combat mode identification number, located at IDUM (4099).
IFNT (56, 3)	ONE	File name table.
ITBL (16, 4)	TWO	GCM control table, located at IDUM (4035).
UMAIN (500)	DF1	Unit Status File.
IOUT (256)	ONE	GCM history records.
IOVLY	TWO	GCM secondary overlay identification number, located at IDUM (4102).
IT	ONE	Time of unit's next event. (Derived from EVTABLE.)
IE	ONE	Unit's next event code. (Derived from EVTABLE.)

c. Output Variables:

Name	Destination	Contents
UMAIN (500)	DF1	Unit Status File.
MODE	TWO	GCM mode identification number located at IDUM (4099).
IT	ONE	Time of unit's next event.
IE	ONE	Unit's next event code.
UNTLOC	ONE	Current unit location.
IMSET	DF16	Barrier identification, if barrier was encountered.

d. Logical Flow (Figure IV-7-B-4).

(1) Block 1. Begin loop on units in GCM control table.

(2) Block 2. Determine first/next unit in GCM control table.

(3) Block 3. Determine GCM mode for this unit.

(4) Block 4. Is the GCM mode for this unit = 1? If not = 1, go to block 33.

(5) Block 5. Is the time of the last GCM cycle greater than or equal to the current time (TCLOCK)? If so, go to block 33.

(6) Block 6. Get the unit's Unit Status File from DF1.

(7) Block 7. Calculate the time since the last GCM cycle.

(8) Block 8. Is DF2 loaded? If not, go to block L20.

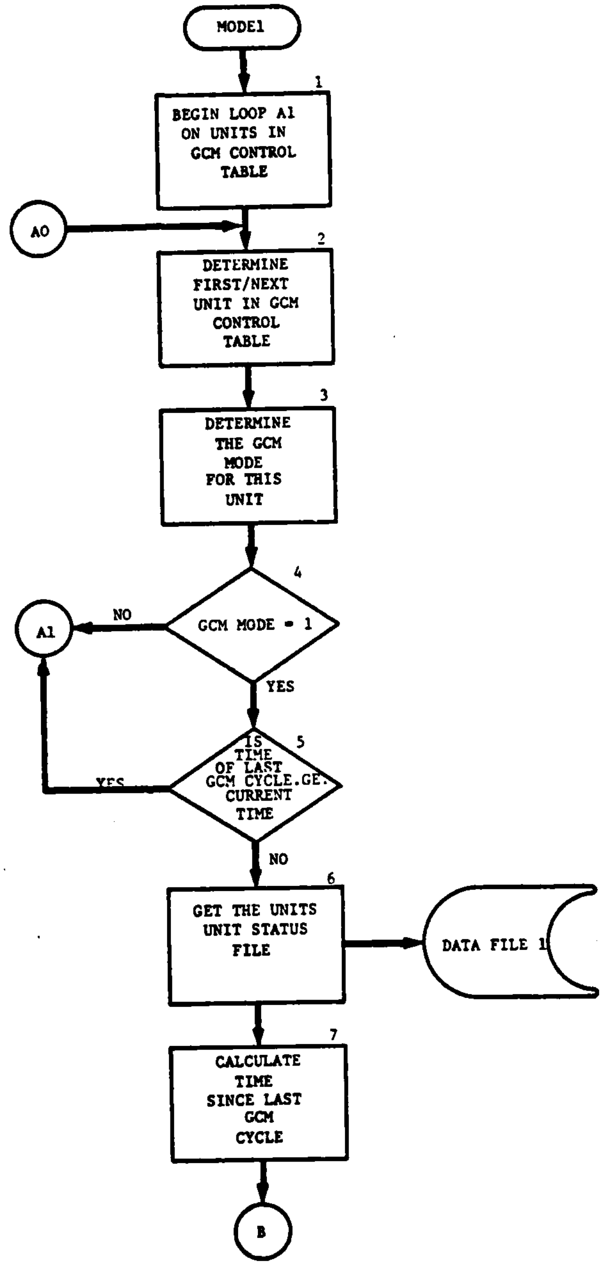
(9) Block 9. Initialize barrier encounter flag.

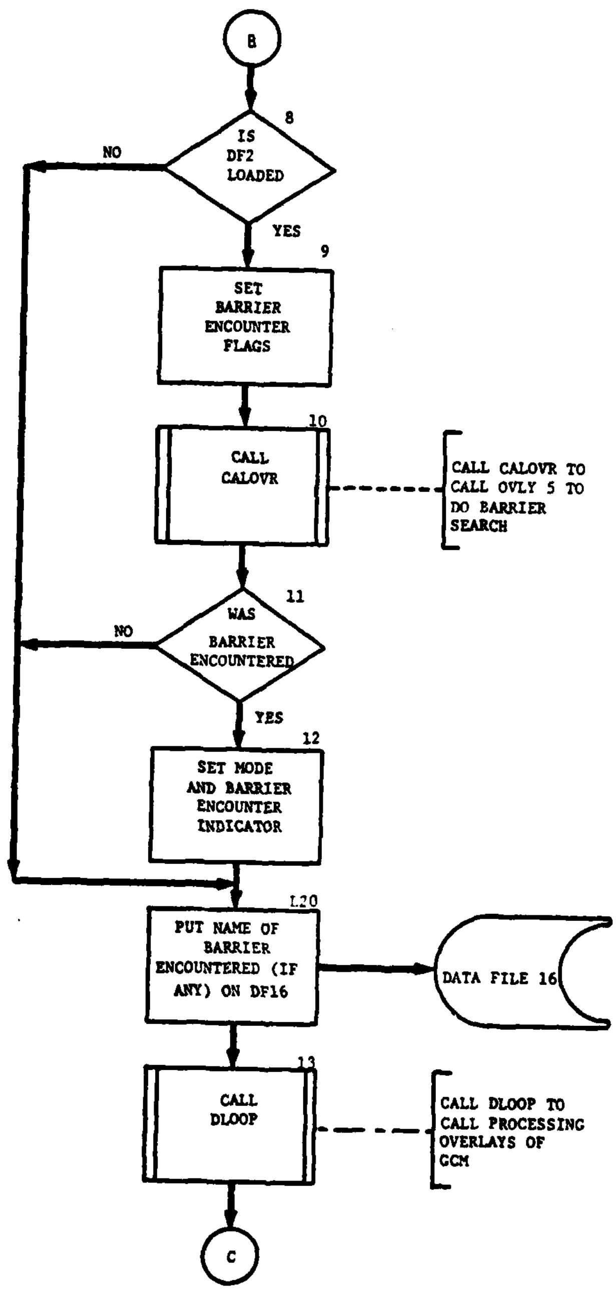
(10) Block 10. Call routine CALOVR with IOVLY=5 to do barrier search for this unit.

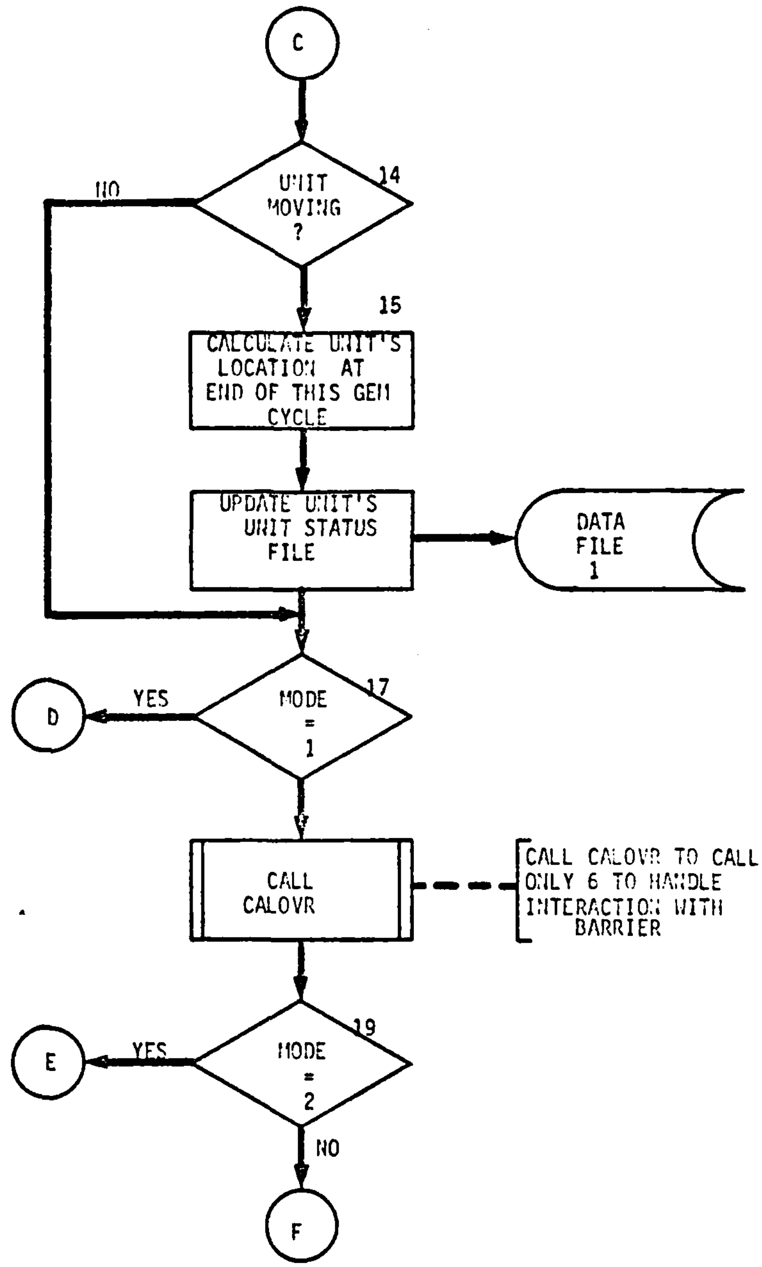
(11) Block 11. Was a barrier encountered? If not, go to block L20.

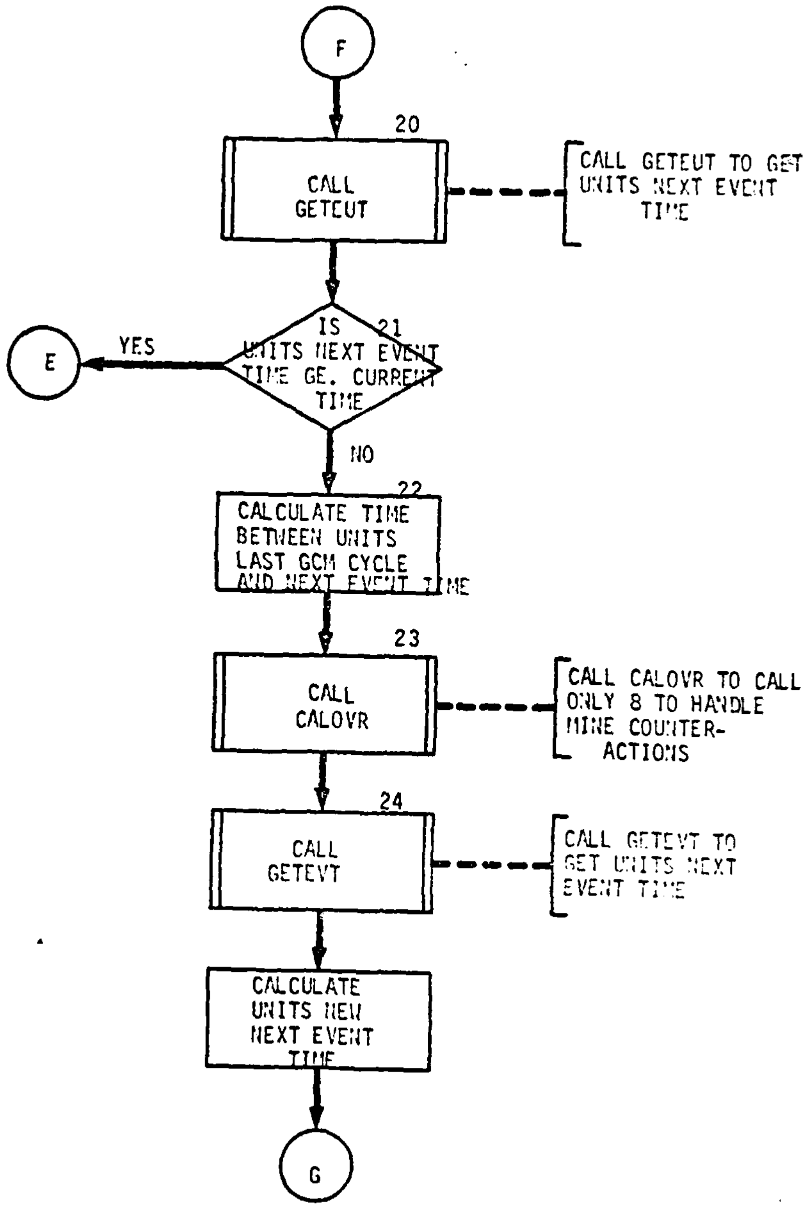
(12) Block 12. Set mode and barrier encounter flags.

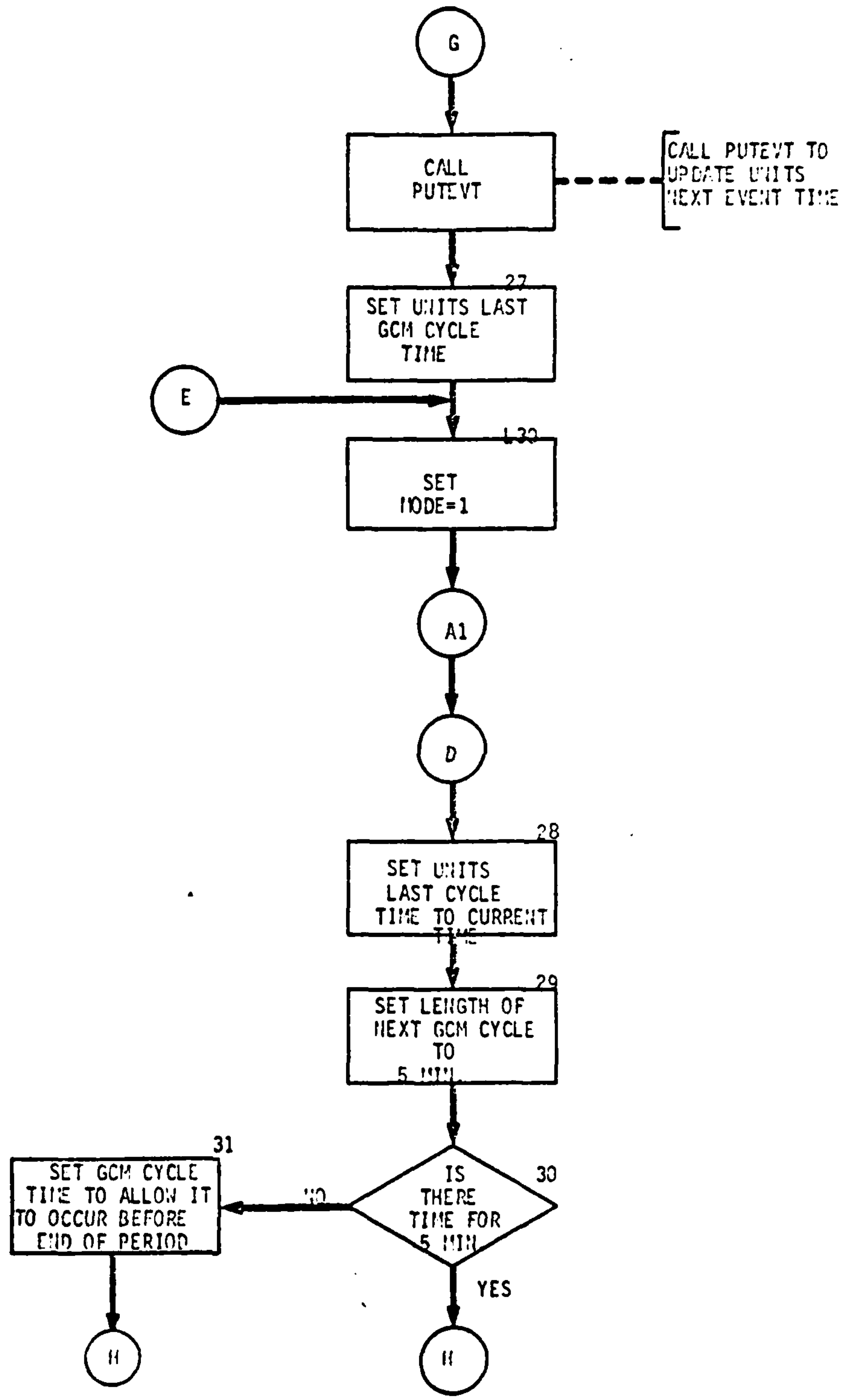
(13) Block L20. Put barrier encounter flag on DF16.

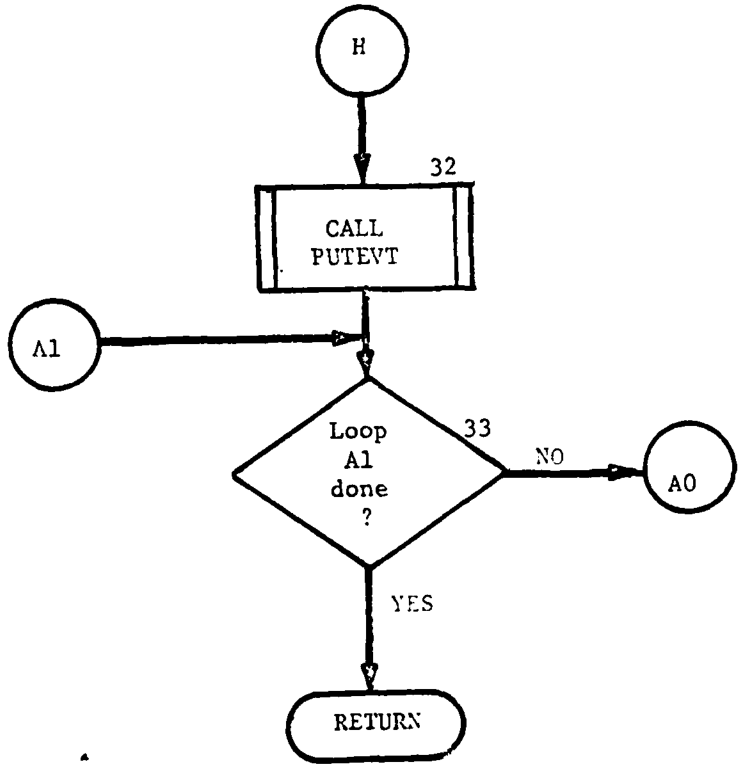

MODE1
1
BEGIN LOOP A1 ON UNITS IN GCM CONTROL TABLE
A0
2
DETERMINE FIRST/NEXT UNIT IN GCM CONTROL TABLE
3
DETERMINE THE GCM MODE FOR THIS UNIT
4
GCM MODE = 1
NO
A1
YES
5
IS TIME OF LAST GCM CYCLE.GE. CURRENT TIME
YES
NO
6
GET THE UNITS UNIT STATUS FILE
DATA FILE 1
7
CALCULATE TIME SINCE LAST GCM CYCLE
B


B
8
IS DF2 LOADED
NO
YES
9
SET BARRIER ENCOUNTER FLAGS
10
CALL CALOVR
CALL CALOVR TO CALL OVLY 5 TO DO BARRIER SEARCH
11
WAS BARRIER ENCOUNTERED
NO
YES
12
SET MODE AND BARRIER ENCOUNTER INDICATOR
L20
PUT NAME OF BARRIER ENCOUNTERED (IF ANY) ON DF16
DATA FILE 16
13
CALL DLOOP
CALL DLOOP TO CALL PROCESSING OVERLAYS OF GCM
C


C
NO
UNIT MOVING ?
14
15
CALCULATE UNIT'S LOCATION AT END OF THIS GEM CYCLE
UPDATE UNIT'S UNIT STATUS FILE
DATA FILE 1
D
YES
MODE = 1
17
CALL CALOVR
CALL CALOVR TO CALL ONLY 6 TO HANDLE INTERACTION WITH BARRIER
E
YES
MODE = 2
19
NO
F


F
20
CALL GETEUT
CALL GETEUT TO GET UNITS NEXT EVENT TIME
21
IS UNITS NEXT EVENT TIME GE. CURRENT TIME
YES
E
NO
22
CALCULATE TIME BETWEEN UNITS LAST GCM CYCLE AND NEXT EVENT TIME
23
CALL CALOVR
CALL CALOVR TO CALL ONLY 8 TO HANDLE MINE COUNTER-ACTIONS
24
CALL GETEVT
CALL GETEVT TO GET UNITS NEXT EVENT TIME
CALCULATE UNITS NEW NEXT EVENT TIME
G


G
CALL PUTEVT
CALL PUTEVT TO UPDATE UNITS NEXT EVENT TIME
27
SET UNITS LAST GCM CYCLE TIME
E
L30
SET MODE=1
A1
D
28
SET UNITS LAST CYCLE TIME TO CURRENT TIME
29
SET LENGTH OF NEXT GCM CYCLE TO 5 MIN.
30
IS THERE TIME FOR 5 MIN
NO
YES
31
SET GCM CYCLE TIME TO ALLOW IT TO OCCUR BEFORE END OF PERIOD
H
H


H
32
CALL
PUTEVT
A1
Loop
A1
done
?
33
NO
A0
YES
RETURN

(14) Block 13. Call routine DLOOP which calls processing routines of GCM.

(15) Block 14. Is the unit moving? If not, go to block 17.

(16) Block 15. Calculate unit's location at the end of this GCM cycle.

(17) Block 16. Update unit's Unit Status File (DF1).

(18) Block 17. Is GCM mode = 1? If so, go to block 28.

(19) Block 18. Call routine CALOVR with IOVLY = 6 to handle interaction with barrier.

(20) Block 19. Is GCM mode = 2? If so, go to block L30.

(21) Block 20. Call routine GETEVT to obtain unit's next event time.

(22) Block 21. Is unit's next event time greater than or equal to current time (TCLOCK)? If so, go to block L30.

(23) Block 22. Calculate time difference between unit's last GCM cycle and next event time.

(24) Block 23. Call routine CALOVR with IOVLY=8 to handle mine interaction.

(25) Block 24. Call routine GETEVT to obtain unit's next event time.

(26) Block 25. Calculate unit's new next event time.

(27) Block 26. Call routine PUTEVT to update unit's next event time.

(28) Block 27. Set unit's last GCM cycle time.

(29) Block L30. Set GCM mode = 1, and go to block 33.

(30) Block 28. Set unit's last GCM cycle time to current time.

(31) Block 29. Set length of next GCM cycle to 5 minutes.

(32) Block 30. Is there time for a 5 minute GCM cycle during this period? If not, go to block 31.

(33) Block 31. Set GCM cycle time to allow it to occur before the end of period.

(34) Block 32. Call routine PUTEVT to set up event for next GCM cycle.

(35) Block 33. End of loop for units in the GCM control table? If not, go to block 2 to process next unit (if any).

5. ROUTINE MODE2

a. Purpose. MODE2 is the driving routine of Ground Combat when MODE=2 which is when termination of ground combat is pending.

b. Input Variables:

Name	Source	Contents
TCLOCK	ONE	Time since start of period.
LGTPER	ONE	Length of period.
ITBL (16, 4)	TWO	GCM control table, located at IDUM (4035).
UMAIN (500)	DF1	Unit Status File.

c. Output Variables:

Name	Destination	Contents
ISKED	ONE	Time increment (cycle time) of unit's next GCM event.
DELT	ONE	Cycle time of unit's current GCM event.

d. Logical Flow (Figure IV-7-B-5).

(1) Block 1. Begin loop on units in GCM control table.

(2) Block 2. Determine first/next unit in GCM control table.

(3) Block 3. Determine GCM MODE for this unit.

(4) Block 4. Is the GCM MODE for this unit = 2? If not, go to block 14.

(5) Block 5. Is the time of the last GCM cycle greater than or equal to the current time (TCLOCK)? If so, go to block 14.

(6) Block 6. Get the unit's Unit Status File for DF1.

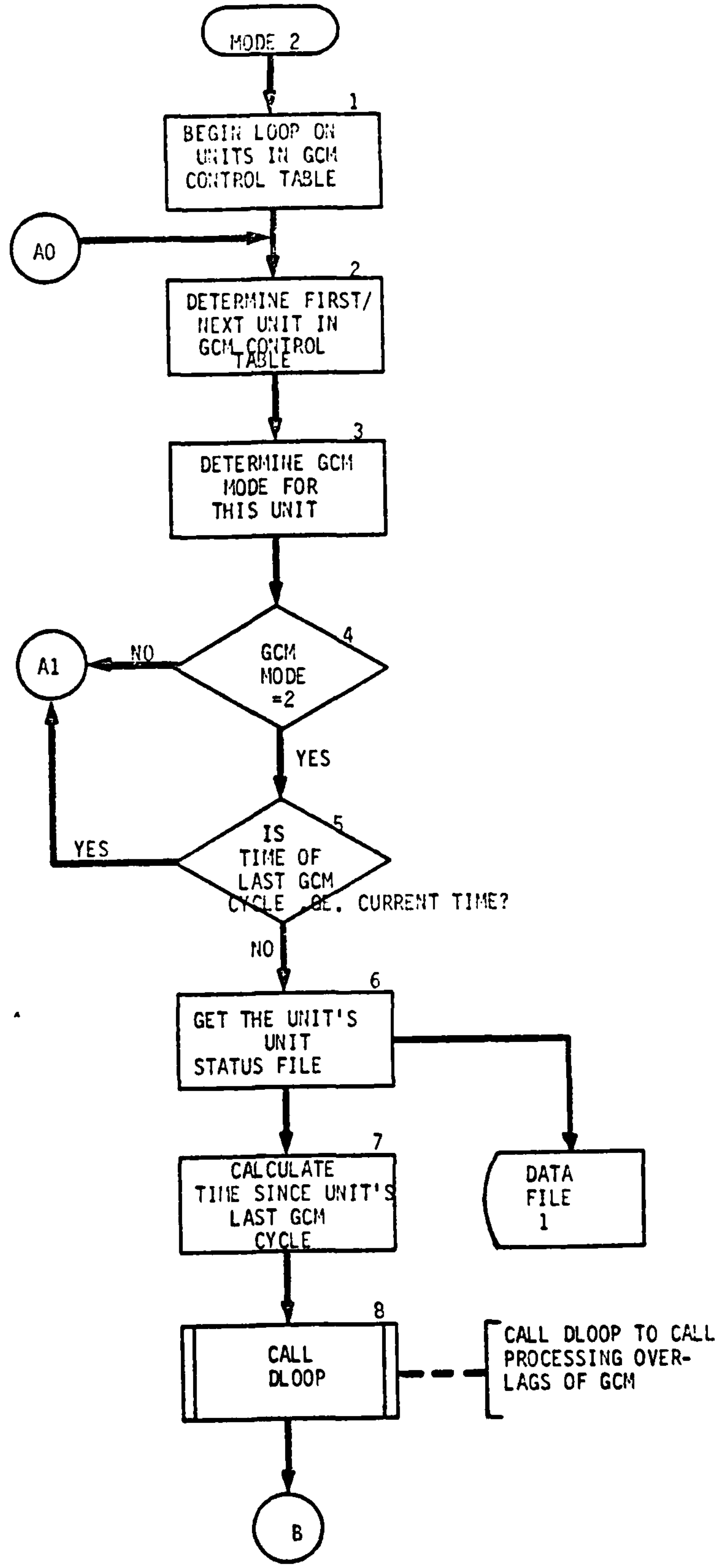
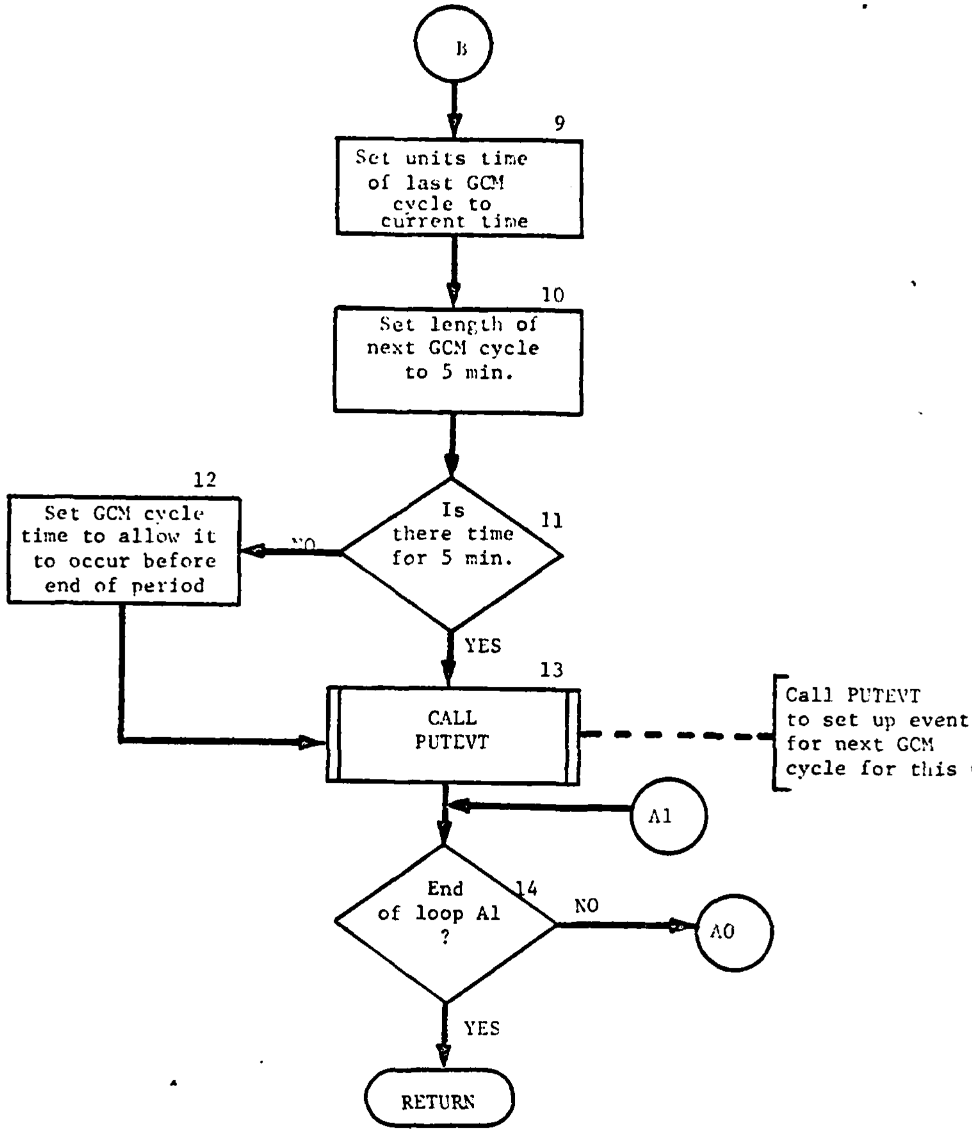


FIGURE IV-7-B-5 ROUTINE MODE2


B
9
Set units time of last GCM cycle to current time
10
Set length of next GCM cycle to 5 min.
11
Is there time for 5 min.
NO
12
Set GCM cycle time to allow it to occur before end of period
YES
13
CALL PUTEVT
Call PUTEVT to set up event for next GCM cycle for this
A1
14
End of loop A1 ?
NO
A0
YES
RETURN

(7) Block 7. Calculate time since the last GCM cycle.

(8) Block 8. Call routine DLOOP to call processing overlays of GCM.

(9) Block 9. Set unit's time since last GCM cycle to current time.

(10) Block 10. Set length of next GCM cycle to 5 minutes.

(11) Block 11. Is there time for a 5 minute GCM cycle during this period? If so, go to block 13.

(12) Block 12. Set GCM cycle time to allow it to occur before the end of the period.

(13) Block 13. Call routine PUTEVT to set up an event for the next GCM cycle for this unit.

(14) Block 14. End of loop for units on GCM Control Table? If not, go to block 2 to process next unit (if any).

6. ROUTINE INRPT.

a. Purpose. INRPT is called when a GCM termination condition has been sensed. It interrupts all ongoing GCM actions except MODE9. Interrupted actions are set into MODE2.

b. Input Variables:

Name	Source	Contents
TCLOCK	ONE	Time since start of period.
MODE	TWO	GCM mode identification number, located at IDUM (4099).
UMAIN (500)	DF1	Unit Status File.
ITBL (16, 4)	TWO	GCM Control Table, located at IDUM (4035).

c. Output Variables:

Name	Destination	Contents
MODE	TWO	GCM mode identification number, located at IDUM (4099).
TCLOCK	ONE	Time since start of period.

INRUPT	TWO	GCM interruption flag.
ISKED	ONE	Time increment (cycle time) of unit's next GCM event.
IFTBL (16)	TWO	Table for units in GCM Control Table, located at IDUM (4000).

d. Logical Flow (Figure IV-7-B-6).

(1) Block 1. Zero out table for units in the GCM control table.

(2) Block 2. Begin loop on units in GCM Control Table.

(3) Block 3. Determine GCM mode of this unit.

(4) Block 4. Is MODE = 0? If so, go to block L5.

(5) Block 5. Determine time remaining after current GCM cycle. If greater than zero, go to block L5; if less than zero, go to block L10.

(6) Block L3. Is MODE greater than or equal to 2? If so, go to block L10.

(7) Block L5. End of loop on units in GCM Control Table? If not, go to block 3 to process next unit in table (if any).

(8) Block 6. Set interrupt flag = 2. Go to block L15.

(9) Block L10. Set interrupt flag = 1.

(10) Block 7. Set GCM MODE = 1.

(11) Block 8. Call routine MODE1 (normal GCM mode).

(12) Block 9. Set GCM MODE = 2.

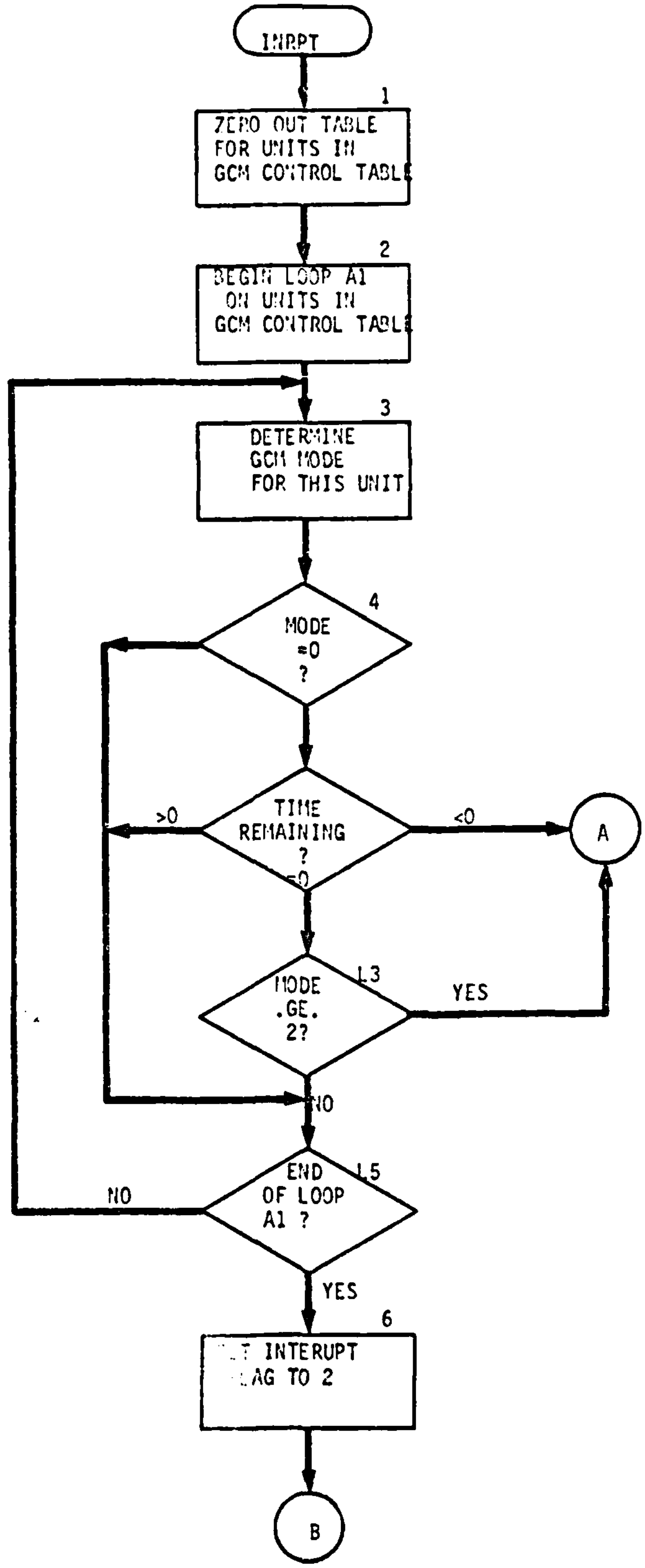
(13) Block 10. Call routine MODE2 (pending termination).

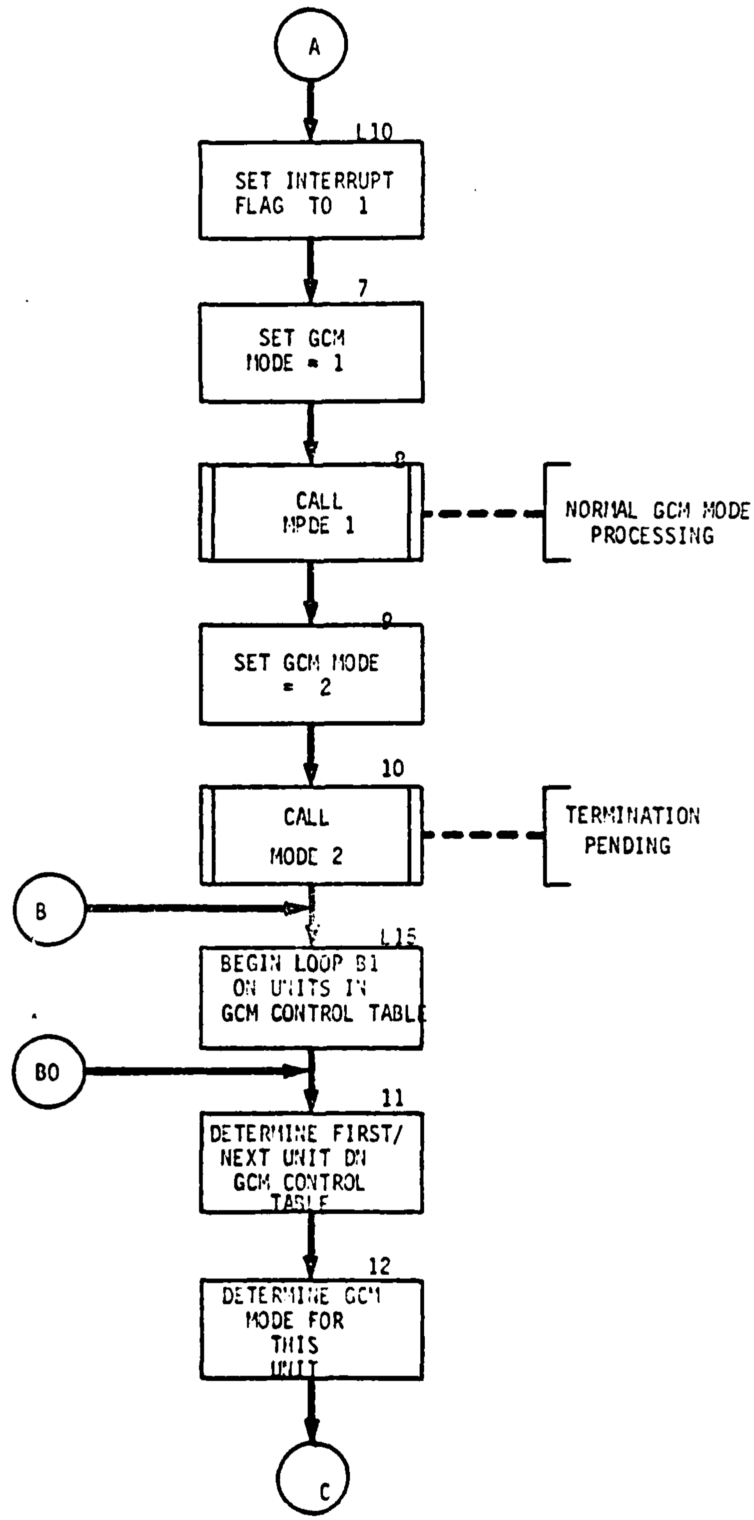
(14) Block L15. Begin 2d loop on units in GCM Control Table.

(15) Block 11. Determine first/next unit in GCM Control Table.

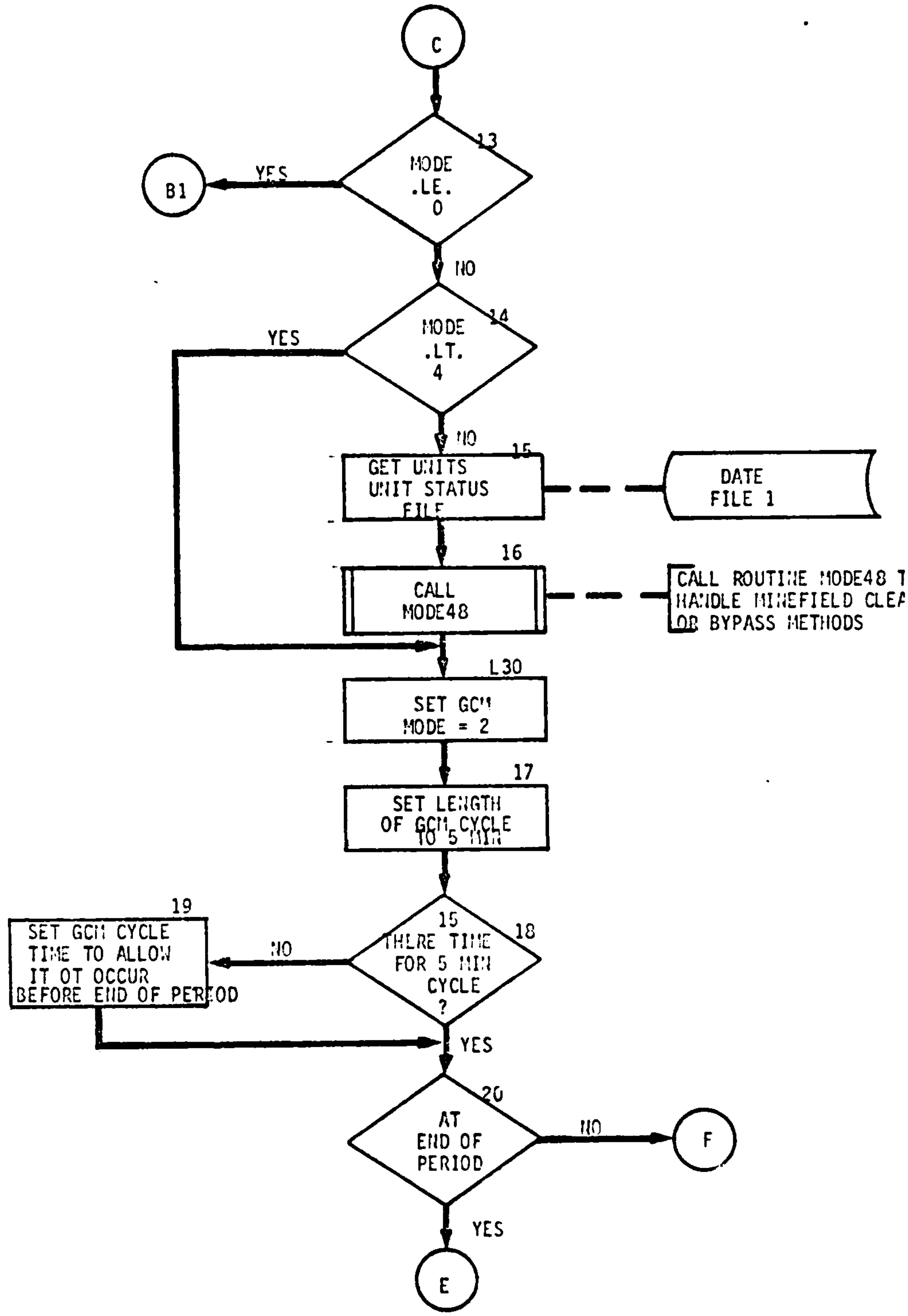
(16) Block 12. Determine GCM MODE for this unit.

(17) Block 13. Is MODE less than or equal to ZERO? If so, go to block L100.

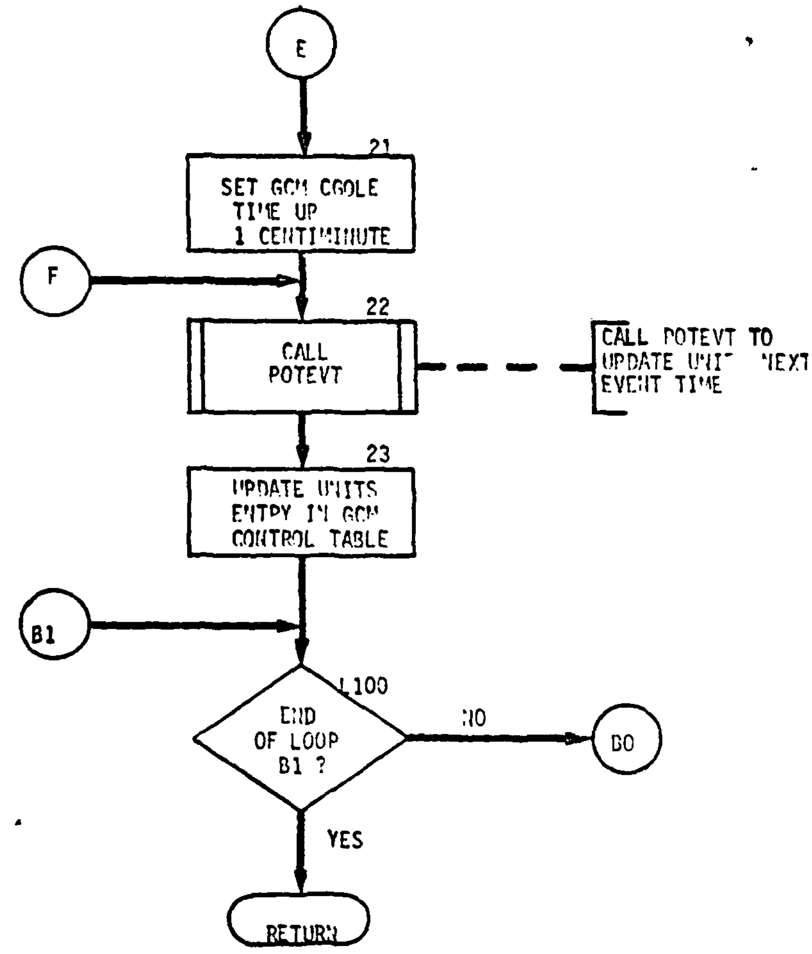

INRPT
1
ZERO OUT TABLE FOR UNITS IN GCM CONTROL TABLE
2
BEGIN LOOP A1 ON UNITS IN GCM CONTROL TABLE
3
DETERMINE GCM MODE FOR THIS UNIT
4
MODE =0 ?
TIME REMAINING ?
>0
<0
=0
A
L3
MODE .GE. 2?
YES
NO
L5
END OF LOOP A1 ?
NO
YES
6
SET INTERUPT FLAG TO 2
B



A
L10
SET INTERRUPT FLAG TO 1
7
SET GCM MODE = 1
8
CALL MPDE 1
NORMAL GCM MODE PROCESSING
9
SET GCM MODE = 2
10
CALL MODE 2
TERMINATION PENDING
B
L15
BEGIN LOOP B1 ON UNITS IN GCM CONTROL TABLE
BO
11
DETERMINE FIRST/NEXT UNIT ON GCM CONTROL TABLE
12
DETERMINE GCM MODE FOR THIS UNIT
C



C
13
MODE .LE. 0
YES
B1
NO
14
MODE .LT. 4
YES
NO
15
GET UNITS UNIT STATUS FILE
DATE FILE 1
16
CALL MODE48
CALL ROUTINE MODE48 T
HANDLE MINEFIELD CLEA
OR BYPASS METHODS
L30
SET GCM MODE = 2
17
SET LENGTH OF GCM CYCLE TO 5 MIN
18
IS THERE TIME FOR 5 MIN CYCLE ?
NO
19
SET GCM CYCLE TIME TO ALLOW IT OT OCCUR BEFORE END OF PERIOD
YES
20
AT END OF PERIOD
NO
F
YES
E


E
21
SET GCM CGOLE TIME UP 1 CENTIMINUTE
F
22
CALL POTEVT
CALL POTEVT TO UPDATE UNIT NEXT EVENT TIME
23
UPDATE UNITS ENTRY IN GCM CONTROL TABLE
B1
100
END OF LOOP B1 ?
NO
B0
YES
RETURN

(18) Block 14. Is MODE less than 4? If so, go to block L30.

(19) Block 15. Get unit's Unit Status File from DF1.

(20) Block 16. Call MODE48 to handle field clearing or bypass methods.

(21) Block L30. Set GCM MODE=2.

(22) Block 17. Set length of GCM cycle to 5 minutes.

(23) Block 18. Is there time for a 5 minute GCM cycle during this period? If so, go to block 20.

(24) Block 19. Set GCM cycle time to allow it to occur before the end of period.

(25) Block 20. End of period? If not, go to block 22.

(26) Block 21. Set cycle time to 1 centiminute.

(27) Block 22. Call routine PUTEVT to update unit's next event time.

(28) Block 23. Update unit's entry into the GCM Control Table.

(29) Block L100. End of 2d loop on units in GCM control table? If not, go to block 11 to process next unit (if any).

7. ROUTINE DLOOP.

a. Purpose. DLOOP loops through the processing overlays of GCM for each defending in the GCM Control Table.

b. Input Variables:

Name	Source	Contents
ITBL (16, 4)	TWO	GCM Control Table, located at IDUM (4035).
UCOOP	DF1	Unit Status File.
IGO	TWO	Termination condition flag, located at IDUM (4101).

c. Output Variables:

Name	Destination	Contents
ITBL (16, 4)	TWO	GCM Control Table, located at IDUM (4035).

IDXDEF	TWO	Defending unit index number in GCM Control Table.
IOVLY	TWO	GCM secondary overlay, identification number, located at IDUM (4102).
IFTBL (16)	TWO	Table for units in GCM Control Table, located at IDUM (4000).

d. Logical Flow (Figure IV-7-B-7).

(1) Block 1. Set LFLG=1.

(2) Block 2. Begin loop on defending units in GCM Control Table.

(3) Block 3. Determine first/next defending unit in GCM Control Table.

(4) Block 4. Determine MODE of this unit.

(5) Block 5. Is MODE = 0? If so, go to block L100.

(6) Block 6. Set defenders index into GCM Control Table.

(7) Block 7. Get defenders Unit Status File from DF1.

(8) Block 8. Call routine CALOVR with IOVLY=1 to determine engagement geometry.

(9) Block 9. Is IGO = 2? If not, go to block L100.

(10) Block 10. Call routine CALOVR with IOVLY=2 for target acquisition and firepower effectiveness logic.

(11) Block 11. Call routine CALOVR with IOVLY=3 for GCM assessment logic.

(12) Block L30. Set LFLG=1.

(13) Block 12. Call routine CALOVR with IOVLY=4 to create history records for this GCM increment.

(14) Block 13. Set defenders GCM MODE=3.

(15) Block 14. Update defenders entry in the GCM Control Table.

(16) Block L100. End of loop on units in GCM Control Table? If not, go to block 3 to process next unit (if any).

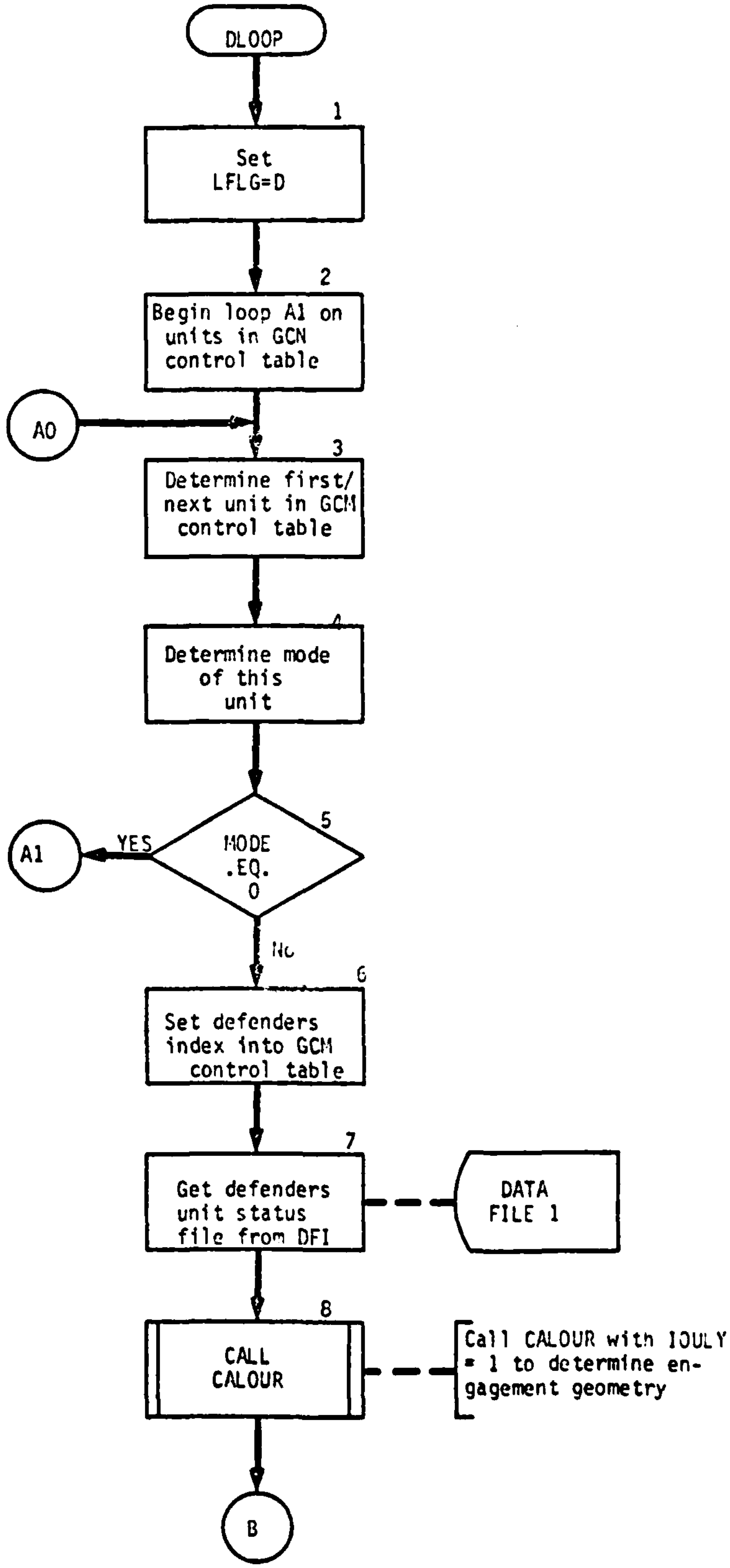
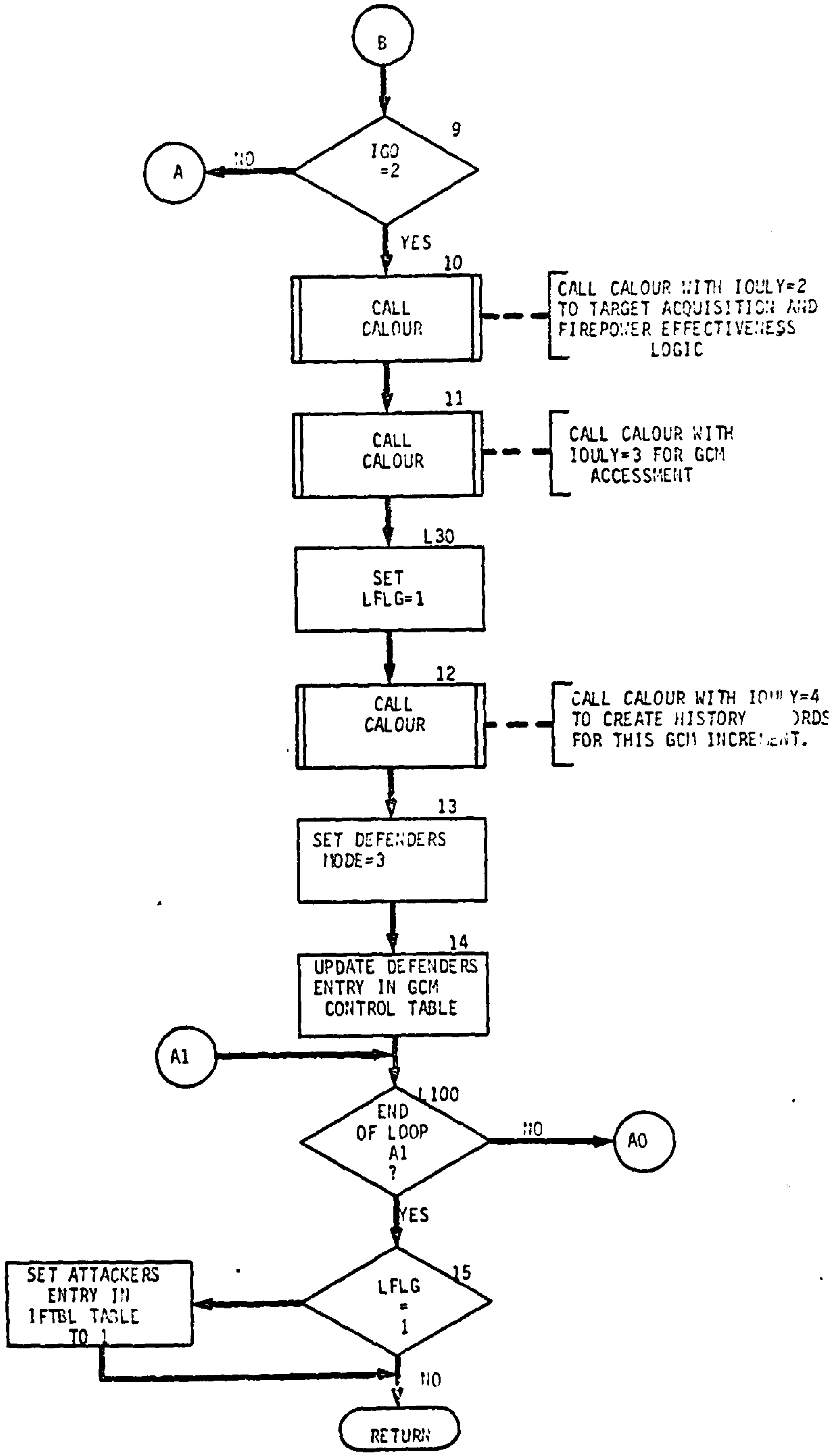


Figure IV-7-B-7 ROUTINE DLOOP


B
9
IGO =2
NO
A
YES
10
CALL CALOUR
CALL CALOUR WITH IOULY=2 TO TARGET ACQUISITION AND FIREPOWER EFFECTIVENESS LOGIC
11
CALL CALOUR
CALL CALOUR WITH IOULY=3 FOR GCM ACCESSMENT
L30
SET LFLG=1
12
CALL CALOUR
CALL CALOUR WITH TO CREATE HISTORY FOR THIS GCM
13
SET DEFENDERS MODE=3
14
UPDATE DEFENDERS ENTRY IN GCM CONTROL TABLE
A1
L100
END OF LOOP A1 ?
NO
A0
YES
15
LFLG = 1
SET ATTACKERS ENTRY IN IFTBL TABLE TO 1
NO
RETURN

(17) Block 15. If LFLG≠1, RETURN.

(18) Block 16. Set attackers entry in IFTBL=1, then RETURN.

8. ROUTINE CALOVR.

a. Purpose. CALOVR calls the appropriate GCM overlay depending on the value of IOVER.

b. Input Variables:

Name	Source	Contents
IOVER	TWO	GCM overlay identification number.

c. Output Variables. None.

d. Logical Flow (Figure IV-7-B-8).

(1) Block 1. Is IOVER between 1 and 9? If so, go to block 3.

(2) Block 2. Error processing.

(3) Block 3. Call routine OVERLAY to call the GCM overlay required.

9. ROUTINE MODE48

a. Purpose. MODE48 handles the field clearing or bypass methods.

b. Input Variables:

Name	Source	Contents
ITBL (16, 4)	TWO	GCM Control Table, located at IDUM (4035).
TCLOCK	ONE	Time since start of period.
MODE	TWO	GCM MODE identification number, located at IDUM (4099).

c. Output Variables:

Name	Destination	Contents
ITBL (16, 4)	TWO	GCM Control Table, located at IDUM (4035).
IGO	TWO	Termination condition flag, located at IDUM (4101).

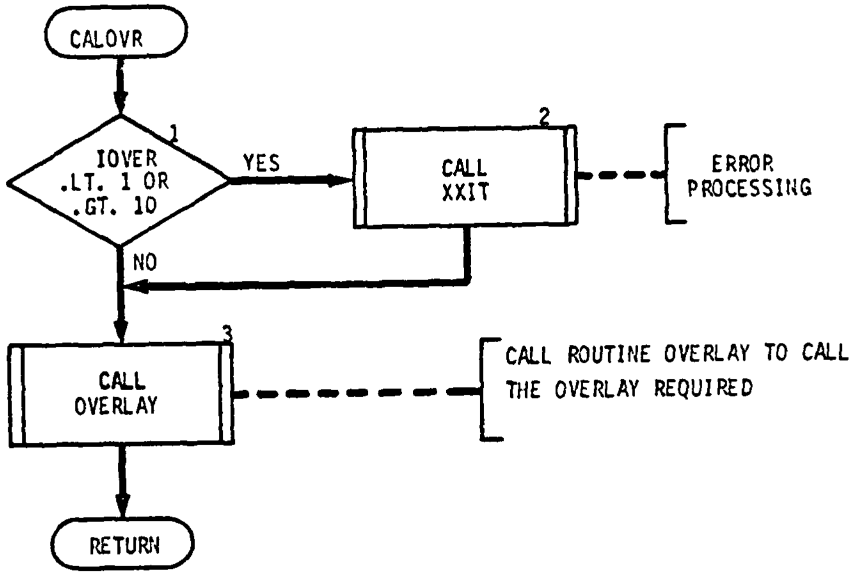


FIGURE IV-7-B-8 ROUTINE CALOVR

MODE	TWO	GCM mode identification number, located at IDUM (4099).

d. Logical Flow (Figure IV-7-B-9).

(1) Block 1. Can the GCM increment be completed this period? If not, return to calling program.

(2) Block 2. Will this GCM increment end exactly at the end of period? If so, go to block L50.

(3) Block 3. Calculate time remaining in the period after GCM increment completion.

(4) Block 4. Call routine DLOOP to call processing overlays of GCM.

(5) Block L50. Set termination condition flag (IGO) equal to 1.

(6) Block 5. Set IOVLY=8.

(7) Block 6. Is MODE = 8? If not, go to block 8.

(8) Block 7. Set IOVLY=7.

(9) Block 8. Call routine CALOVR to call overlay with either the field clearing or bypass method logic.

(10) Block 9. Update the attacking units entry in the GCM Control Table.

(11) Block 10. Is the GCM MODE=9 and IOVLY=7? If so, go to block L50. Otherwise return to calling program.

10. ROUTINE MODE9.

a. Purpose. MODE9 handles unit's crossing of an open field, and cannot be interrupted.

b. Input Variables:

Name	Source	Contents
ITBL (16, 4)	TWO	GCM Control Table, located at IDUM (4035).

c. Output Variables:

Name	Destination	Contents
IGO	TWO	Termination condition flag.

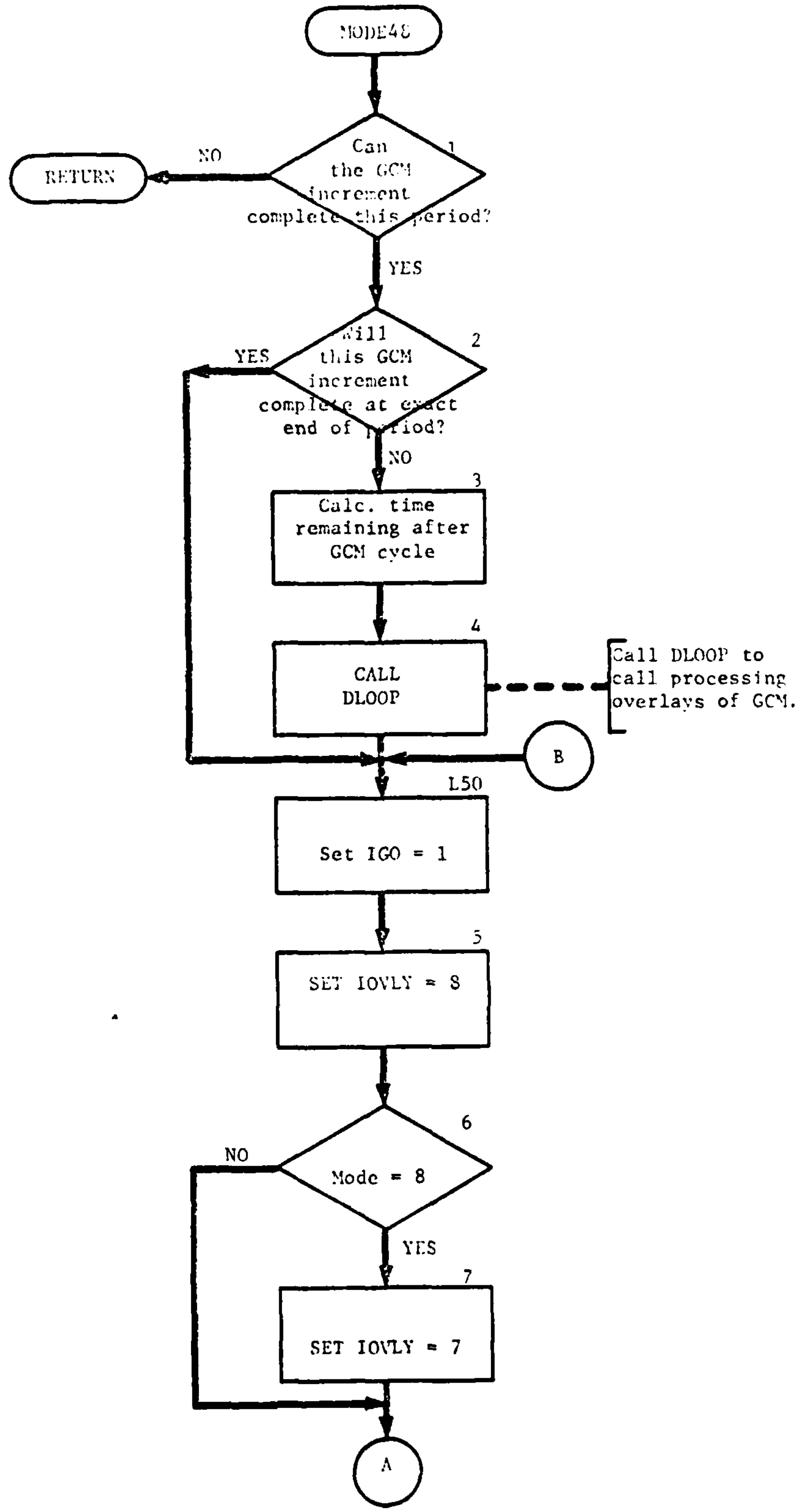
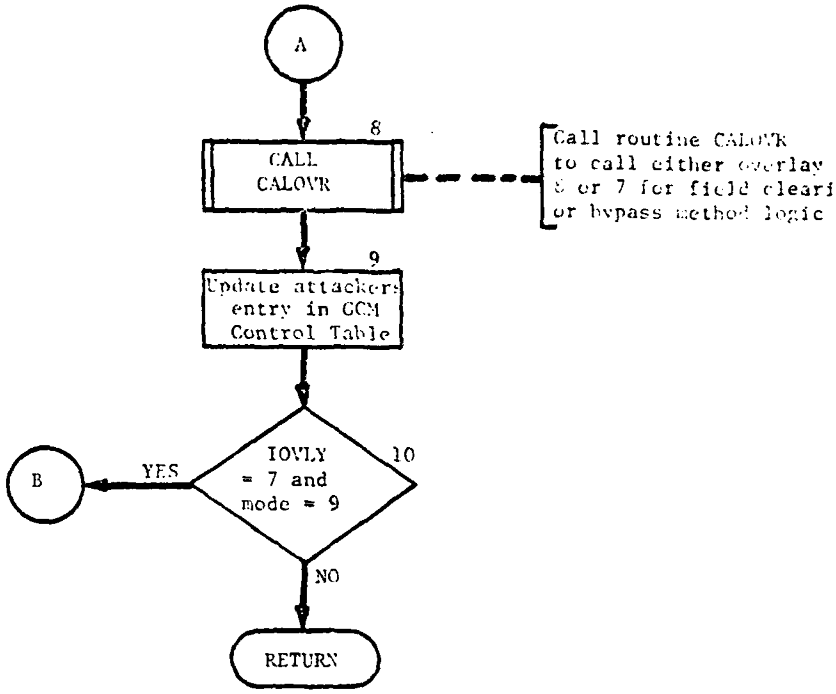


Figure IV-7-B-9. Routine MODE48.


A
8
CALL
CALOVR
Call routine CALOVR
to call either overlay
or 7 for field cleari
or bypass method logic
9
Update attackers
entry in GCM
Control Table
IOVLY
= 7 and
mode = 9
10
YES
B
NO
RETURN

IOVLY	TWO	GCM secondary overlay identification number, located at IDUM (4102).

d. Logical Flow (Figure IV-7-B-10).

(1) Block 1. Set termination condition = 0.

(2) Block 2. Calculate time remaining after GCM increment completes.

(3) Block 3. Call routine DLOOP to call processing overlays of GCM.

(4) Block 4. Set termination condition = 1.

(5) Block 5. Call routine CALOVR with IOVLY=8 to handle unit's crossing an open field, then return.

11. ROUTINE EXEC1.

a. Purpose. EXEC1 calls the routines which set up the data and parameters for ground combat.

b. Input Variables:

Name	Source	Contents
ISEP	DF16	Separation distance, located at IDUM (157).
IGO	TWO	Termination condition flag, located at IDUM (4101).
MODE	TWO	GCM mode identification number, located at IDUM (4099).
ROUT (64)	DF21	Barrier interaction data.

c. Output Variables:

Name	Destination	Contents
ISEP	TWO	Minimum separation distance, located at IDUM (157).
ROUT (64)	ONE	Barrier interaction data.

d. Logical Flow (Figure IV-7-B-11).

(1) Block 1. Zero out IDUM (1-400).

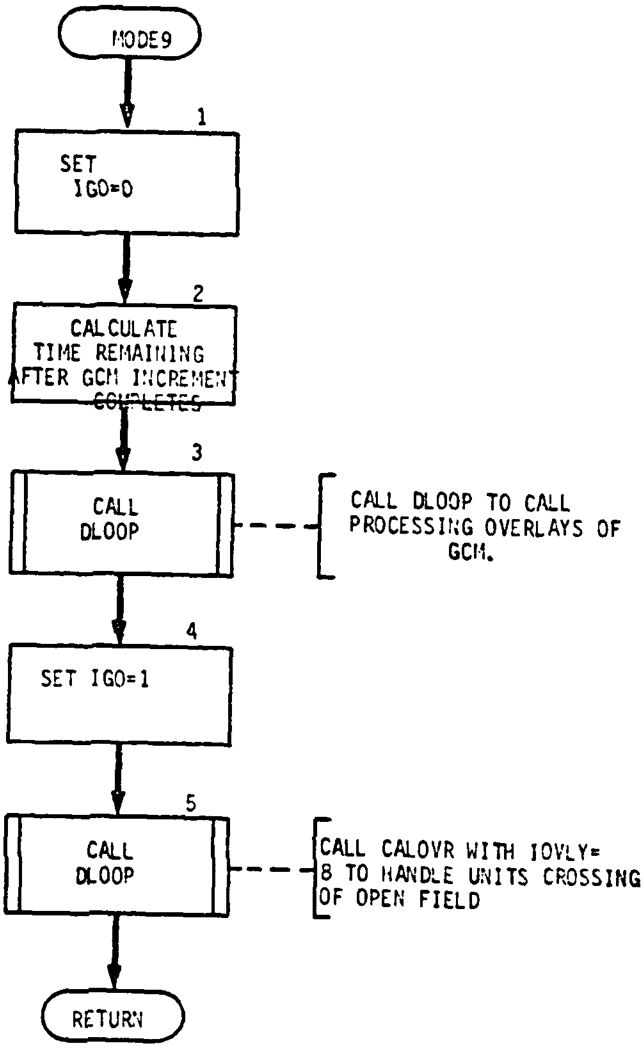


FIGURE IV-7-B-10 ROUTINE MODE9

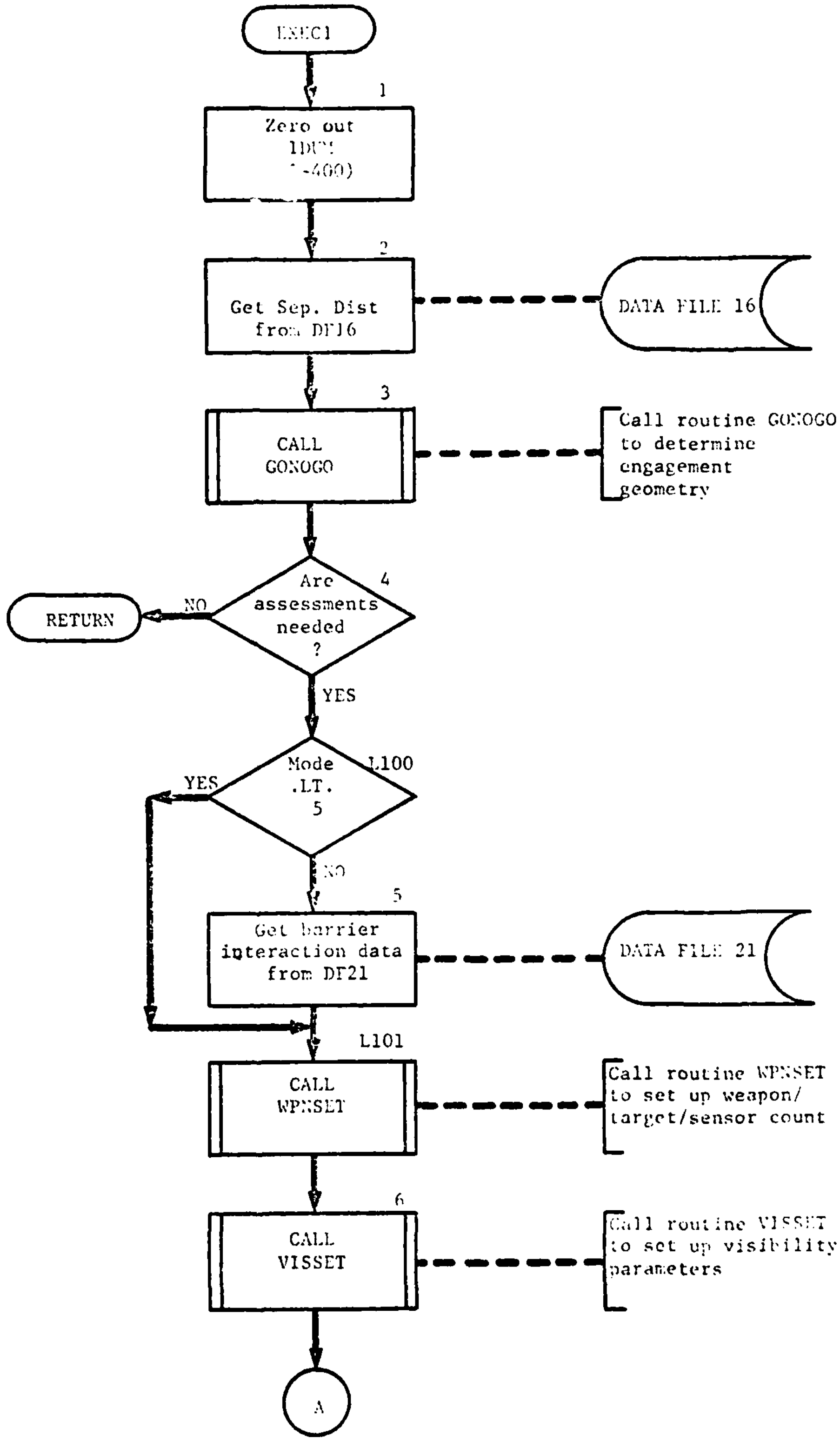
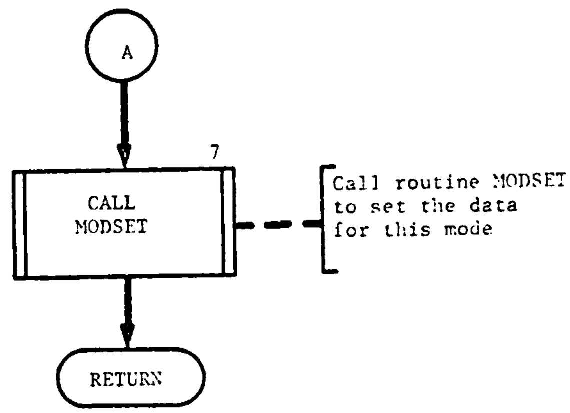


Figure IV-7-B-11. Routine EXEC1.


A
7
CALL MODSET
Call routine MODSET to set the data for this mode
RETURN

(2)	Block 2.	Call routine GET to obtain separation distance (ISEP) from DF16 - 21088.
(3)	Block 3.	Call routine CONOGO to determine engagement geometry.
(4)	Block 4.	Are assessments needed (IGO=2)? If not, return.
(5)	Block L100.	Is MODE less than 5? If so, barrier interaction data is not required. Go to block L101.
(6)	Block 5.	Call routine GETRCD to obtain barrier interaction data from DF21.
(7)	Block L101.	Call routine WPNSET to set up weapon/target/sensor count.
(8)	Block 6.	Call routine VISSET to set up visibility parameters.
(9)	Block 7.	Call routine MODSET to set up data for this MODE, then return.

12. ROUTINE GONOGO.

a. Purpose. GONOGO sets up a call to routine RANGER which determines the engagement geometry required for ground combat.

b. Input Variables:

Name	Source	Contents
UMAIN (500)	ONE	Unit Status File for attacking unit.
UCOOP (500)	ONE	Unit Status File for defending unit.
MODE	TWO	GCM MODE identification number, located at IDUM (4099).
ITBL (16, 4)	TWO	GCM Control Table, located at IDUM (4035).
WEAD	TWO	Amount (in meters) of defender's engagement frontage, located at IDUM (155).
SINIT	TWO	Initial separation distance, located at IDUM (370).
SPINAL	TWO	Final separation distance, located at IDUM (372).

IDUM (401-652)	DF16	GCM constant data.

c. Output Variables:

Name	Destination	Contents
IDUM (1-400)	TWO	GCM static data.
IDUM (401-652)	TWO	GCM constant data.
IGO	TWO	Termination condition flag, located at IDUM (4101).

d. Logical Flow (Figure IV-7-B-12).

(1) Block 1. Obtain the attacker's initial location, objective location, velocity, width, and depth from its Unit Status File and place in Common TWO.

(2) Block 2. Obtain the defender's initial location, objective location, velocity, width, and depth from its Unit Status File and place in Common TWO.

(3) Block 3. Calculate delta time of pending GCM event.

(4) Block 4. Is delta time less than or equal to zero? If so, go to block L200.

(5) Block 5. Is the defender moving (VDEF ≠ 0)? If not, go to block 7.

(6) Block 6. Calculate new initial location for the defender based on its speed.

(7) Block 7. Call routine RANGER to actually determine the engagement geometry.

(8) Block 8. When the attacker and defender are facing each other, do there fronts overlap (WEAD > 0)? If not, go to block L200.

(9) Block 9. Will the front to front separation distance between the attacker and defender ever be less than 3000 meters? If not, go to block L200.

(10) Block 10. Call routine GET several times to obtain GCM constant data from DF16.

(11) Block 11. Set termination condition flag (IGO=2). Indicates everything is set up for the battle.

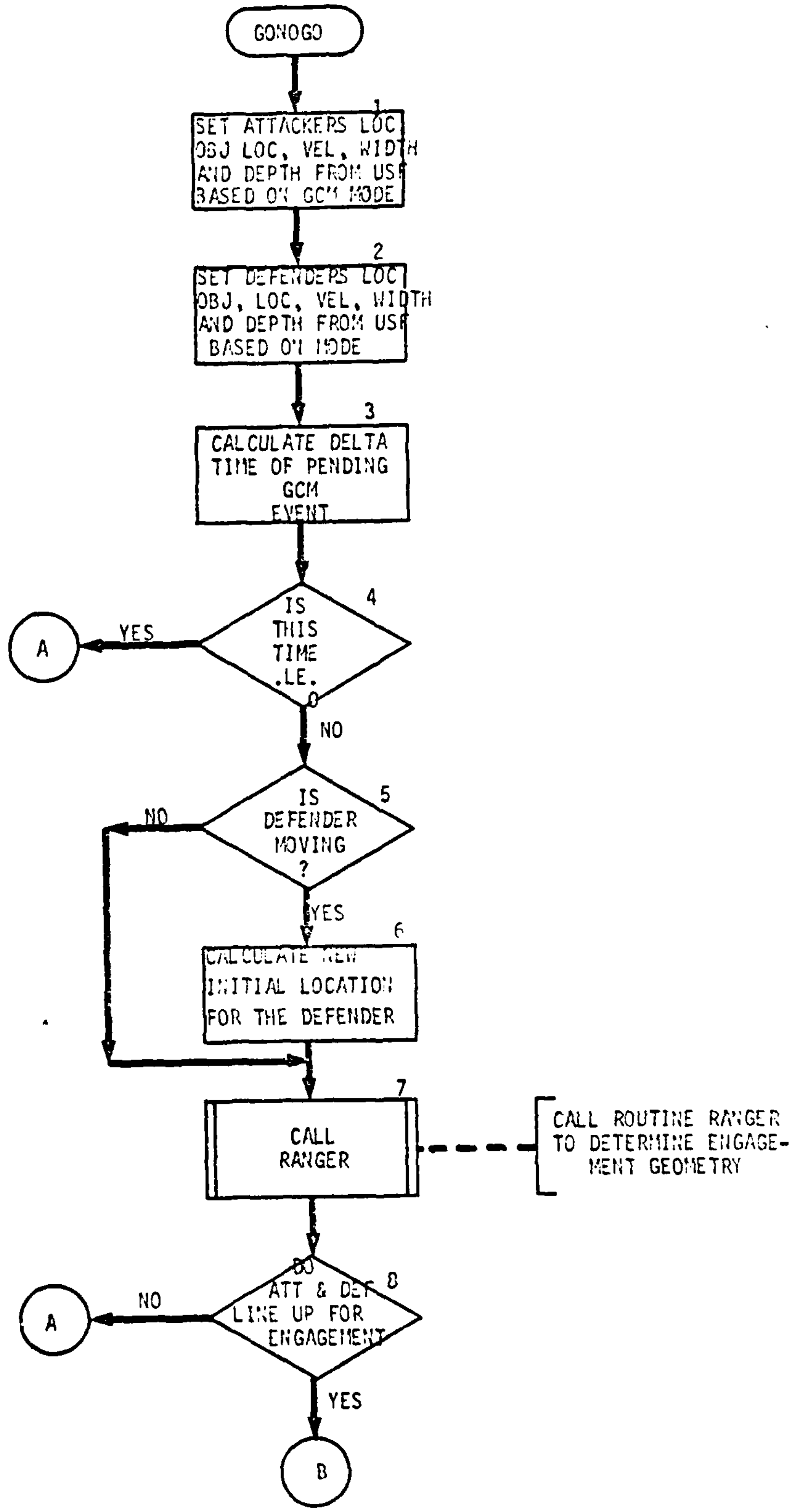
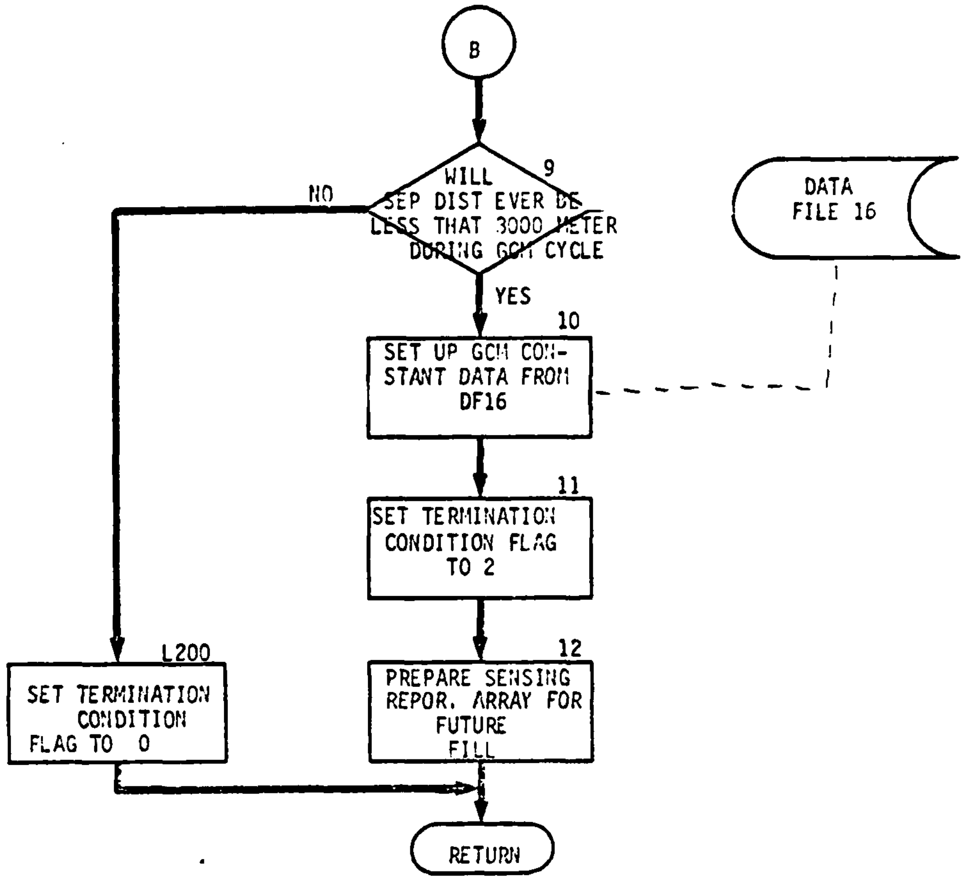


FIGURE IV-7-B-12 ROUTINE GONOGO


B
WILL SEP DIST EVER BE LESS THAT 3000 METER DURING GCM CYCLE
9
NO
YES
DATA FILE 16
10
SET UP GCM CONSTANT DATA FROM DF16
11
SET TERMINATION CONDITION FLAG TO 2
12
PREPARE SENSING REPOR. ARRAY FOR FUTURE FILL
L200
SET TERMINATION CONDITION FLAG TO 0
RETURN

(12) Block 12. Set sensing report array to 1000000. This prepares it for future filling. RETURN to calling routine.

(13) Block L200. Set termination condition flag (IGO=0). Indicates no battle can take place between these units. RETURN to calling routine.

13. ROUTINE RANGER.

a. Purpose. RANGER determines the engagement geometry for ground combat.

b. Input Variables:

Name	Source	Contents
IDUM (1-400)	TWO	GCM static data.
NORD	ONE	Attacker's DSL'd order number.
CNORD	ONE	Defender's DSL'd order number.
DEPTH	ONE	Attacking unit's depth.
CDEPTH	ONE	Defending unit's depth.

c. Output Variables:

Name	Destination	Contents
SINIT	TWO	Intial front to front separation distance, located at IDUM (369).
SFINAL	TWO	Final front to front separation distance, located at IDUM (371).
S	TWO	Front to front separation distance, located at IDUM (153).
WEAD	TWO	Amount of overlap between attacker and defender (engagement frontage), located at IDUM (155).

d. Logical Flow (Figure IV-7-B-13).

(1) Block 1. Are the attacker and defender both in a PREPARE activity? If not, go to block L20.

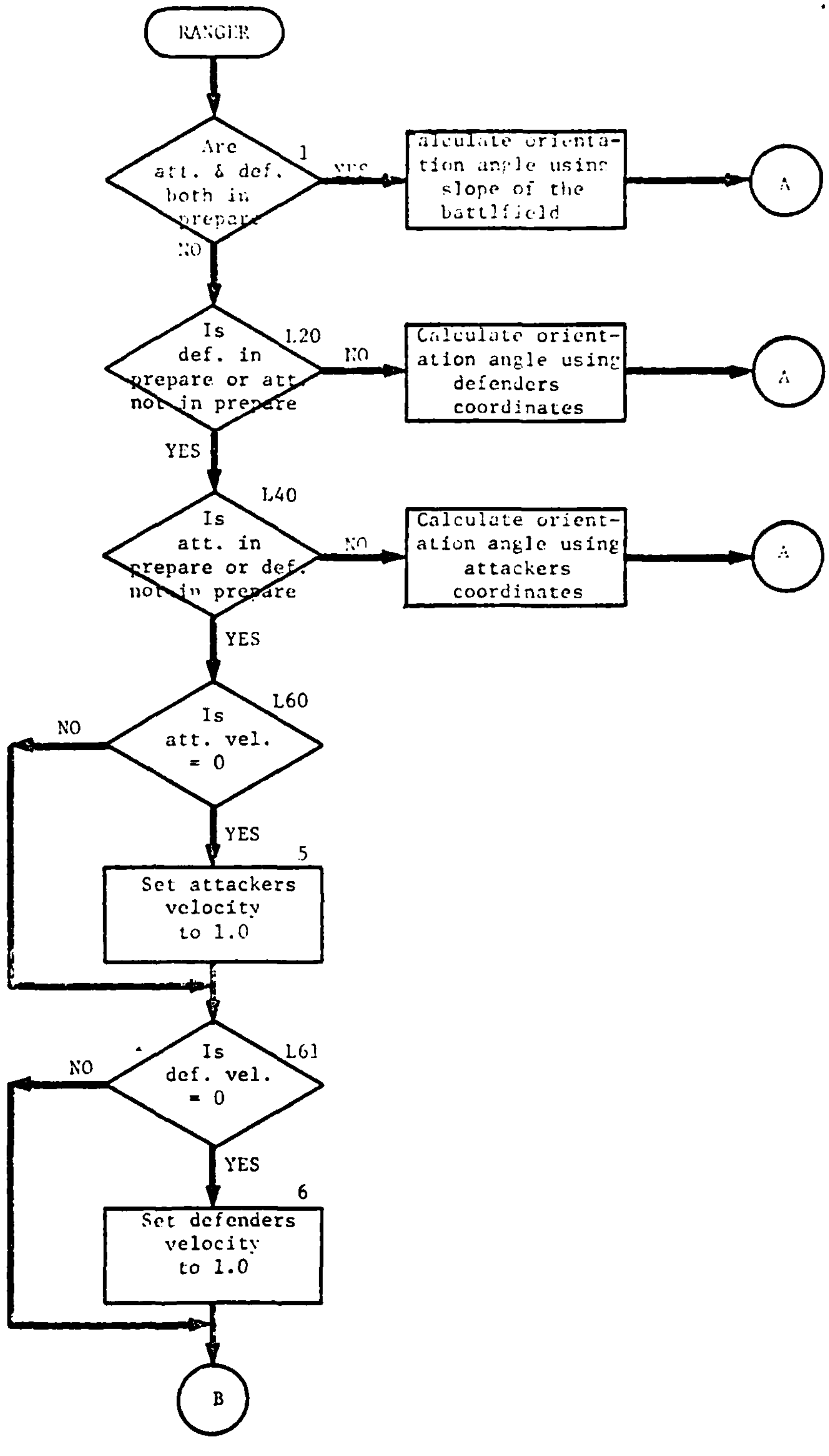
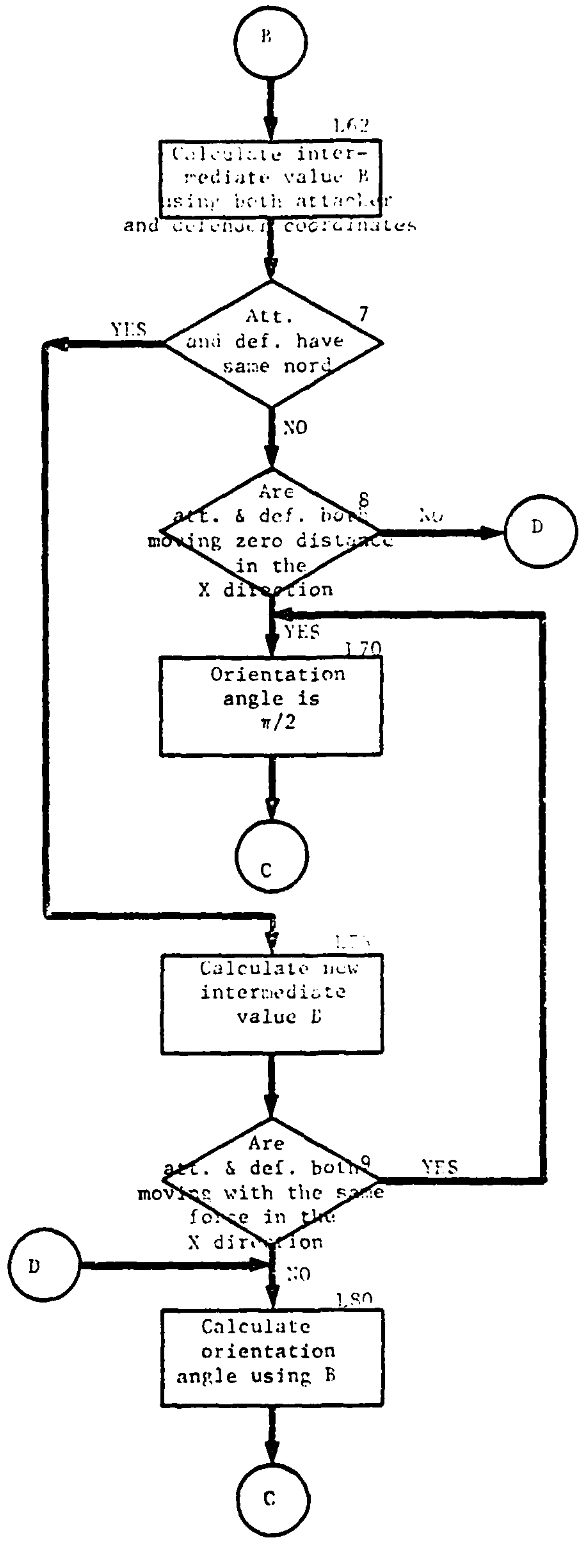
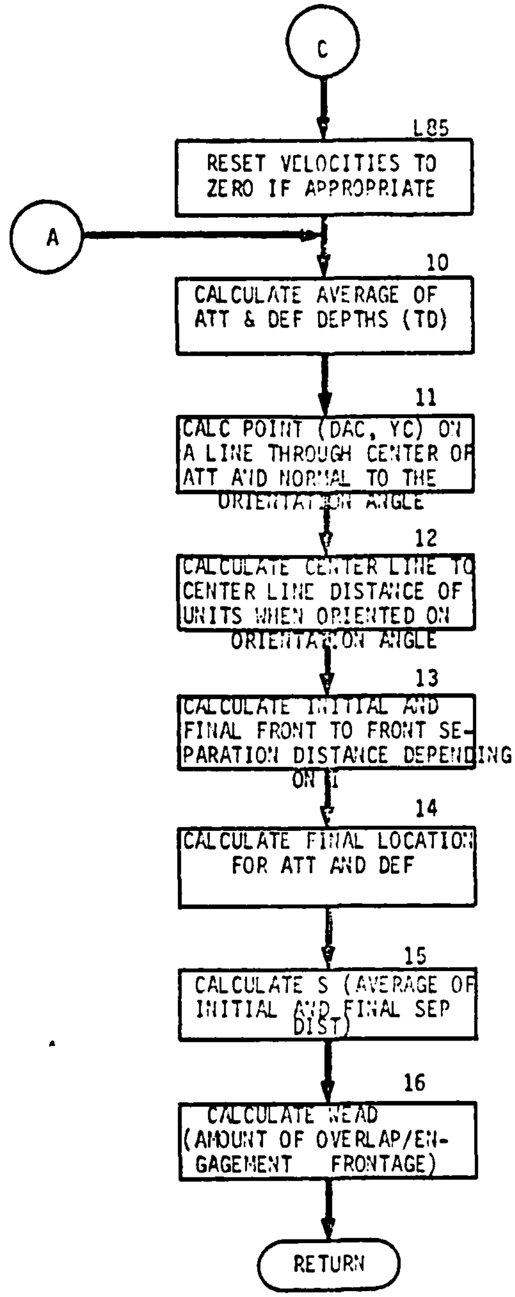


Figure IV-7-B-13. Routine RANGER.


B
162
Calculate inter-
mediate value B
using both attacker
and defender coordinates
7
Att.
and def. have
same nord
YES
NO
Are
att. & def. both
moving zero distance
in the
X direction
8
NO
D
YES
170
Orientation
angle is
π/2
C
Calculate new
intermediate
value B
Are
att. & def. both
moving with the same
force in the
X direction
9
YES
D
NO
180
Calculate
orientation
angle using B
C


C
L85
RESET VELOCITIES TO ZERO IF APPROPRIATE
A
10
CALCULATE AVERAGE OF ATT & DEF DEPTHS (TD)
11
CALC POINT (DAC, YC) ON A LINE THROUGH CENTER OF ATT AND NORMAL TO THE ORIENTATION ANGLE
12
CALCULATE CENTER LINE TO CENTER LINE DISTANCE OF UNITS WHEN ORIENTED ON ORIENTATION ANGLE
13
CALCULATE INITIAL AND FINAL FRONT TO FRONT SEPARATION DISTANCE DEPENDING ON I
14
CALCULATE FINAL LOCATION FOR ATT AND DEF
15
CALCULATE S (AVERAGE OF INITIAL AND FINAL SEP DIST)
16
CALCULATE WEAD (AMOUNT OF OVERLAP/ENGAGEMENT FRONTAGE)
RETURN

(2) Block 2. Calculate orientation angle using the slope of the battlefield (SLOPE), then go to block 10.

(3) Block L20. Is the defender in a PREPARE activity or is the attacker not in a PREPARE activity? If so, go to block L40.

(4) Block 3. Calculate orientation angle using the defender's locations and velocity, then go to block 10.

(5) Block L40. Is the attacker in a PREPARE activity or is the defender not in a PREPARE activity? If so, go to block L60.

(6) Block 4. Calculate orientation angle using the attacker's locations and velocity, then go to block 10.

(7) Block L60. Is the attacker's velocity equal to zero? If not, go to block L61.

(8) Block 5. Temporarily set the attacker's velocity equal to 1.0.

(9) Block L61. Is the defender's velocity equal to zero? If not, go to block L62.

(10) Block 6. Temporarily set the defender's velocity to 1.0.

(11) Block L62. Calculate an intermediate value B using both the attacker's and defender's locations and velocities.

(12) Block 7. Do the attacker and defender have the same NORD (activity)? If so, go to block L75.

(13) Block 8. Are both the attacker and defender moving zero distance in the X direction? If this is not so, go to block L80.

(14) Block L70. Set orientation angle equal to $\pi/2$, then go to block L85.

(15) Block L75. Calculate a new intermediate value for B.

(16) Block 9. Are the attacker and the defender both moving with the same force in the X direction? If so, go to block L70.

(17) Block L80. Calculate orientation angle using the intermediate value B.

(18) Block L85. Reset attacker's and defender's velocities to ZERO, if they were previously ZERO.

(19) Block 10. Calculate the average depth (TD) for attacker plus defender.

(20) Block 11. Calculate a point (XL, YL) which passes through the center of the attacking unit and is normal to the orientation angle.

(21) Block 12. Calculate the center line to center line distance when the units are oriented on the orientation angle.

(22) Block 13. Calculate the initial separation distance and final separation distance when I is equal to 1 and 2 respectively.

(23) Block 14. Calculate final locations for the attacker and the defender.

(24) Block 15. Calculate the separation distance (S) between the attacker and defender (average of initial and final separation distances).

(25) Block 16. Calculate WEAD, the amount of overlap (engagement frontage) between the attacker and defender when oriented on orientation angle, then RETURN.

14. ROUTINE WPNSET.

a. Purpose. WPNSET sets up various weapon/target/sensor counts for ground combat and limits unit velocity.

b. Input Variables:

Name	Source	Contents
IDUM (1-400)	TWO	GCM static data.
IDUM (401-652)	TWO	GCM constant data.
UMAIN (500)	ONE	Attacker's Unit Status File.
UCOOP (500)	ONE	Defender's Unit Status File.
FIL28A (189)	DF28	Attacker's item distribution table.
FIL28D (189)	DF28	Defender's item distribution table.

AUEOHA (202)	DF50	Attacker's authorized EOH table.
LSEOH2 (2000)	DF6	Attacker's/Defender's secondary EOH table.
AUEOHD (202)	DF50	Defender's authorized EOH table.
MODE	TWO	GCM MODE identificatioh number, located at IDUM (4099).

c. Output Variables:

Name	Destination	Contents
IGO	TWO	GCM termination condition flag, located at IDUM (4101).
ANSEN (10)	TWO	Total number of attacking unit's sensors, located at IDUM (267).
DNSEN (10)	TWO	Total number of defending unit's sensors, located at IDUM (287).
AMAUTA (16)	TWO	Number of attacker rounds authorized, located at IDUM (73).
AMAUTD (16)	TWO	Number of defender rounds authorized, located at IDUM (203).
AMINIA (16)	TWO	Number of attacker rounds on hand, located at IDUM (105).
AMINID (16)	TWO	Number of defender rounds on hand, located at IDUM (235).
AWEAP (8)	TWO	Number of weapons in attacker's front band, located at IDUM (121).
DWEAP (8)	TWO	Number of weapons in defender's front band, located at IDUM (251).
ATGT (8)	TWO	Number of weapon systems (transports) in attacker's front band, located at IDUM (159).
DTGT (8)	TWO	Number of weapon systems (transports) in defender's front band, located at IDUM (175).
VATT	TWO	Velocity of the attacker, located at IDUM (199).

VDEF	TWO	Velocity of the defender, located at IDUM (201).
MVRATE	ONE	Velocity of the attacker, located at UMAIN (264).
CMVRAT	ONE	Velocity of the defender, located at UCOOP (264).
UMAIN (500)	DF1	Attacker's Unit Status File.
UCOOP (500)	DF1	Defender's Unit Status File.

d. Logical Flow (Figure IV-7-B-14).

(1) Block 1. Get the attacker's item distribution table (FIL28A) from DF28.

(2) Block 2. Get the defender's item distribution table (FIL28D) from DF28.

(3) Block 3. Begin loop on eight weapon systems (transports).

(4) Block 4. Get item code of the first/next weapon system for the attacker from IEOHAT.

(5) Block 5. Is this item code valid? If not, go to block L50.

(6) Block 6. Calculate quantity (ATGT) of this item code that is located in the front band of the attacker by a call to routine DNUMBR.

(7) Block L50. Get the item code of the first/next weapon system for the defender from IEOHDT.

(8) Block 7. Is this item code valid? If not, go to block L100.

(9) Block 8. Calculate quantity (DTGT) of this item code that is located in the front band of the defender by a call to routine DNUMBR.

(10) Block L100. End of loop on 8 weapon systems (transports)? If not, go to block 4 to process next weapon system (if any).

(11) Block 9. Is GCM MODE less than or equal to 5? If so, go to block 11.

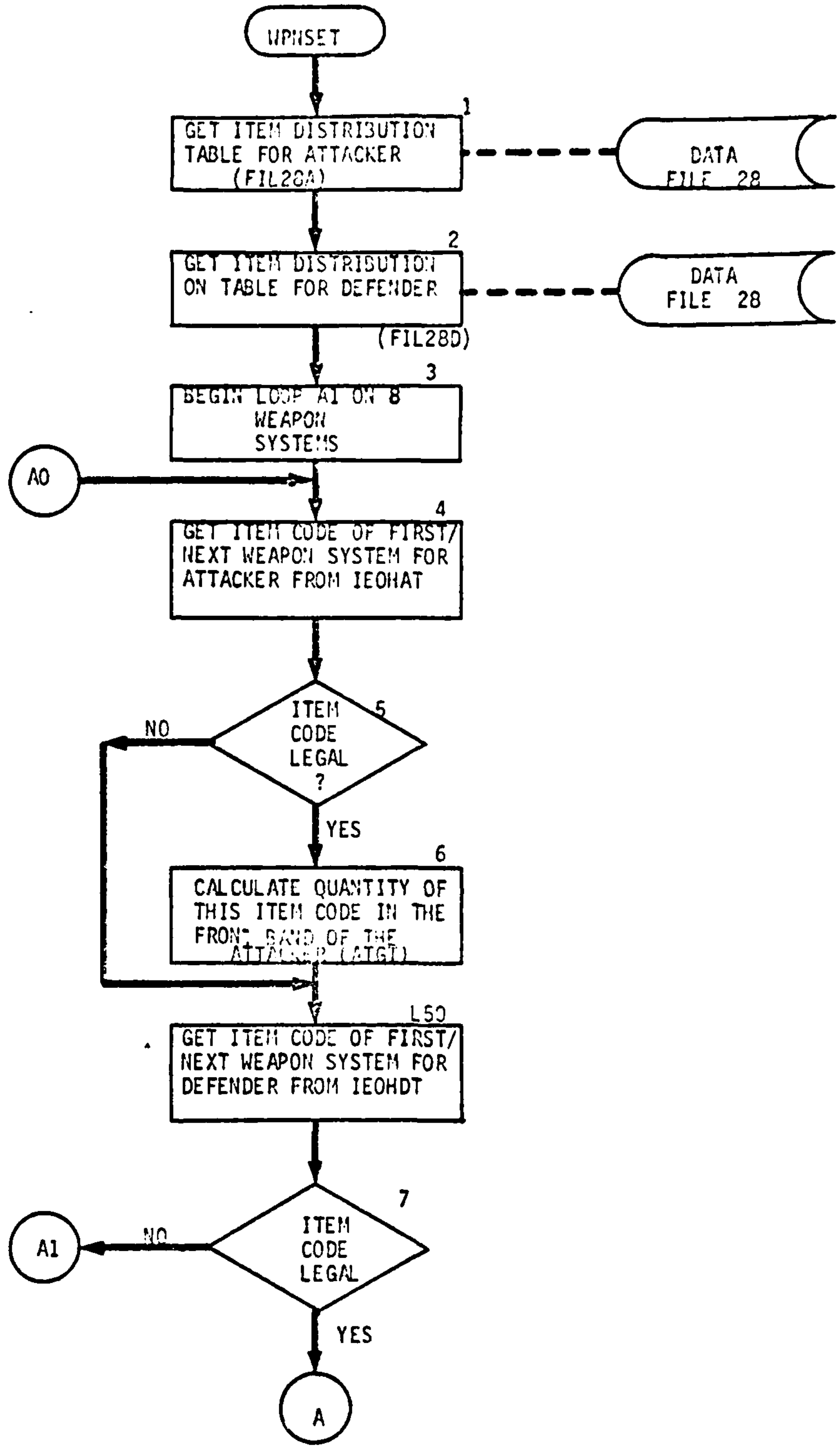
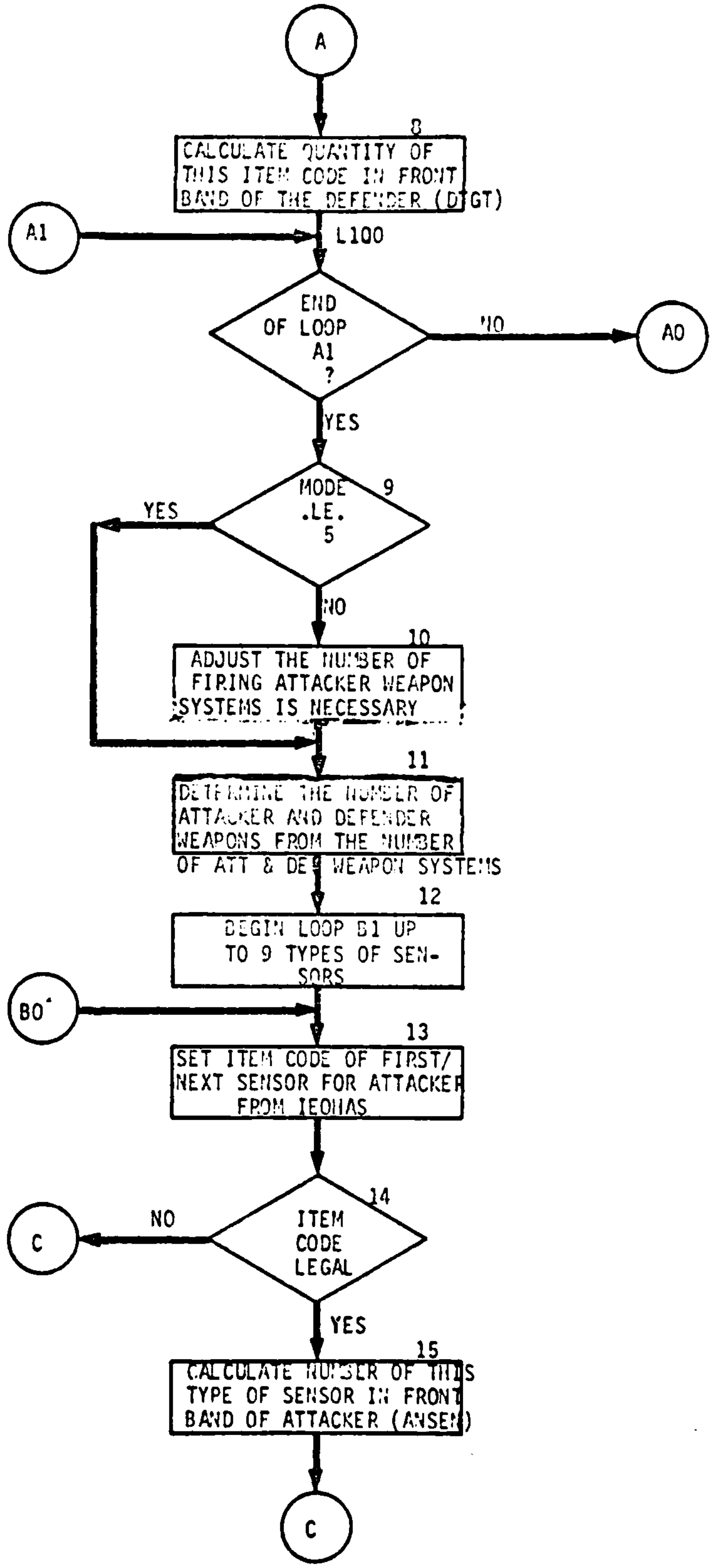
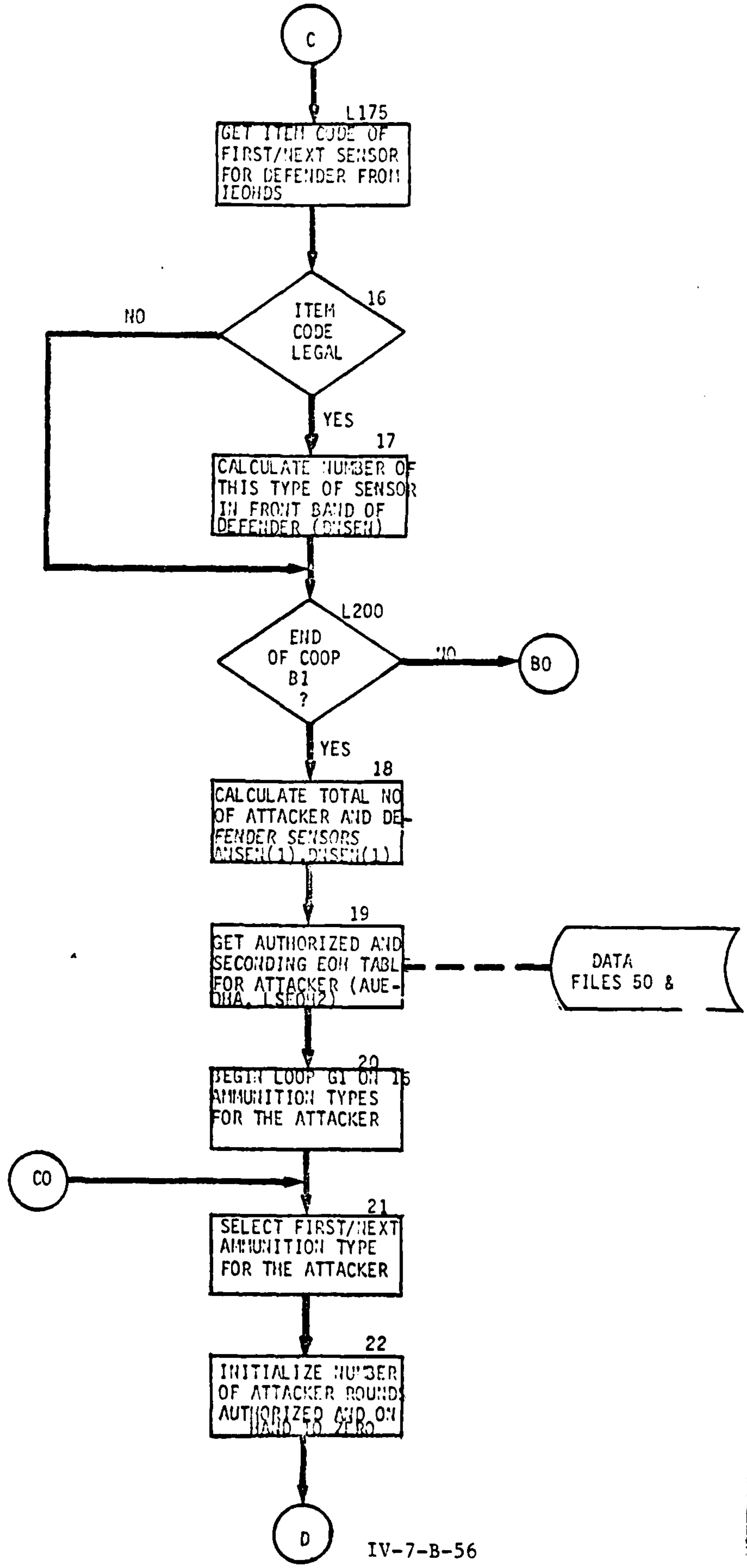
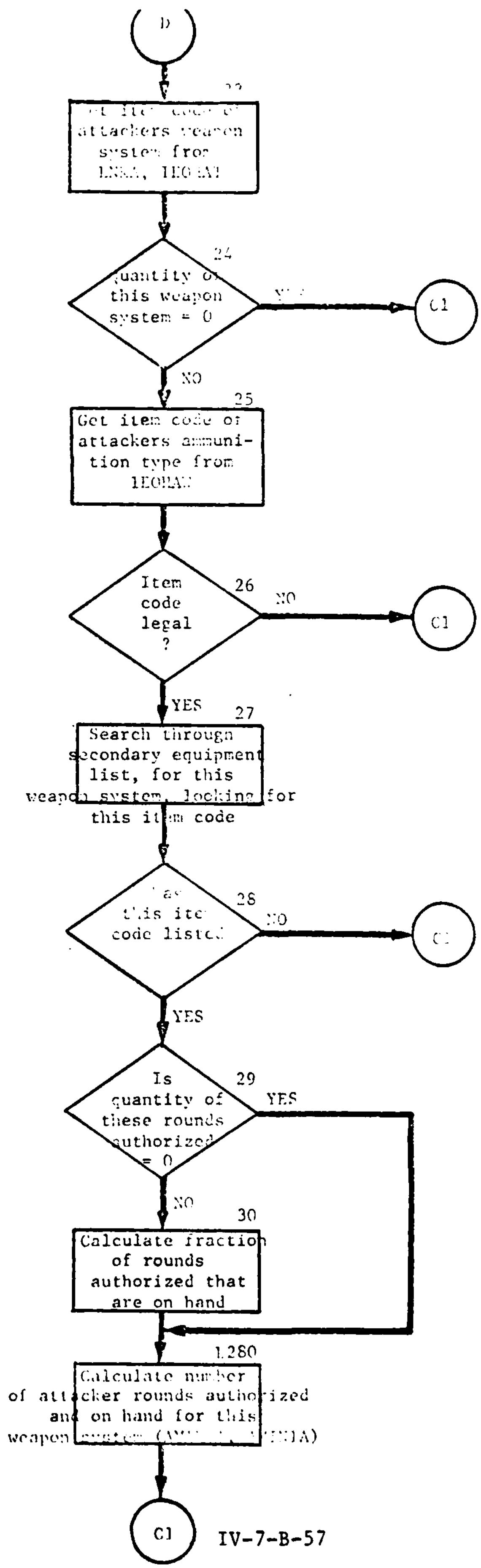
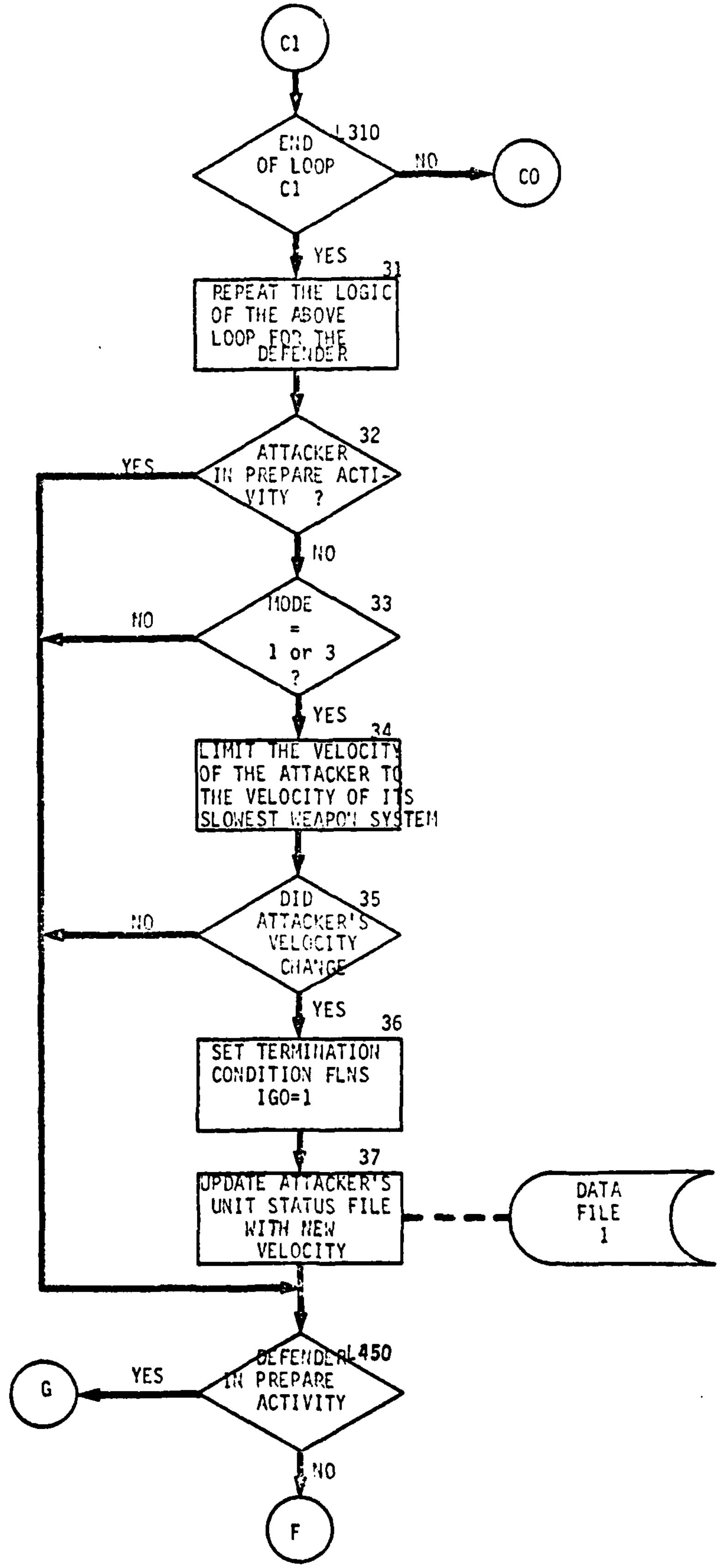


FIGURE IV-7-B-14   ROUTINE WPNSET

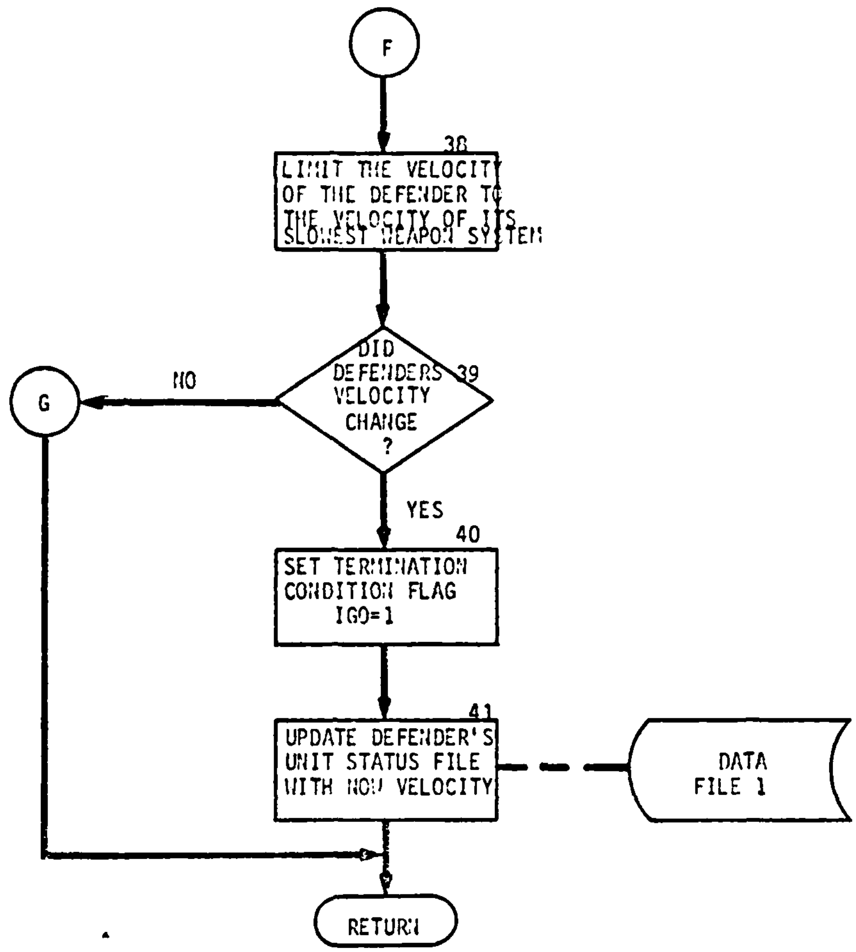

A
8
CALCULATE QUANTITY OF THIS ITEM CODE IN FRONT BAND OF THE DEFENDER (DTGT)
A1
L100
END OF LOOP A1 ?
NO
A0
YES
MODE .LE. 5
9
YES
NO
10
ADJUST THE NUMBER OF FIRING ATTACKER WEAPON SYSTEMS IS NECESSARY
11
DETERMINE THE NUMBER OF ATTACKER AND DEFENDER WEAPONS FROM THE NUMBER OF ATT & DEF WEAPON SYSTEMS
12
BEGIN LOOP B1 UP TO 9 TYPES OF SENSORS
B0
13
SET ITEM CODE OF FIRST/NEXT SENSOR FOR ATTACKER FROM IEQUAS
14
ITEM CODE LEGAL
NO
C
YES
15
CALCULATE NUMBER OF THIS TYPE OF SENSOR IN FRONT BAND OF ATTACKER (ANSEN)
C


C
L175
GET ITEM CODE OF FIRST/NEXT SENSOR FOR DEFENDER FROM ICONDS
16
ITEM CODE LEGAL
NO
YES
17
CALCULATE NUMBER OF THIS TYPE OF SENSOR IN FRONT BAND OF DEFENDER (DNSEN)
L200
END OF COOP B1 ?
NO
B0
YES
18
CALCULATE TOTAL NO OF ATTACKER AND DEFENDER SENSORS ANSEN(1), DNSEN(1)
19
GET AUTHORIZED AND SECONDING EOH TABLE FOR ATTACKER (AUEOHA, LSEOH2)
DATA FILES 50 &
20
BEGIN LOOP G1 ON 16 AMMUNITION TYPES FOR THE ATTACKER
C0
21
SELECT FIRST/NEXT AMMUNITION TYPE FOR THE ATTACKER
22
INITIALIZE NUMBER OF ATTACKER ROUNDS AUTHORIZED AND ON HAND TO ZERO
D


D
24
quantity of this weapon system = 0
C1
NO
25
Get item code of attackers ammunition type from
26
Item code legal ?
NO
C1
YES
27
Search through secondary equipment list, for this weapon system, looking for this item code
28
this item code listed
NO
YES
29
Is quantity of these rounds authorized = 0
YES
NO
30
Calculate fraction of rounds authorized that are on hand
1.280
Calculate number of attacker rounds authorized and on hand for this weapon
C1



C1
END OF LOOP C1
L310
NO
CO
YES
31
REPEAT THE LOGIC OF THE ABOVE LOOP FOR THE DEFENDER
32
ATTACKER IN PREPARE ACTIVITY ?
YES
NO
33
MODE = 1 or 3 ?
NO
YES
34
LIMIT THE VELOCITY OF THE ATTACKER TO THE VELOCITY OF ITS SLOWEST WEAPON SYSTEM
35
DID ATTACKER'S VELOCITY CHANGE
NO
YES
36
SET TERMINATION CONDITION FLNS IGO=1
37
UPDATE ATTACKER'S UNIT STATUS FILE WITH NEW VELOCITY
DATA FILE 1
L450
DEFENDER IN PREPARE ACTIVITY
YES
G
NO
F


F
38
LIMIT THE VELOCITY OF THE DEFENDER TO THE VELOCITY OF ITS SLOWEST WEAPON SYSTEM
DID DEFENDERS VELOCITY CHANGE ?
39
NO
G
YES
40
SET TERMINATION CONDITION FLAG IGO=1
41
UPDATE DEFENDER'S UNIT STATUS FILE WITH NOW VELOCITY
DATA FILE 1
RETURN

(12) Block 10. Adjust the number of firing attacker weapon systems if so dictated by IOUT.

(13) Block 11. Determine the number of attacker and defender weapons from the number of attacker and defender weapon systems (transports).

(14) Block 12. Begin loop of up to 9 types of sensors.

(15) Block 13. Get the item code of the first/next sensor for the attacker from IEOHAS.

(16) Block 14. Is the item code valid? If not, go to block L175.

(17) Block 15. Calculate how many of the attacking unit's sensors with this item code are in the front band of the attacker by a call to DNUMBR.

(18) Block L175. Get the item code of the first/next sensor for the defender from IEOHDS.

(19) Block 16. Is the item code valid? If not, go to block L200.

(20) Block 17. Calculate how many of the defending unit's sensors with this item code are in the front band of the defender by a call to DNUMBR.

(21) Block L200. End of loop on up to 9 types of sensors? If not, go to block 13 to process next sensor type (if any).

(22) Block 18. Calculate total number of attacker, and total number of defender weapon systems and save in ANSEN(1) and DNSEN(1).

(23) Block 19. Get authorized (AUEOHA) and secondary (LSEOH2) EOH tables from Data File 50 and data file 6 respectively.

(24) Block 20. Begin loop on 16 ammunition types for the attacker.

(25) Block 21. Select first/next ammunition type for the attacker.

(26) Block 22. Initialize the number of attacker rounds authorized (AMAUTA) and number of attacker rounds on hand (AMINIA) to ZERO.

(27) Block 23. Get item code of attacker's weapon system using LNKA and IEOHAT.

(28) Block 24. Is the quantity of this attacker's weapon system that is on hand equal to zero? If so, go to block L310.

(29) Block 25. Get item code of the attacker's ammunition type from IEOHAW.

(30) Block 26. Is the item code valid? If not, go to block L310.

(31) Block 27. Search through secondary equipment list for this weapon system, looking for this item code.

(32) Block 28. Was this item code (for ammunition) listed as secondary equipment for this weapon system? If not, go to block L310.

(33) Block 29. Is the amount (number of rounds) of this ammunition type authorized equal to ZERO? If so, go to block L280.

(34) Block 30. Calculate faction of rounds authorized that are on hand (FRAC).

(35) Block L280. Calculate number of attacker rounds authorized and on hand for this weapon system (AMAUTA and AMINIA).

(36) Block L310. End of loop on 16 ammunition types for the attacker? If not, go to block to process the next ammunition type (if any).

(37) Block 31. Repeat the above logic for the defender to calculate his number of rounds authorized and on hand (AMAUTD and AMINID).

(38) Block 32. Is the attacker in a PREPARE activity (NORD=2)? If so, go to block L450.

(39) Block 33. Is the GCM mode equal to 1 or 3? If not, go to block L450.

(40) Block 34. Limit the velocity of the attacking unit to the velocity of his slowest weapon system (transport).

(41) Block 35. Did the velocity of the attacker change? If not, go to block L450.

(42) Block 36. Set termination condition flag to 1 (IGO=1).

(43) Block 37. Update attacker's Unit Status File on Data File 1 to reflect his new velocity.

(44) Block L450. Is the defender in a PREPARE activity? If so, RETURN.

(45) Block 38. Limit the velocity of the defender to the velocity of his slowest weapon system (transport).

(46) Block 39. Did the velocity of the defender change? If not, RETURN.

(47) Block 40. Set termination condition flag to 1 (IGO=1).

(48) Block 41. Update defenders Unit Status File on Data File 1 to reflect his new velocity.

15. ROUTINE VISSET

a. Purpose. VISSET calculates the visibility, sky-ground ratio, and weapon system intrinsic contrasts for the attacker and defender.

b. Input Variables:

Name	Source	Contents
IWETH	DF4	Weather index for current time of day and location.
SUNRIS	ONE	Time of sunrise.
SUNSET	ONE	Time of sunset.
SKGR(3)	TWO	Sky-ground ratio data.
ATREF(8)	TWO	Reflectance of attacker's eight weapon systems (transports).
DTREF(8)	TWO	Reflectance of defender's eight weapon systems (transports).

c. Output Variables:

Name	Destination	Contents
IVIS	TWO	Visibility (in meters), located at IDUM (376).
ATBETA	TWO	Visibility factor, located at IDUM (35).
MODSNS	TWO	Day/night indicator, located at IDUM (158).
ASKGR	TWO	Attacking unit's sky-ground ratio, located at IDUM (71).
COA(8)	TWO	Intrinsic constrasts of 8 attacking weapon systems (transports), located at IDUM (39).
COD(8)	TWO	Intrinsic contrasts of 8 defending weapon systems (transports) ted at IDUM (1).

d. Logical Flow (Figure IV-7-B-15).

(1) Block 1. Call routine IOWETH to obtain weather index for current location and time of day.

(2) Block 2. Calculate visibility according to weather index.

(3) Block 3. Calculate current militaty time of day.

(4) Block 4. Is it daytime? If so, go to block 6.

(5) Block 5. Set attacker and defender sky-ground ratios to 1.0, then go to block 12.

(6) Block 6. Calculate the direction the attacker is facing.

(7) Block 7. Is it exactly 1200 hrs? If not, go to block 9.

(8) Block 8. Calculate attacker and defender sky-ground ratios, and set equal, then go to block 12.

(9) Block 9. Calculate intermediate values depending on current time of day.

(10) Block 10. Is the attacker facing east? If so, go to block L60.

(11) Block 11. Is it morning? If so, go to block L65. If not, go to block L55.

(12) Block L60. Is it morning? If so, go to block L55.

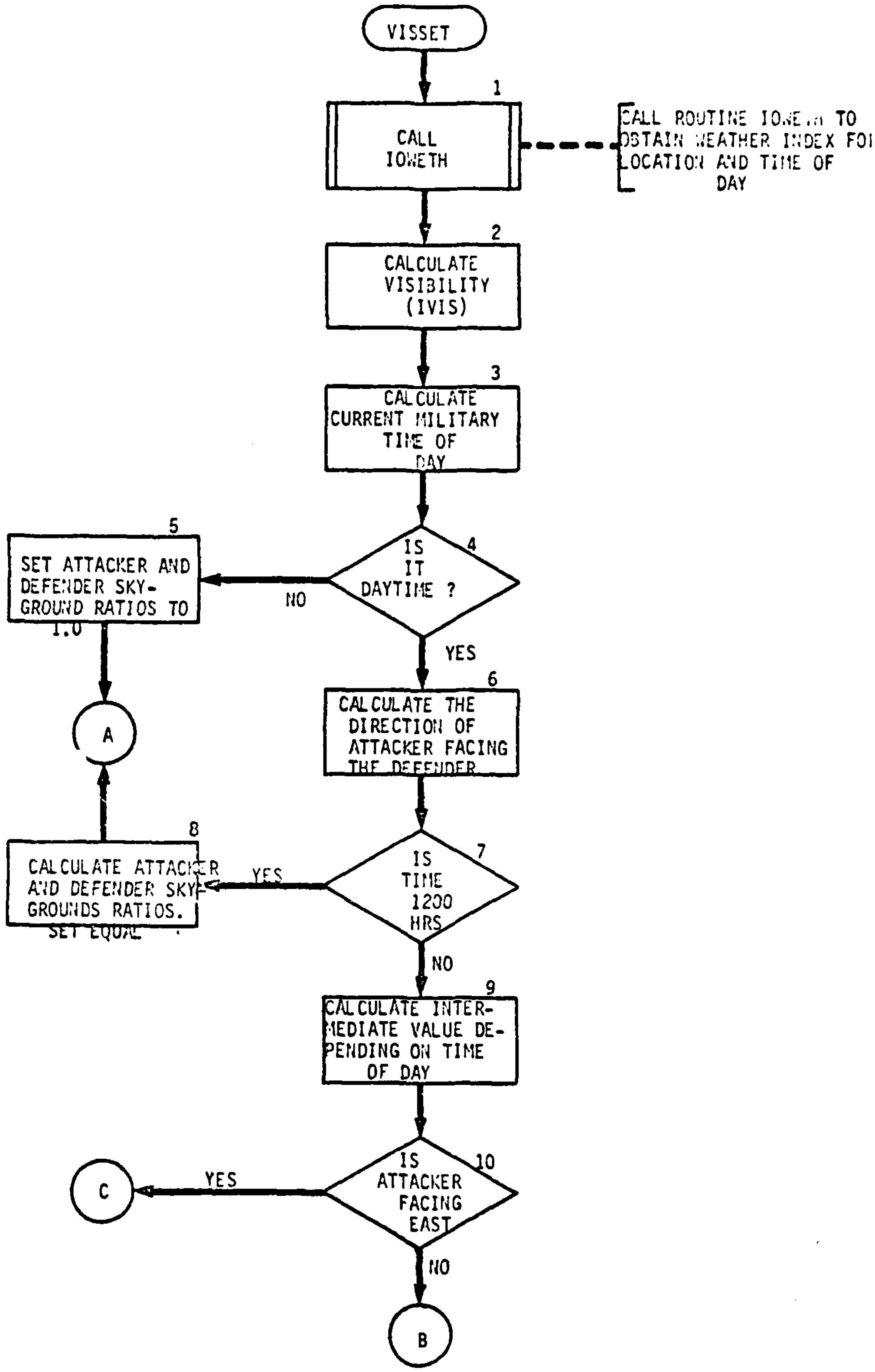
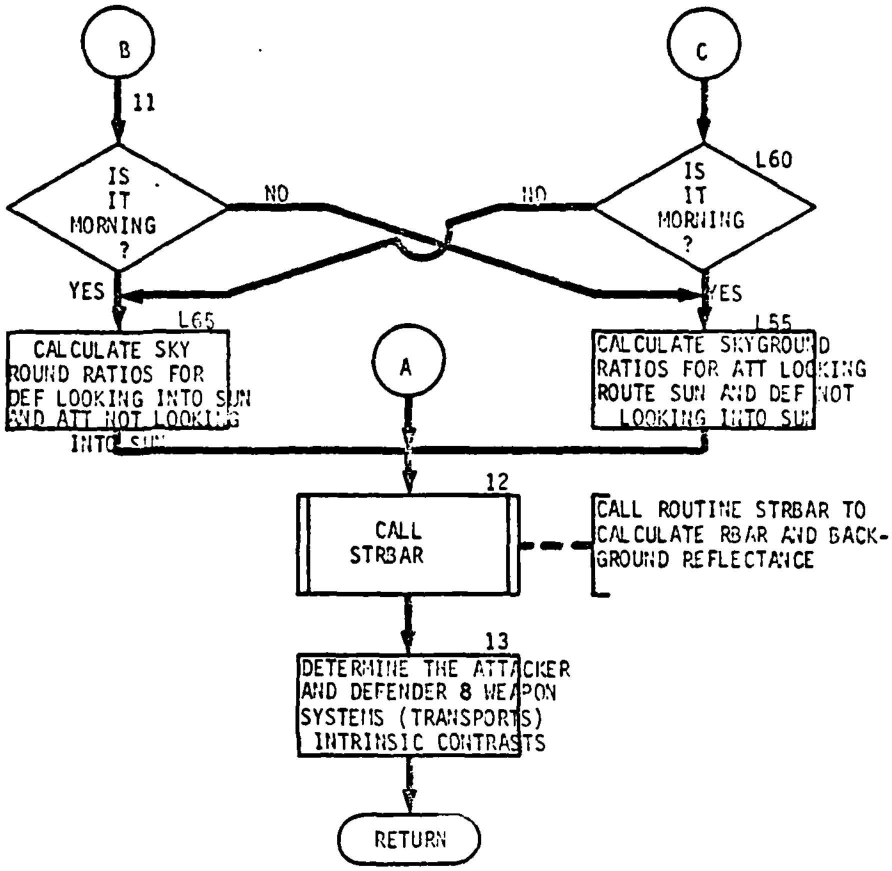


FIGURE IV-V-B-15 ROUTINE VISSET


B
C
11
IS
IT
MORNING
?
NO
L60
YES
L65
CALCULATE SKY
ROUND RATIOS FOR
DEF LOOKING INTO SUN
AND ATT NOT LOOKING
INTO SUN
A
L55
CALCULATE SKYGROUND
RATIOS FOR ATT LOOKING
ROUTE SUN AND DEF NOT
LOOKING INTO SUN
12
CALL
STRBAR
CALL ROUTINE STRBAR TO
CALCULATE RBAR AND BACK-
GROUND REFLECTANCE
13
DETERMINE THE ATTACKER
AND DEFENDER 8 WEAPON
SYSTEMS (TRANSPORTS)
INTRINSIC CONTRASTS
RETURN

(13) Block L65. Calculate sky-ground ratios for the defender looking into the sun, then go to block 12.

(14) Block L55. Calculate sky-ground ratios for the attacker looking into the sun.

(15) Block 12. Call routine STRBAR to calculate RBAR and background reflectance.

(16) Block 13. Calculate the attacker and defender weapon system (transport) intrinsic constrasts, then RETURN.

16. ROUTINE MODSET

a. Purpose. MODSET modifies data for various GCM modes and puts this data out on Data File 16.

b. Input Variables:

Name	Source	Contents
IGO	TWO	Flag indicating change in velocities by routine WPNSET. (1=change, 2=no change).
MODE	TWO	GCM MODE identification number.
SINIT	TWO	Initial front to front separation distance.
SFINAL	TWO	Final front to front separation distance.
S	TWO	Average of initial and final front to front separation distance.
ISEP	TWO	Minimum separation distance.
ROUT(64)	ONE	Unit locations located at ROOT(10-13).
VATT	TWO	Velocity of the attacker.
VDEF	TWO	Velocity of the defender.
WEAD	TWO	Amount of overlap between attacker and defender (engagement frontage).

c. Output Variables:

Name	Destination	Contents
IGO	TWO	Termination condition flag, located at IDUM (4101).

SINIT	TWO	Initial front to front separation, located at IDUM (370).
SFINAL	TWO	Final front to front separation, located at IDUM (372).
S	TWO	Average of initial and final front to front separation.
VATT	TWO	Velocity of the attacker, located at IDUM (199).
VDEF	TWO	Velocity of the defender, located at IDUM (201).
MURATE	DF1	Attacker's movement rate.
CMVRAT	DF1	Defender's movement rate.
IDUM(1-394)	DF16	GCM static data.

d. Logical Flow (Figure IV-7-B-16).

(1) Block 1. Is GCM MODE equal to 2? If so, go to block L175.

(2) Block 2. Is GCM MODE equal to 9? If so, go to block L125.

(3) Block 3. Is GCM MODE equal to 5? If so, go to block L100.

(4) Block L25. Was attacker's or defender's velocity changed by routine WPNSET (IGO=1)? If not, go to block L35.

(5) Block L30. Call routine RANGER to determine new engagement geometry.

(6) Block L35. Is initial front to front separation greater than established minimum separation distance (ISEP)? If so, go to block L45.

(7) Block 4. Is final front to front separation distance greater than or equal to initial front to front separation distance? If so, go to block L175.

(8) Block 5. Is GCM MODE equal to 3? If so, return. If not, go to block L60.

(9) Block L45. Is final front to front separation distance greater than established minimum separation distance? If so, go to block 18.

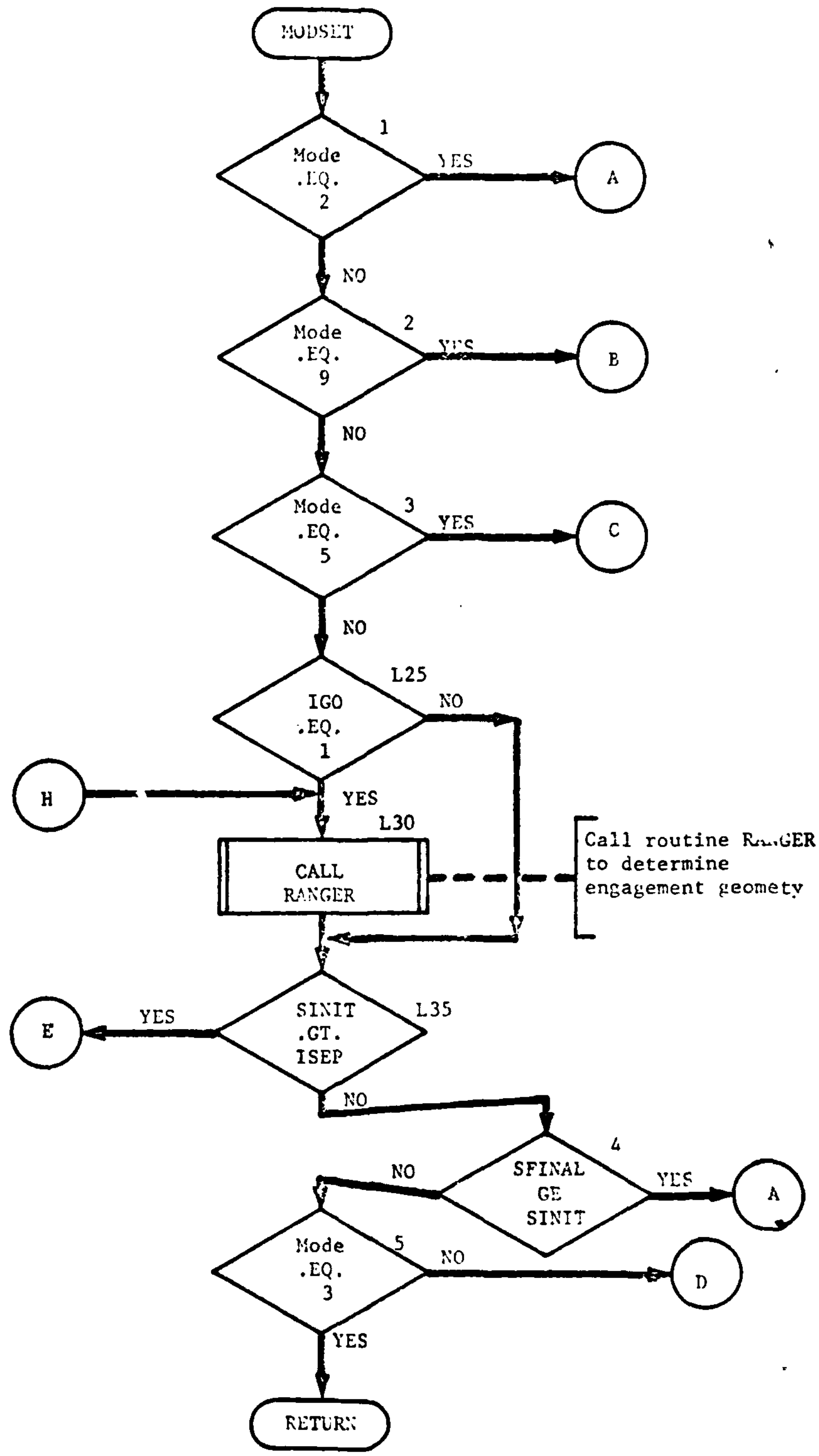
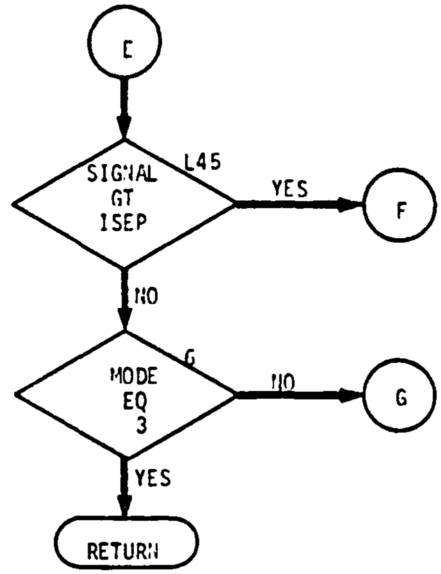
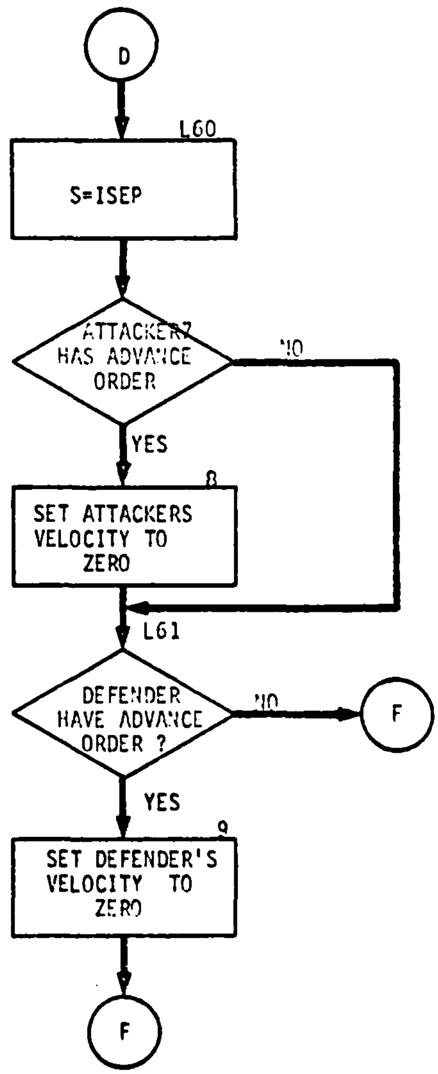
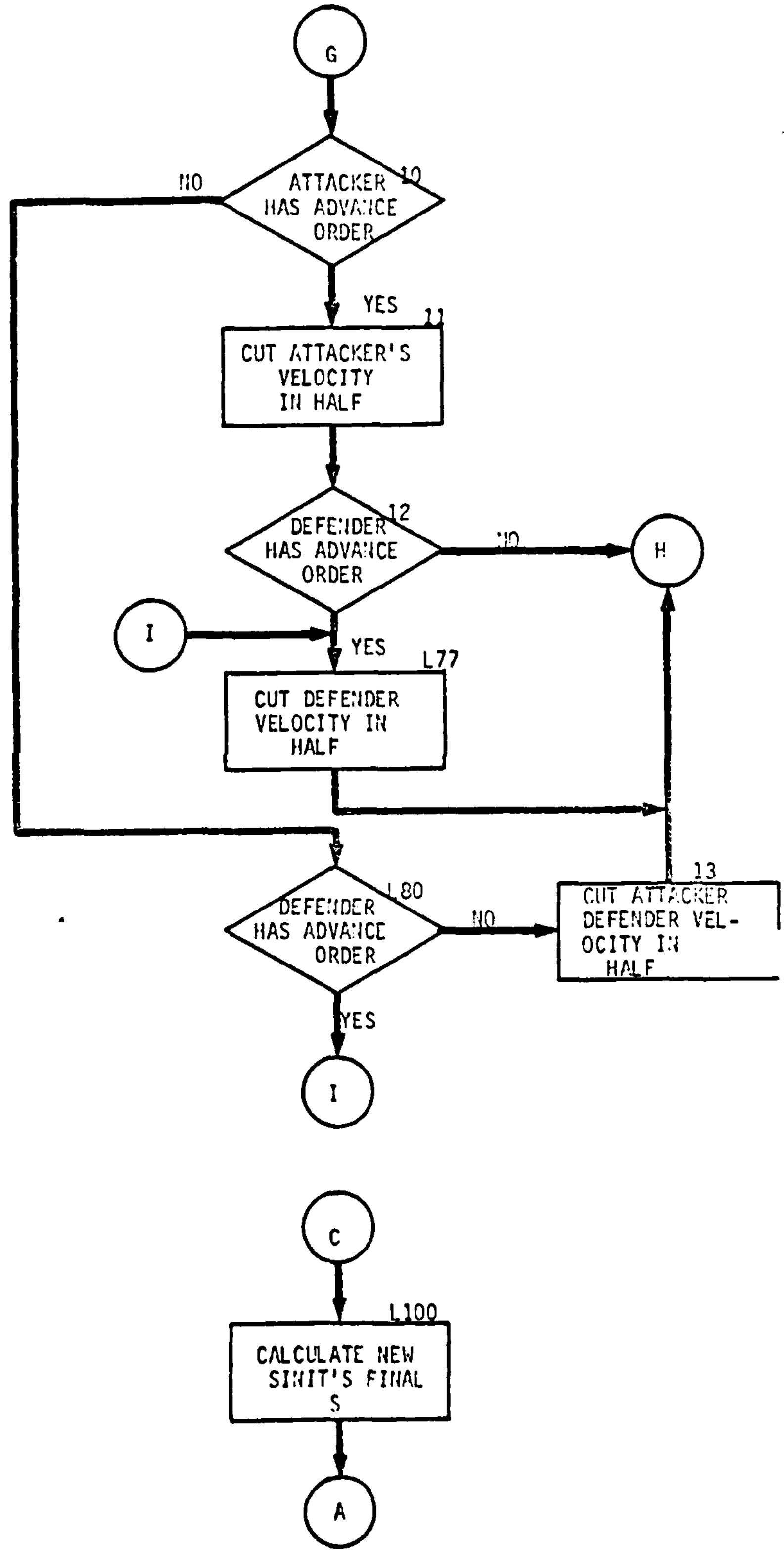
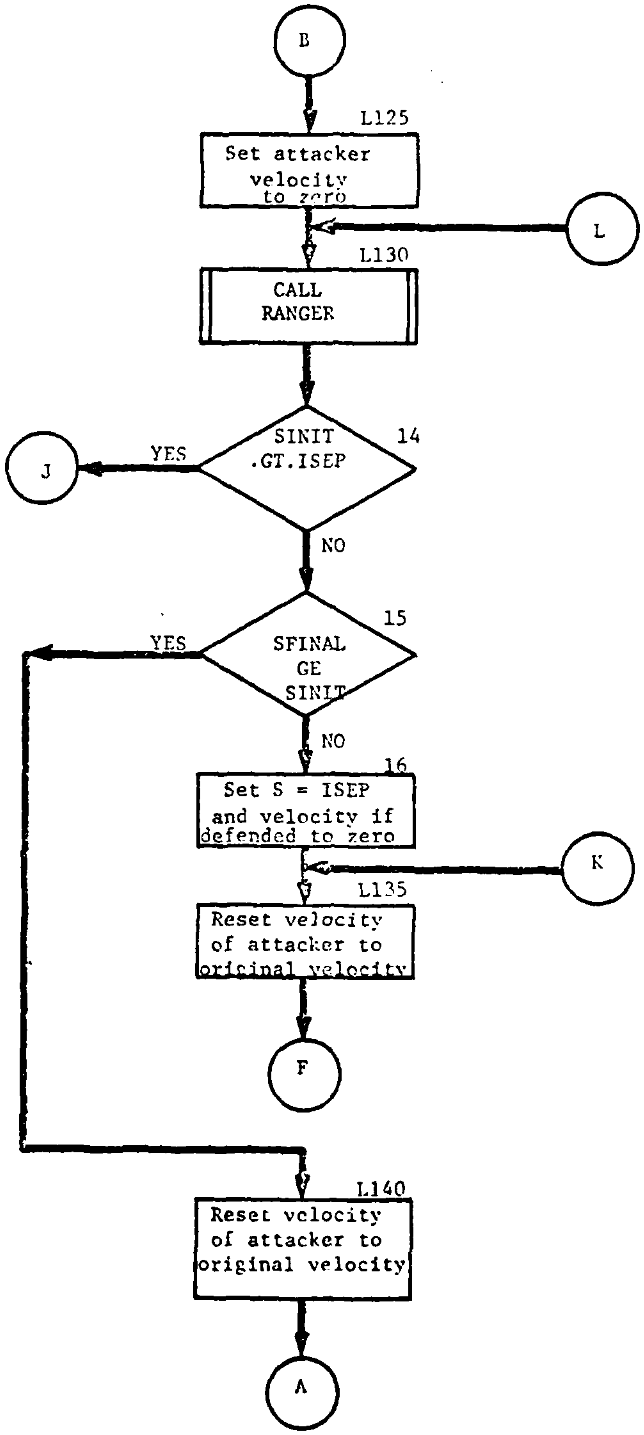


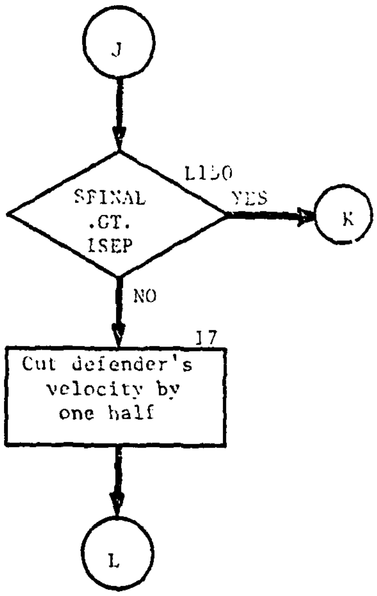
Figure IV-7-B-16. Routine MODSET.

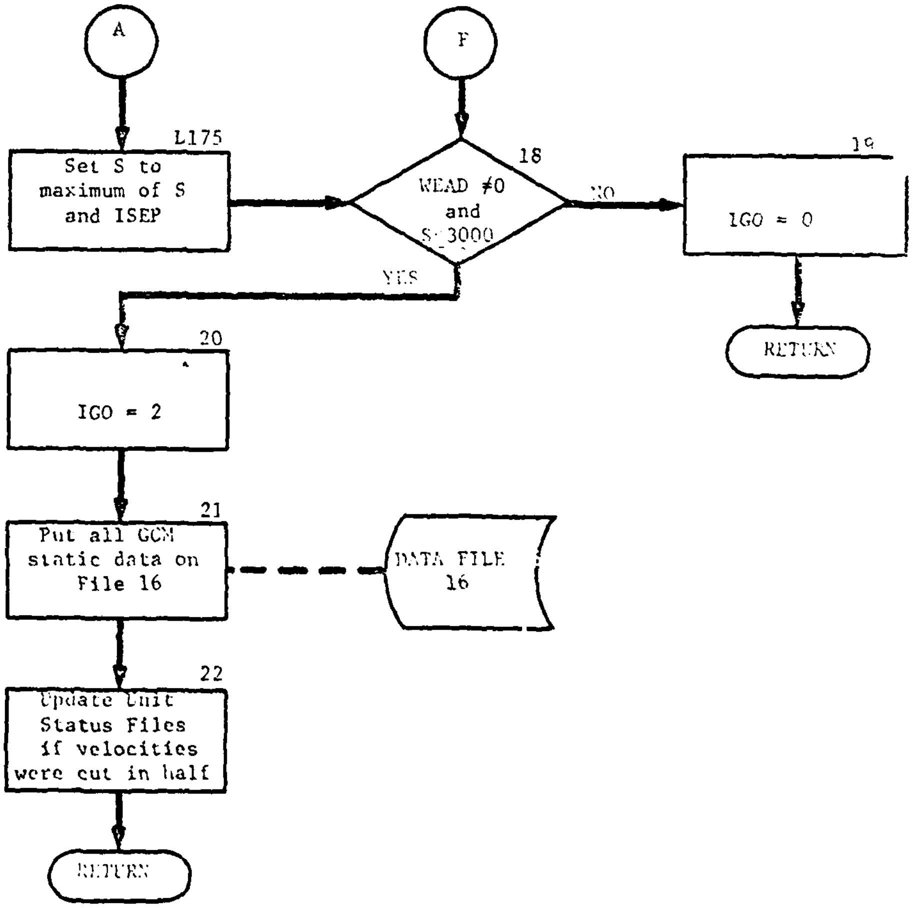

E
SIGNAL GT ISEP
L45
YES
F
NO
MODE EQ 3
6
NO
G
YES
RETURN


D
L60
S=ISEP
ATTACKER? HAS ADVANCE ORDER
NO
YES
8
SET ATTACKERS VELOCITY TO ZERO
L61
DEFENDER HAVE ADVANCE ORDER ?
NO
F
YES
9
SET DEFENDER'S VELOCITY TO ZERO
F


G
NO
ATTACKER HAS ADVANCE ORDER
10
YES
11
CUT ATTACKER'S VELOCITY IN HALF
DEFENDER HAS ADVANCE ORDER
12
NO
H
I
YES
L77
CUT DEFENDER VELOCITY IN HALF
DEFENDER HAS ADVANCE ORDER
L80
NO
13
CUT ATTACKER DEFENDER VELOCITY IN HALF
YES
I
C
L100
CALCULATE NEW SINIT'S FINAL S
A


B
L125
Set attacker velocity to zero
L
L130
CALL RANGER
SINIT .GT.ISEP
14
YES
J
NO
SFINAL GE SINIT
15
YES
NO
16
Set S = ISEP and velocity if defended to zero
K
L135
Reset velocity of attacker to original velocity
F
L140
Reset velocity of attacker to original velocity
A


J
SFINAL
.GT.
ISEP
L150
YES
K
NO
17
Cut defender's
velocity by
one half
L


A
F
L175
Set S to
maximum of S
and ISEP
18
WEAD ≠0
and
NO
19
IGO = 0
RETURN
YES
20
IGO = 2
21
Put all GCM
static data on
File 16
DATA FILE
16
22
Update Unit
Status Files
if velocities
were cut in half
RETURN

(11) Block L60. Set front to front separation to established minimum separation distance.

(12) Block 7. Does the attacker have an ADVANCE order (NORD=6)? If not, go to block L61.

(13) Block 8. Set attacker's velocity to ZERO.

(14) Block L61. Does the defender have an ADVANCE order (CNORD=6)? If not, go to block 18.

(15) Block 9. Set defender's velocity to ZERO, then go to block 18.

(16) Block 10. Does the attacker have an ADVANCE order (NORD=6)? If not, go to block L80.

(17) Block 11. Cut attacker's velocity in half.

(18) Block 12. Does defender have an ADVANCE order (CNORD=6)? If not, go to block L30.

(19) Block L77. Cut defender's velocity in half, then go to block L30.

(20) Block L80. Does the defender have an ADVANCE order (CNORD=6)? If so, go to block L77.

(21) Block 13. Cut attacker's and defender's velocity in half, then go to block L30.

(22) Block L100. Calculate new initial, final, and average front to front separation distances by calls to routine RANGER, then go to block 31.

(23) Block L125. Set attacker's velocity to ZERO.

(24) Block L130. Call routine RANGER to calculate new separation distances.

(25) Block 14. Is the initial front to front separation distance greater than the established minimum separation distance? If so, go to block L150.

(26) Block 15. Is the final front to front separation distance greater than or equal to the initial front to front separation distance? If so, go to block 28.

(27) Block 16. Set average front to front separation distance to the established minimum separation distance, and the velocity of the defender to zero.

(28)	Block L135.	Reset the attacker's velocity to original velocity, then go to block 18.
(29)	Block L140.	Reset the attacker's velocity to original velocity, then go to block L175.
(30)	Block L150.	Is the final front to front separation distance greater than the established minimum separation distance? If so, go to block L135.
(31)	Block 17.	Cut defender's velocity in half, then go to block 23.
(32)	Block L175.	Set average separation distance to the mimimum separation distance if this minimum separation distance is greater.
(33)	Block 18.	If WEAD = 0 and S $\leq$ 3000, go to block 20.
(34)	Block 19.	Set termination condition flag to zero then RETURN.
(35)	Block 20.	Set flag indicating no termination condition has been determined (IGO=2).
(36)	Block 21.	Call routine PUT to place GCM static data into DF16.
(37)	Block 22.	Update Unit Status Files for the attacker and defender if their velocities were cut in half, then RETURN.

17. ROUTINE STRBAR

a. Purpose. STRBAR calculates the roughness and vegetation index, forestation index, background reflectance, and RBAR's for the attacker and defender.

b. Input Variables:

Name	Source	Contents
TRECRD(10)	DF3	Terrain record.
BKGREP(3,3)	TWO	Background reflectance table.
RBAR(4,4)	TWO	Line-of-sight parameter table.
ITYPA(8)	TWO	Weapon system (transport) types for the attacker.

ITYPD(8)	TWO	Weapon system (transport) types for the defender.

c. Output Variable:

Name	Destination	Contents
IAVRF	TWO	Pack average roughness and forestation indexes for the attacker and defender.
ARBAR(8,2)	TWO	Line-of-sight parameters for attackers weapon systems (transports), located at IDUM (55).
DRBAR(8,2)	TWO	Line-of-sight parameters for defenders weapon systems (transports), located at IDUM (17).
ABKGRF	TWO	Attacker's background reflectance, located at IDUM (297).
DBKGRF	TWO	Defender's background reflectance, located at IDUM (299).

d. Logical Flow (Figure IV-7-B-17).

(1) Block 1. Set attacker/defender completion flag (IATDEF) to 1.

(2) Block 2. Calculate coordinates of the front corner points of the attacker, then go to block L520.

(3) Block L500. Set attacker/defender completion flag to 2.

(4) Block 3. Calculate coordinates of the front corner points of the defender.

(5) Block L520. Call routine CELLST to get a list of all terrain cells that are along the leading edge of the attacker/defender.

(6) Block 4. Calculate the sum of roughness and vegetation, and forestation indexes along the leading edge.

(7) Block 5. Calculate the average roughness and vegetation, and forestation indexes.

(8) Block 6. Pack these indexes into one word.

(9) Block 7. Calculate good/bad index for roughness, vegetation and forestation.

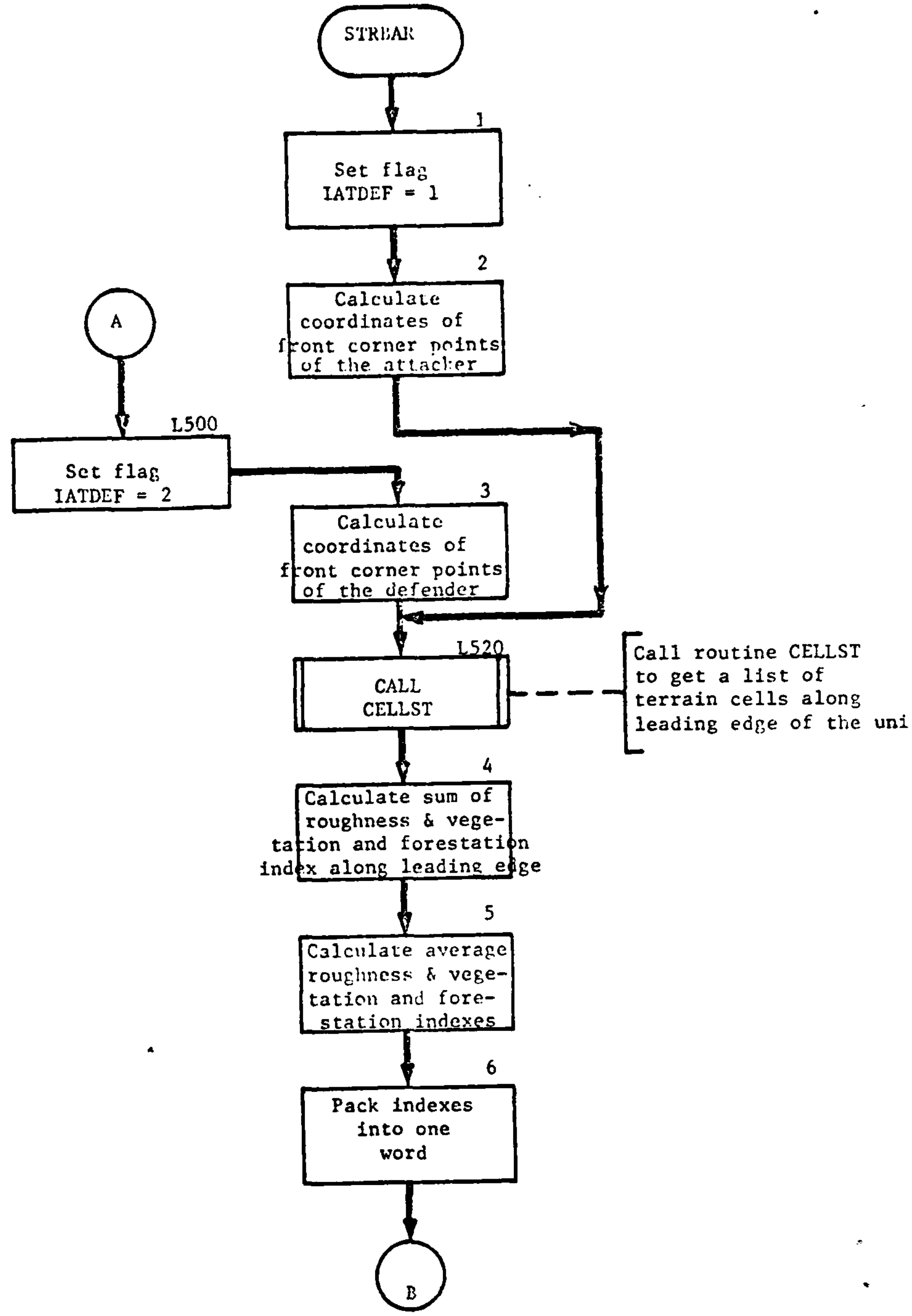
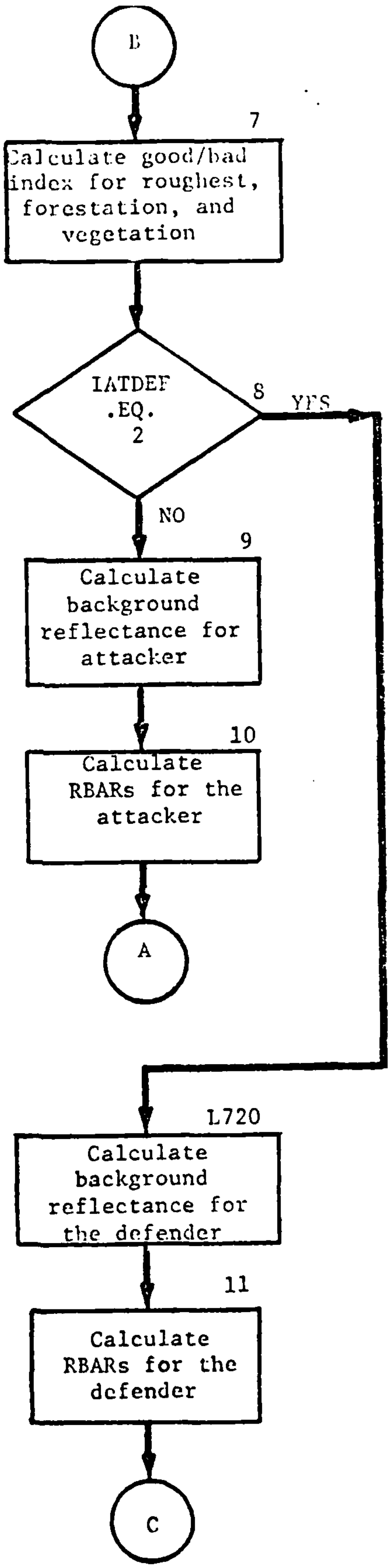
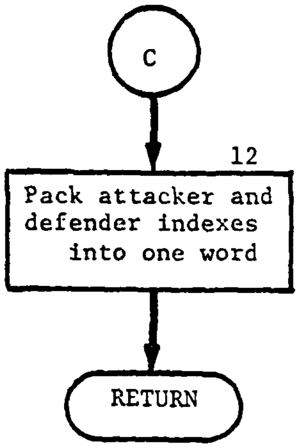


Figure IV-7-B-17. Routine STRBAR.


B
7
Calculate good/bad index for roughest, forestation, and vegetation
IATDEF .EQ. 2
8
YES
NO
9
Calculate background reflectance for attacker
10
Calculate RBARs for the attacker
A
L720
Calculate background reflectance for the defender
11
Calculate RBARs for the defender
C


C
12
Pack attacker and defender indexes into one word
RETURN

(10) Block 8. Has the attacker already been processed (IATDEF= 2)? If so, go to block L720.

(11) Block 9. Calculate background reflectance for the attacker.

(12) Block 10. Calculate line-of-sight parameters for attacker's weapon systems (transports), then go to block L500.

(13) Block L720. Calculate background reflectance for the defender.

(14) Block 11. Calculate line-of-sight parameter for the defender's weapon systems (transports).

(15) Block 12. Pack attacker and defender roughness and vegetation, and forestation indexes into one word (needed for GCM history record #333 - BATSUM), then RETURN.

18. ROUTINE DNUMBR

a. Purpose. DNUMBR determines the number of items or personnel in a unit band according to the distribution table from Data File 28.

b. Input Variables:

Name	Source	Contents
THINGS	CALL	Total number of equipment items or personnel in the unit.
INDEX	CALL	Equipment item code (zero indicates personnel).
IBAND	CALL	Band in question (1-4).
NBAND	CALL	Number of bands in the unit.
REC28(189)	CALL	Distribution record for the unit.
IACTX	CALL	Activity index (1-7).

c. Output Variables:

Name	Destination	Contents
DNUMBR	Calling routine	Number of equipment items or personnel in the band in question for a particular unit.

d. Logical Flow (Figure IV-7-B-18).

(1) Block 1. Does this unit have more than 1 band? If so, go to block .

(2) Block 2. Set number of items or personnel in first band to total number in the unit since there is only 1 band, then RETURN to calling program.

(3) Block L50. Does this unit have any nonuniform distribution? If so, go to block L200.

(4) Block L100. Since equipment and personnel is uniformly distributed, (or since some anomally exists) set number of items or personnel to the average for the number of bands, then return to calling program.

(5) Block L200. Are we concerned with nonuniform distribution of equipment or personnel? If personnel, go to block L500.

(6) Block L300. Find number of this unit's items of equipment with nonuniform distribution.

(7) Block 3. Find the pointer into REC28 for the nonuniform distribution of this particular item of equipment.

(8) Block 4. Was this pointer found? If not, go to block L100.

(9) Block L500. Is the entry in REC28 equal to zero? If so, go to block L100.

(10) Block 5. Call routine PACK28 to unpack nonuniform distribution for this item code or personnel.

(11) Block 6. Calculate DNUMBR for nonuniform distribution of this item code or personnel, then return to calling routine.

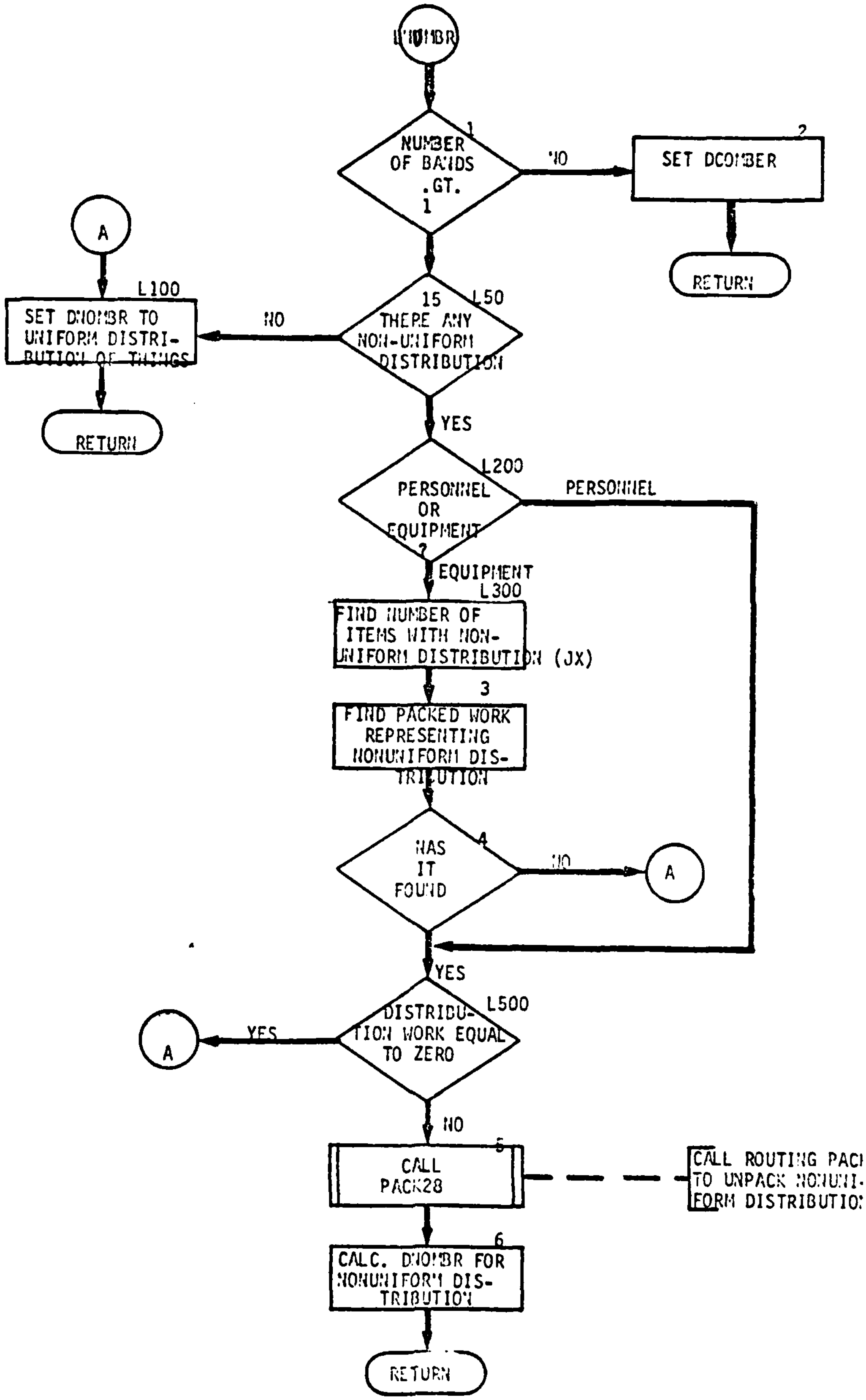


FIGURE IV-7-B-18 ROUTINE DNOMBR

19. ROUTINE GCFIRE.

a. Purpose. GCFIRE determines the number of active weapons and targets, computes the coverage pattern within the target unit, distributes the total rounds fired based upon target acquisition and priorities, and controls and velocities of the units.

b. Input Variables:

Name	Source	Contents
DATDUM(322)	DF16	Data for firing attacking unit. DATDUM (1) equivalent to FILE39 (2345). Located at IDUM (1).
LNK(16)	DF16	Weapon to transport link table.
PRIOR(16,8)	DF16	Weapon-target priorities, located at IDUM (323).
AMLIM(16,4)	DF16	Ammunition supply conditionals, locatea at IDUM (451).
NWT	DF16	Total number of attacking unit's weapon types, located at IDUM (515).
NTT	DF16	Total number of defending unit's weapon types, located at IDUM (517).
NWST	DF16	Total number of attacking unit's weapon system types, located at IDUM (516).
RNDLDT(8)	DF16	Total number of rounds fired during last iteration, located at IDUM (1606).
TIMEIT	DF16	Battle iteration duration, located at IDUM (1697).
RBAR(8,2)	DF16	Line-of-sight parameters, located at IDUM (2809).
PDET(8,3,3)	ONE	Detection probabilities, located at IDUM (1270).
TDET	ONE	Time to acquire a target, located at IDUM (1683).
PLOS(8,3,2)	ONE	Line-of-sight probabilities, located at IDUM (1174).
DCAS(16,8)	ONE	Conditional losses, defending unit, located at IDUM (174).

ANRNDS(16,8)	ONE	Conditional rounds fired, attacking unit, located at IDUM (518).
DATDUM(240)	DF16	Data for firing, defending unit (DATDUM (1) equivalenced to FILE39 (2667).

c. Output Variables:

Name	Destination	Contents
NTGT(8,3,3)	TWO	Total number of targets by type, coverage region type, and posture, located at IDUM (1030).
A(3)	TWO	Area of each coverage region type, located at IDUM (1670).
R(3)	TWO	Range to each coverage region type, located at IDUM (1676).
SERANG	TWO	Search angle, located at IDUM (1688).
FTPOSA(8)	TWO	Fraction of targets moving, located at IDUM (1574).
FTPOSB(8)	TWO	Fraction of targets stationary, located at IDUM (1590).
RNDS(8,3,3)	TWO	Distribution of rounds by target type, coverage region type, and posture, located at IDUM (1414).
DFIRE(16)	TWO	Depth-of-fire indicator, located at IDUM (1558).
FIRERS	TWO	Total number of firing weapons, located at IDUM (1693).
WSPD	DF16	Attacking unit's velocity, located at IDUM (287).
TSPD	DF16	Defending unit's velocity, located at IDUM (289).
ICODE	TWO	Flag to identify firing unit, located at IDUM (1682).
ACAS(16,8)	DF16	Attacking unit's conditional losses, located at IDUM (774).

DCAS(16,8)	DF16	Defending unit's conditional losses, located at IDUM (774).
ANRNDS(16,8)	DF16	Attacking unit's conditional rounds fired, located at IDUM (518).
DNRNDS(16,8)	DF16	Defending unit's conditional rounds fired, located at IDUM (518).

d. Logical Flow (Figure IV-7-B-19).

(1) Block 1. — Call routine GET to get required attacker data from Data File 16.

(2) Block L1. — Initialize variables.

(3) Block L3. — Call routine GET to get the RBAR values from Data File 16.

(4) Block 2. — Calculate the fractions of the attacker and defender which are engaged (FRACT, FRACN).

(5) Block 3. — Begin loop (A1) on each weapon system type.

(6) Block 4. — If a sensing report is not now requested (I,9), transfer to Block 5.

(7) Block L504 — Calculate the dispatch (DIST) between each of the four forward observers. Transfer to Block L505.

(8) Block 5. — Calculate the distance between the observers (DIST).

(9) Block L505. — Calculate the range to each coverage region (R).

(10) Block 6. — Calculate the area of each coverage region (A).

(11) Block 7. — Set the angle of responsibility (THETA) to 45 degrees.

(12) Block 8. — Determine the percentage of the targets that are in each of the postures (FTPOSA, FTPOSB).

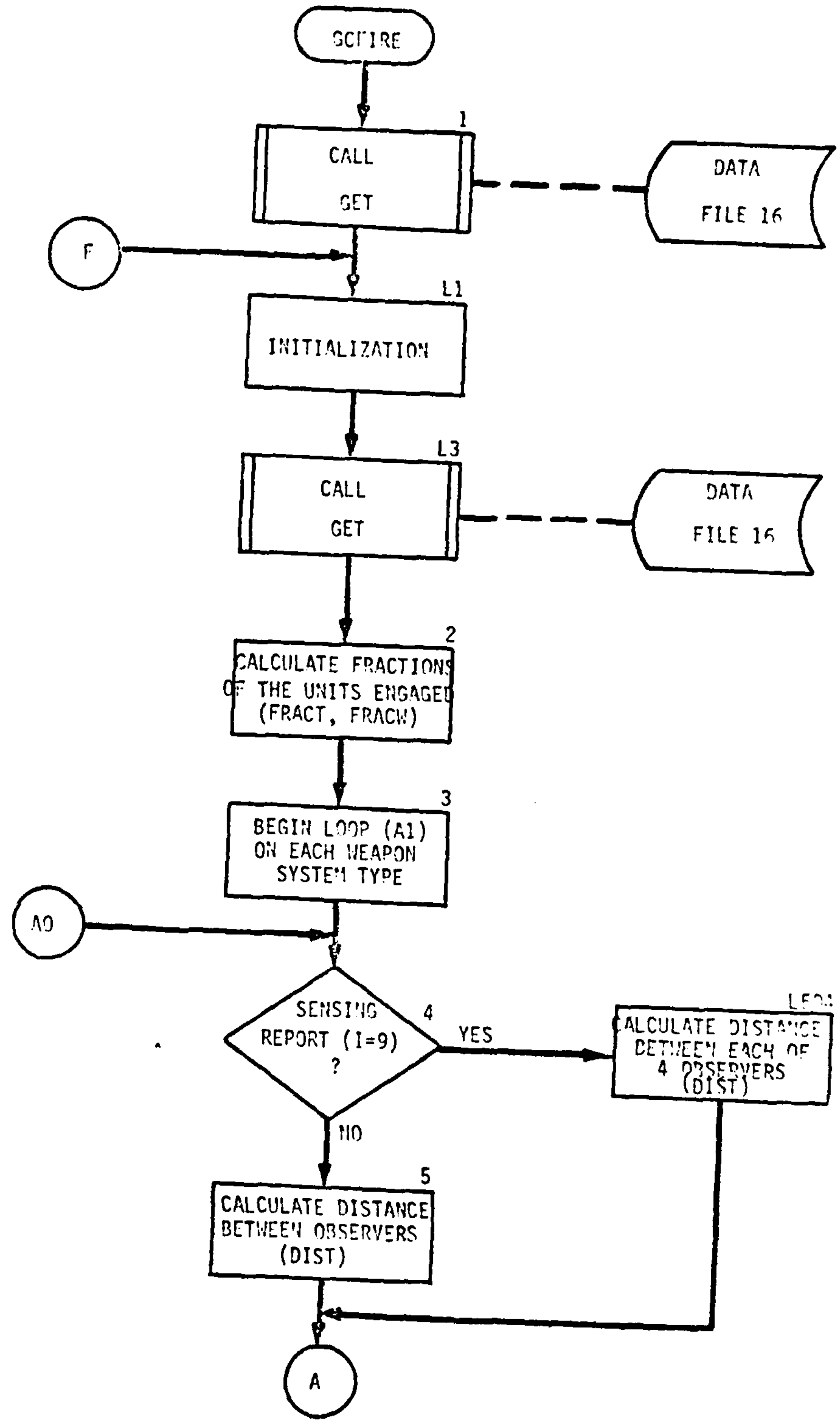
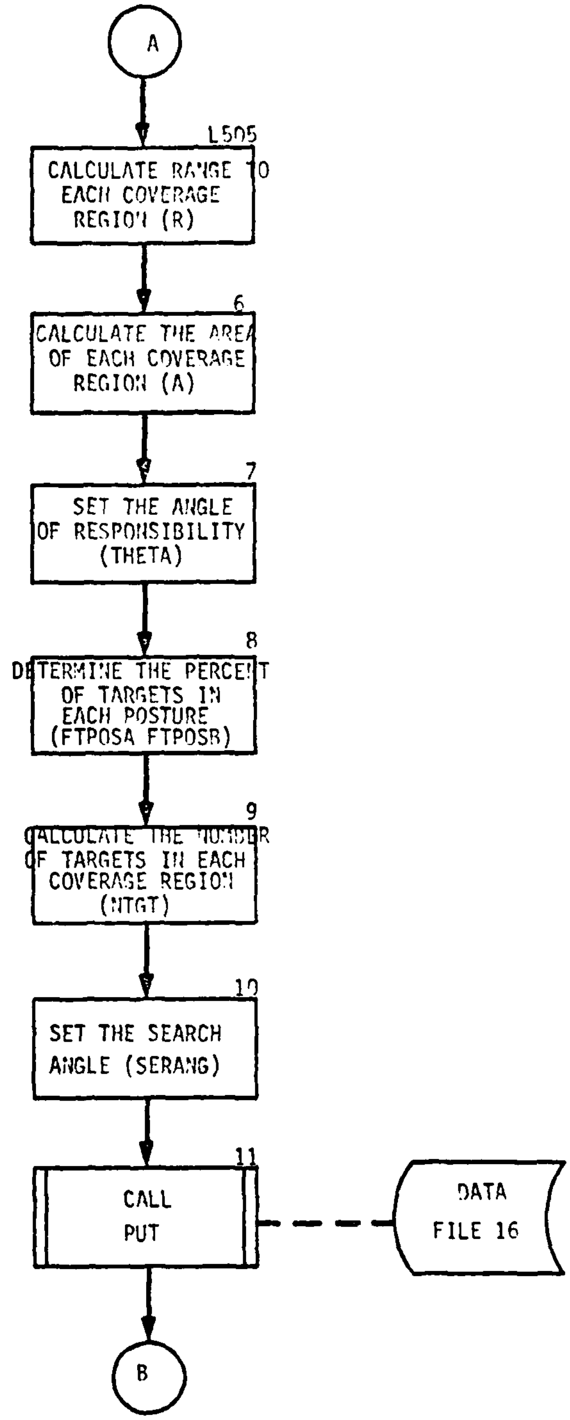
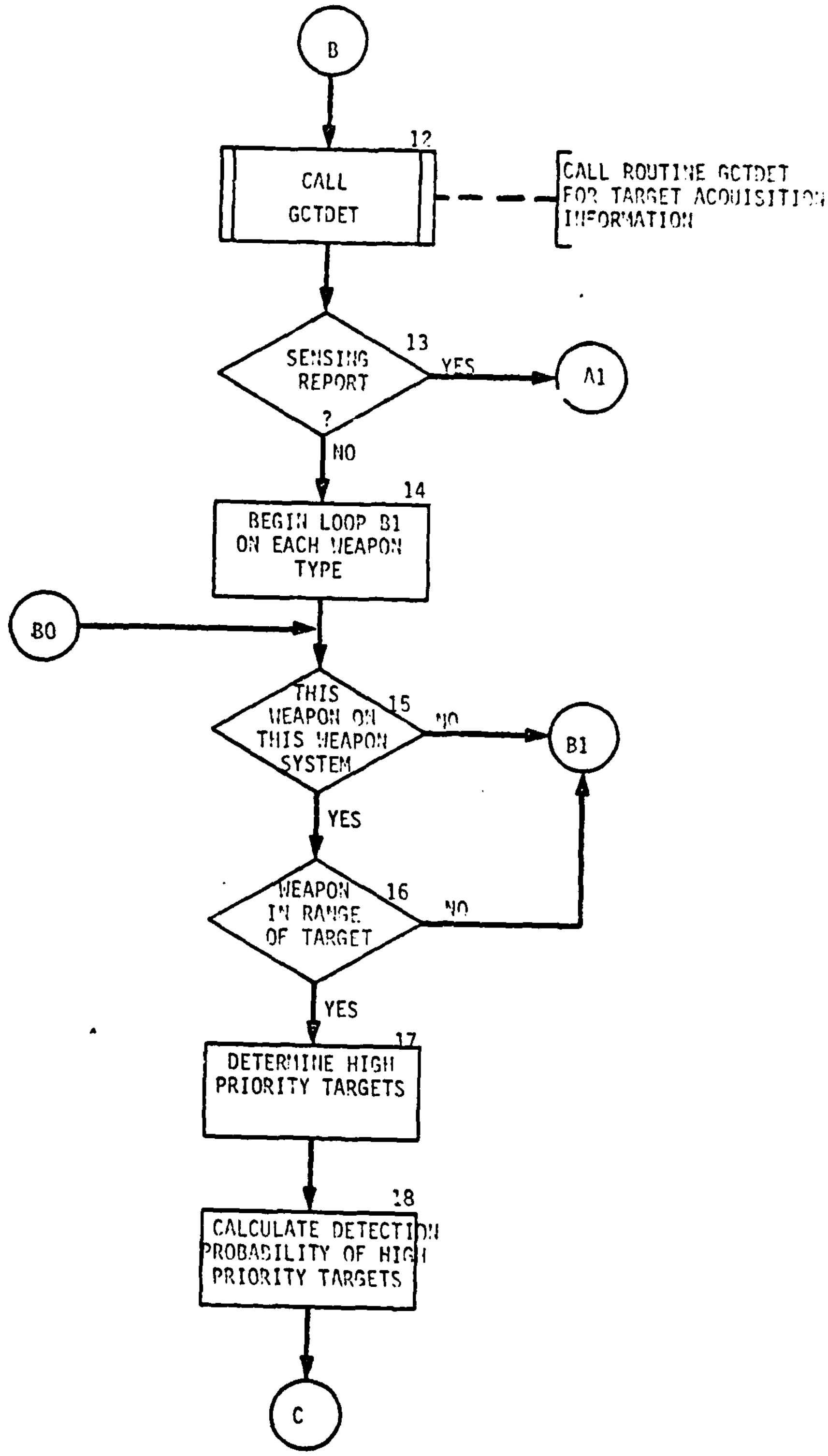
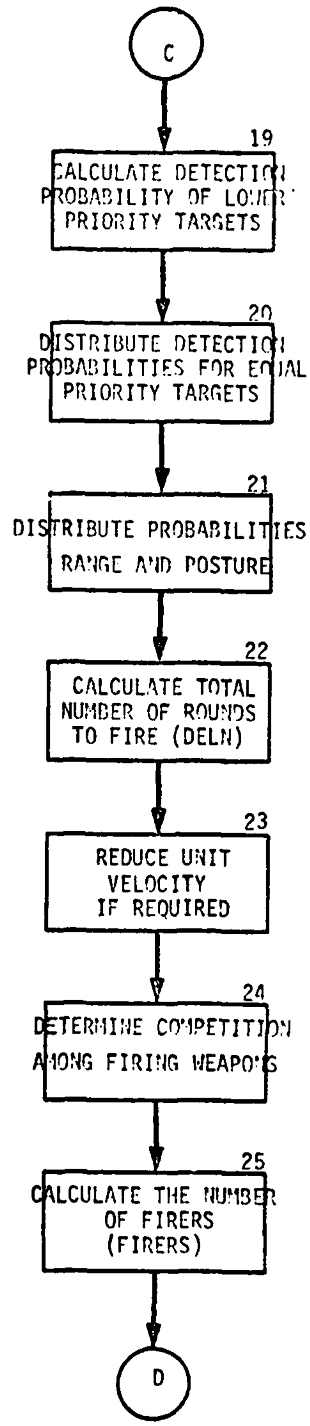
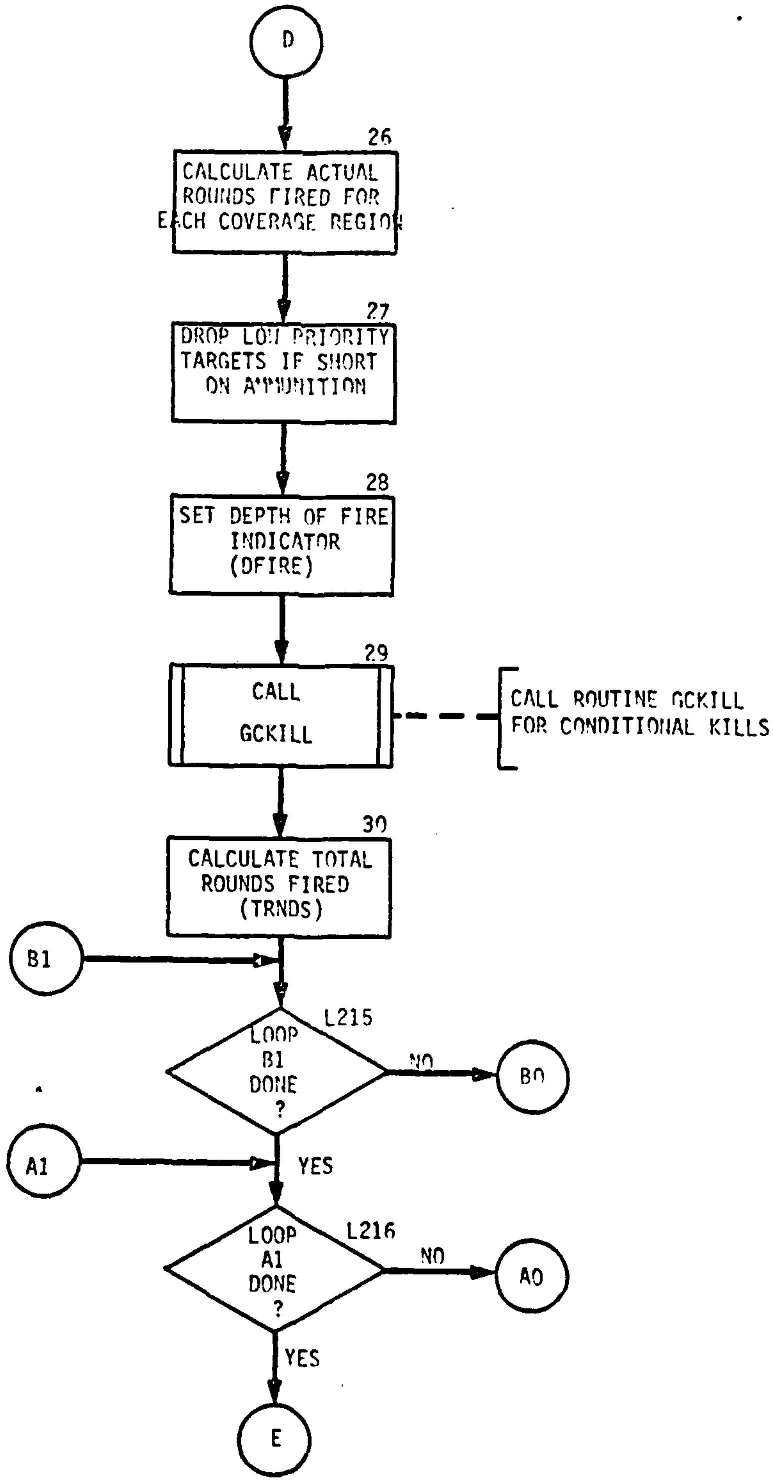


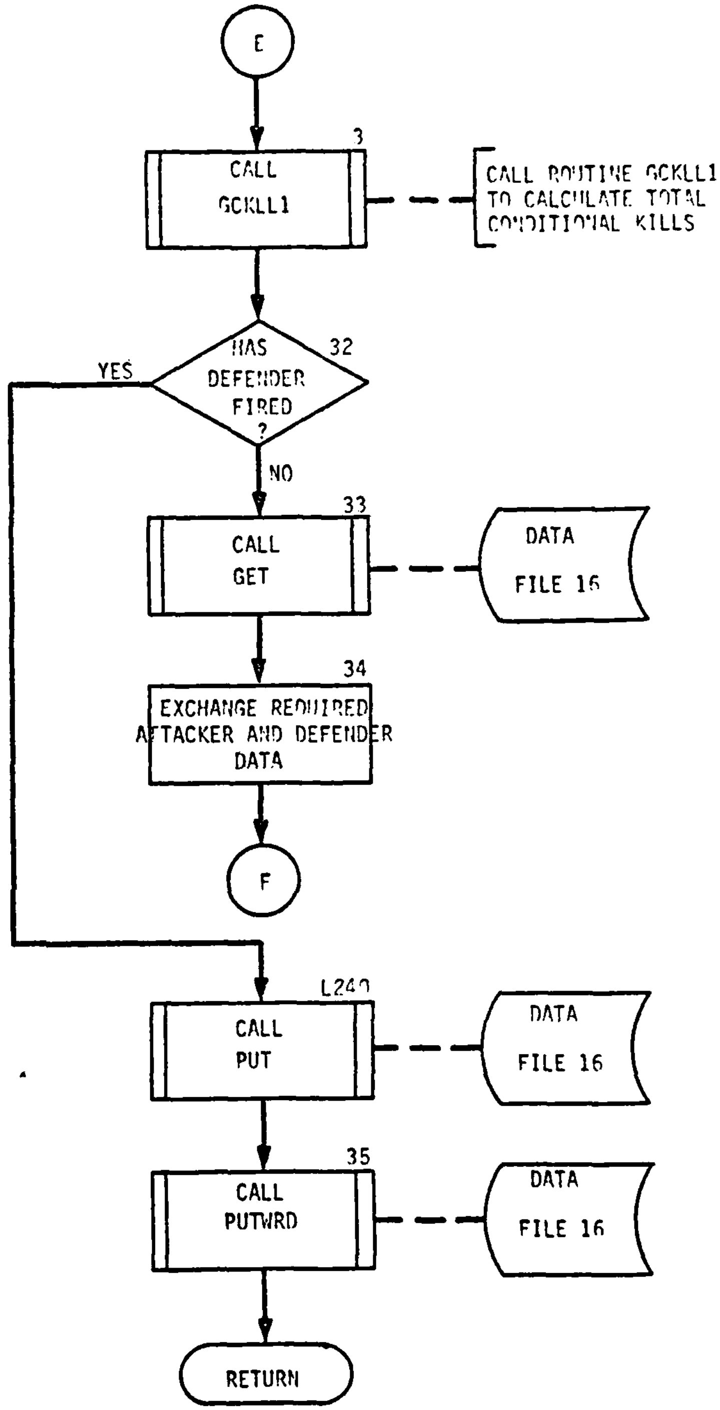
FIGURE IV-7-B-19 ROUTINE GCFIRE


A
L505
CALCULATE RANGE TO EACH COVERAGE REGION (R)
6
CALCULATE THE AREA OF EACH COVERAGE REGION (A)
7
SET THE ANGLE OF RESPONSIBILITY (THETA)
8
DETERMINE THE PERCENT OF TARGETS IN EACH POSTURE (FTPOSA FTPOSB)
9
CALCULATE THE NUMBER OF TARGETS IN EACH COVERAGE REGION (NTGT)
10
SET THE SEARCH ANGLE (SERANG)
11
CALL PUT
DATA FILE 16
B


B
12
CALL
GCTDET
CALL ROUTINE GCTDET
FOR TARGET ACQUISITION
INFORMATION
13
SENSING
REPORT
?
YES
A1
NO
14
BEGIN LOOP B1
ON EACH WEAPON
TYPE
B0
THIS
WEAPON ON
THIS WEAPON
SYSTEM
15
NO
B1
YES
WEAPON
IN RANGE
OF TARGET
16
NO
YES
17
DETERMINE HIGH
PRIORITY TARGETS
18
CALCULATE DETECTION
PROBABILITY OF HIGH
PRIORITY TARGETS
C


C
19
CALCULATE DETECTION PROBABILITY OF LOWER PRIORITY TARGETS
20
DISTRIBUTE DETECTION PROBABILITIES FOR EQUAL PRIORITY TARGETS
21
DISTRIBUTE PROBABILITIES RANGE AND POSTURE
22
CALCULATE TOTAL NUMBER OF ROUNDS TO FIRE (DELN)
23
REDUCE UNIT VELOCITY IF REQUIRED
24
DETERMINE COMPETITION AMONG FIRING WEAPONS
25
CALCULATE THE NUMBER OF FIRERS (FIRERS)
D


D
26
CALCULATE ACTUAL ROUNDS FIRED FOR EACH COVERAGE REGION
27
DROP LOW PRIORITY TARGETS IF SHORT ON AMMUNITION
28
SET DEPTH OF FIRE INDICATOR (DFIRE)
29
CALL GCKILL
CALL ROUTINE GCKILL FOR CONDITIONAL KILLS
30
CALCULATE TOTAL ROUNDS FIRED (TRNDS)
B1
L215
LOOP B1 DONE ?
NO
B0
A1
YES
L216
LOOP A1 DONE ?
NO
A0
YES
E



E
3
CALL
GCKLL1
CALL ROUTINE GCKLL1
TO CALCULATE TOTAL
CONDITIONAL KILLS
HAS
DEFENDER
FIRED
?
32
YES
NO
33
CALL
GET
DATA
FILE 16
34
EXCHANGE REQUIRED
ATTACKER AND DEFENDER
DATA
F
L240
CALL
PUT
DATA
FILE 16
35
CALL
PUTWRD
DATA
FILE 16
RETURN

(13) Block 9. Calculate the number of targets that are in each coverage region (NTGT).

(14) Block 10. Set the search angle (SERAMG) to 45 degrees.

(15) Block 11. Call routine PUT to place fractions engaged (IFR) on Data File 16.

(16) Block 12. Call routine GCTDET for target acquisition information.

(17) Block 13. If a sensing report has been requested at this time, transfer to Block L216.

(18) Block 14. Begin loop (D1) on each weapon type.

(19) Block 15. If this weapon type is not linked to this weapon system type, transfer to Block L215.

(20) Block 16. If this weapon is not in range of the target, transfer to Block L215.

(21) Block 17. Determine the high priority targets.

(22) Block 18. Calculate dectection probabilities for the high priority targets.

(23) Block 19. Calculate detection probabilities for the lower priority targets.

(24) Block 20. Distribute the detection probabilities for equal priority targets.

(25) Block 21. Distribute these probabilities by range and posture.

(26) Block 22. Calculate the total number of rounds to fire (DELN).

(27) Block 23. Reduce the units velocity if appropriate. Do not reduce velocity of unit with a WITHDRAW order.

(28) Block 24. Determine the competition among firing weapons. Adjust is low on ammunition.

(29) Block 25. Calculate the number of firers (FIRERS).

(30)	Block 26.	Calculate the actual rounds fired into each coverage region.
(31)	Block 27.	Drop the low priority targets if short on ammunition.
(32)	Block 28.	Set the depth-of-fire indicator (DFIRE).
(33)	Block 29.	Call routine GCKILL to calculate condition kills by this weapon system.
(34)	Block 30.	Calculate the total number of rounds fired (TRNDS).
(35)	Block L215.	If loop (B1) is not done (more weapon types to process), transfer to Block 15.
(36)	Block L216.	If loop (A1) is not done (more weapon systems to process), transfer to Block 4.
(37)	Block 31.	Call routine GCKLL1 to calculate total condition kills.
(38)	Block 32.	If the defender has fired (ICODE=3), transfer to Block L240.
(39)	Block 33.	Call routine GET to get the required defender data from Data File 16.
(40)	Block 34.	Exchange the necessary data to allow defender to fire. Transfer to Block L1.
(41)	Block L240.	Call routine PUT to store attacker kills and defender rounds fired on Data File 16.
(42)	Block 35.	Call routine PUTWPD to return control word to Data File 1. RETURN to the calling routine.

20. ROUTINE GCKILL.

a. Purpose. GCKILL calculates the conditional survival probabilities based on the total number of rounds fired by each weapon type at each target type.

b. Input Variables.

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
PK(3,8,3)	TWO	Single round kill probabilities, located at IDUM (2793).
RNDS(8,3,3)	TWO	Total number of rounds fired by a weapon type, located at IDUM (1414).
NT(8)	TWO	Total number of targets, located at IDUM (263).
A(3)	TWO	Area of each type of coverage region, located at IDUM (1670).
TA	TWO	Target's front band area, located at IDUM (1695).
FTPOSA(8)	TWO	Fraction of targets fully exposed, located at IDUM (1574).
FTPOSB(8)	TWO	Fraction of targets partially covered, located at IDUM (1590).
NTT	TWO	Total number of target types, located at IDUM (517).
IWT	TWO	Indicator of which weapon is firing, located at IDUM (1692).
DFIRE(16)	TWO	Depth-of-fire indicator, located at IDUM (1558).
NWT	TWO	Total number of weapon types, located at IDUM (515).
FIRERS	TWO	Total number of firing weapons, located at IDUM (1693).

c. Output Variables:

Name	Destination	Contents
CCAS(16,8)	TWO	Survival probabilities for each weapon-target combination, located at IDUM (774).

d. Logical Flow (Figure IV-7-B-20).

(1) Block 1. Call routine GPKILL to get the kill probabilities for this weapon against

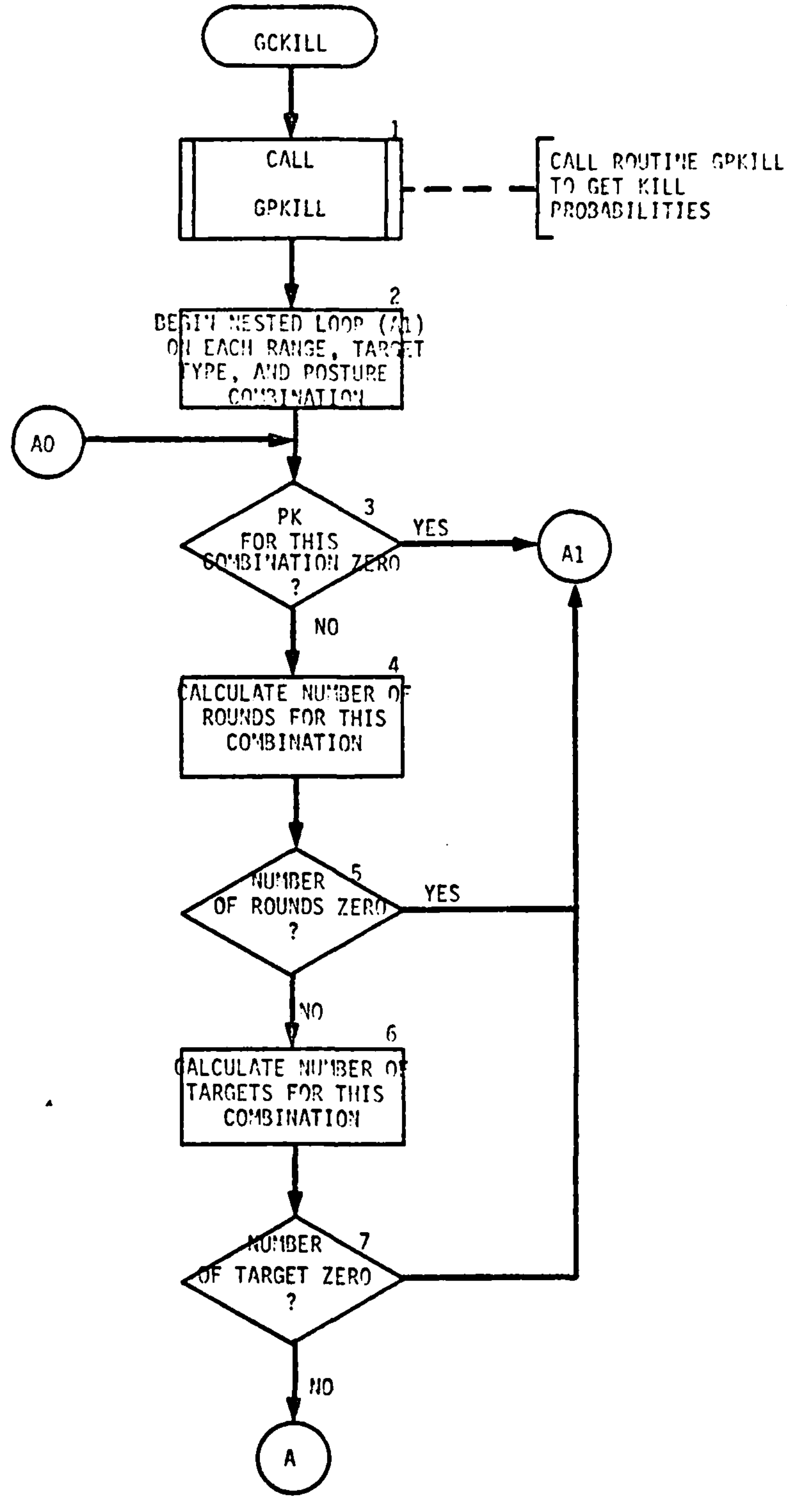
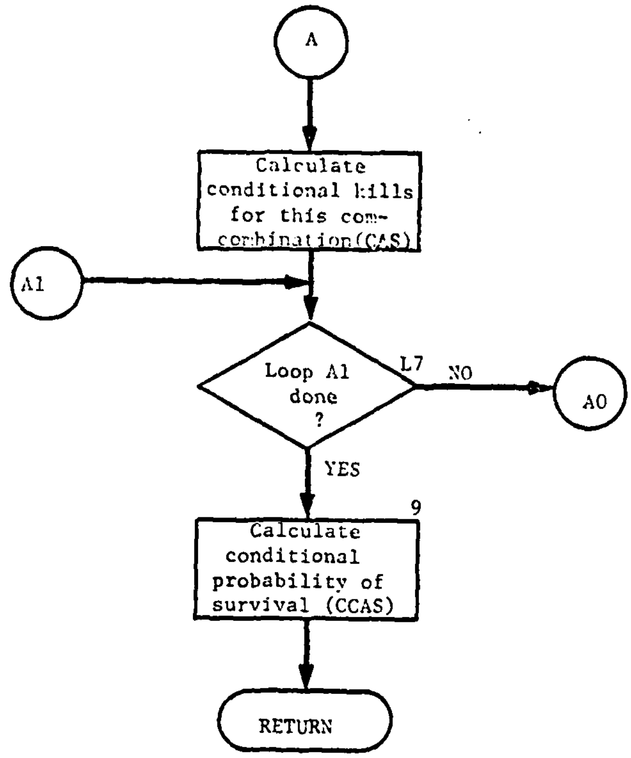


FIGURE IV-7-B-20 ROUTINE GCKILL


A
Calculate conditional kills for this com- combination(CAS)
A1
Loop A1 done ?
L7
NO
A0
YES
9
Calculate conditional probability of survival (CCAS)
RETURN

	each range, target type, and posture combination.
(2) Block 2.	Begin a nested loop (A1) on each range, target type, and posture combination.
(3) Block 3.	If the probability of kill for this combination is ZERO, transfer to Block L7.
(4) Block 4.	Calculate the number of rounds fired at this combination.
(5) Block 5.	If the number of rounds fired is ZERO, transfer to Block L7.
(6) Block 6.	Calculate the number of targets for this combination.
(7) Block 7.	If the number of targets is ZERO, transfer to Block L7.
(8) Block 8.	Calculate the conditional kills for this combination (CAS).
(9) Block L7.	If loop (A1) is not done, transfer to Block 3.
(10) Block 9.	Calculate the conditional survival probabilities (CCAS). RETURN to the calling routine.

21. ROUTINE GCKLL1.

a. Purpose. GCK111 calculates the total number of conditional casualties.

b. Input Variables.

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
PK(3,8,3)	TWO	Single round kill probabilities, located at IDUM (2793).
RNDS(8,3,3)	TWO	Total number of rounds fired by a weapon type, located at IDUM (1414).

NT(8)	TWO	Total number of targets, located at IDUM (263).
A(3)	TWO	Area of each type of coverage region, located at IDUM (1670).
TA	TWO	Target's front band area, located at IDUM (1695).
FTPOSA(8)	TWO	Fraction of targets fully exposed, located at IDUM (1574).
FTPOSB(8)	TWO	Fraction of targets partially covered, located at IDUM (1590).
NTT	TWO	Total number of target types, located at IDUM (517).
IWT	TWO	Indicator of which weapon is firing, located at IDUM (1692).
DFIRE(16)	TWO	Depth-of-fire indicator, located at IDUM (1558).
NWT	TWO	Total number of weapon types, located at IDUM (515).
FIRERS	TWO	Total number of firing weapons, located at IDUM (1693).

c. Output Variables:

Name	Destination	Contents
CCAS(16,8)	TWO	Conditional casualities for each weapon-target combination.

d. Logical Flow (Figure IV-7-B-21)

(1) Block 1. Call routine PUT to place the number of active targets on Data File 16.

(2) Block 2. Set all survival probabilities (PS) initially to 1.

(3) Block 3. Calculate survival probabilities for all combinations.

(4) Block 4. Calculate the total conditional casualties for each combination by averaging the integrating results and a direct

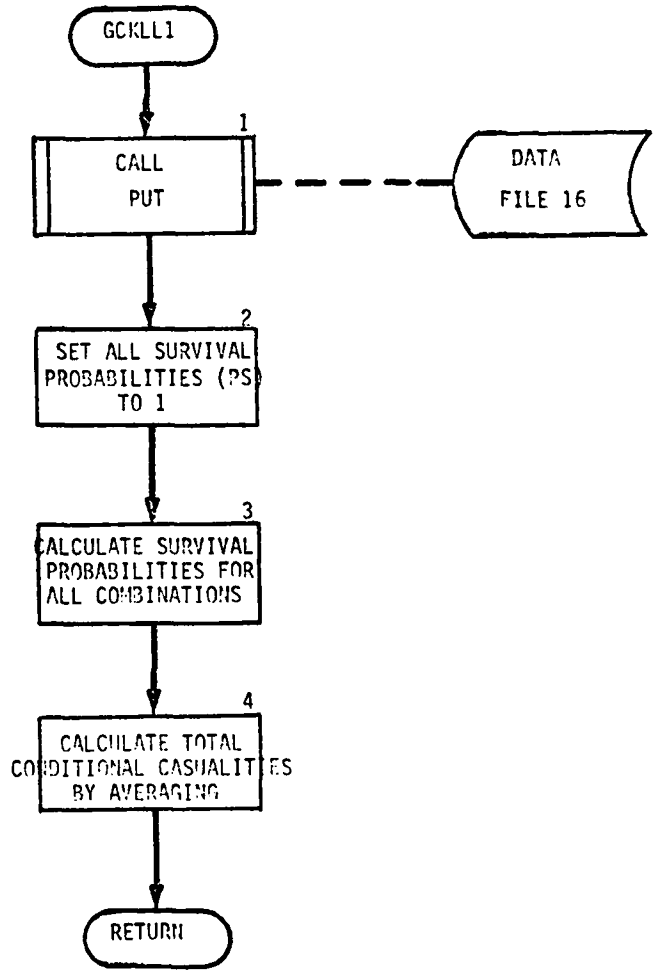


FIGURE IV-7-B-21 ROUTINE GCKLL1

proportion. RETURN to the calling routine.

22. ROUTINE GCDET.

a. Purpose. For each weapon system GCTDET computes the time required, based upon the available sensors, to acquire at least one target from among those defined as nonzero priority targets for some weapon/ammunition combination carried by that weapon system. GCTDET also computes the relative probability of each nonzero priority target type being acquired. Additionally, GCTDET computes detection probabilities for all targets to be used in the sensing report.

b. Input Variables:

Name	Source	Contents
MODSNS	DF16	Day/night indicator for current conditions.
ICODE	TWO	Indicator of which force is searching, located at IDUM (1682).
CO(8)	DF16	Target intrinsic contrast, located at IDUM (2793).
RBAR(8,2)	DF16	Target-posture, line-of-sight parameters, located at IDUM (2809).
DSEN(8,10)	DF16	Sensor distribution among weapon systems, located at IDUM (2825).
SPP(10,4)	DF16	Sensor performance parameters, located at IDUM (2985).
PPIN(8)	DF16	Single round pinpoint probabilities, located at IDUM (3065).
SKGR	DF16	Sky-ground ratio, located at IDUM (3081).
MODE(10)	DF16	Day/night indicator for sensor applicability.
NSEN(10)	DF16	Total number of sensors, located at IDUM (3146).
NSENT	DF16	Total number of sensor types, located at IDUM (3085).
LNK(16)	DF16	Weapon to weapon system link table, located at IDUM (3086).

TTYPE(8)	DF16	Target type, located at IDUM (3103).
ATBETA	DF16	Atmospheric attenuation coefficient, located at IDUM (3083).
R(3)	TWO	Range to each coverage region, located at IDUM (1676).
NTGTT	TWO	Total number of target types, located at IDUM (517).
NTGT(8,3,3)	TWO	Total number of targets by type, posture, and coverage region, located at IDUM (1030).
PRIOR(16,8)	TWO	Weapon-target priorities, lcoated at IDUM (323).
IWT	TWO	Identification of observing weapon system, located at IDUM (1685).
A(3)	TWO	Area of each coverage region, located at IDUM (1670).
THETA	TWO	Angle of responsibility, located at IDUM (1686).
SERANG	TWO	Search angle, located at IDUM (1688).
BIG(8)	TWO	Fully exposed target presented area, located at IDUM (1).
WEAP(8)	TWO	Total number of weapon systems, located at IDUM (247).
TIMEIT	TWO	Duration of current engagement iteration, located at IDUM (1697).

c. Output Variables:

Name	Destination	Contents
TDET	TWO	Time to detect at least one priority target, located at IDUM (1683).
PDET(8,3,3)	TWO	Probability of detection for each target, range, and posture combination, located at IDUM (1270).
PLOS(8,3,2)	TWO	Probability of line-of-sight, located at IDUM (1174).

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DIVWAG MODEL DOCUMENTATION. VOLUME II. PROGRAMMER/ANALYST MANUA--ETC(U)
JUL 76
UNCLASSIFIED CACDA-TR-8-76-VOL-2-PT-3 NL

4 OF 7
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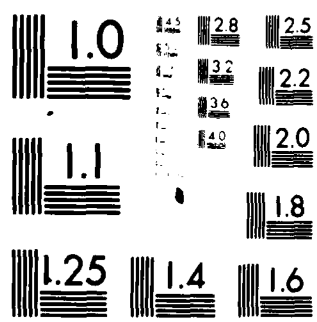


MICROCOPY RESOLUTION TEST CHART

SENRPT(70) DF16 Sensing report.

d. Logical Flow (Figure IV-7-B-22).

(1) Block 1. Call routine GET to get the appropriate (attacker or defender) data.

(2) Block 2. If the calling routine is requesting a sensing report (IWT=9), transfer to Block 5.

(3) Block 3. Calculate the number of sensors of each type (RN,NN).

(4) Block 4. Initialize probabilities of detection (PDET) to ZERO. Transfer to Block L11.

(5) Block 5. Set the number of sensors to 1. (This results in a sensor for each forward observer team).

(6) Block L11. Begin loop (A1) on each type of target.

(7) Block 6. If the calling routine wants a sensing report (REPORT=1), transfer to Block L7.

(8) Block 7. Is this target a priority target for at least one weapon on this weapon system? If not, transfer to Block L1107.

(9) Block L7. Begin loop (B1) on each type of sensor.

(10) Block 8. If there are no sensors of this type, transfer to Block L1105.

(11) Block L9. If the time of day (day/night) is inappropriate for using this type of sensor, transfer to Block L1105.

(12) Block 9. If this sensor is unaided vision, transfer to Block L200.

(13) Block 10. Calculate the target's presented area.

(14) Block 11. Calculate the probability that the sensor is looking at the target.

(15) Block 12. Combine with the probability of contrast detection of a single target of this type.

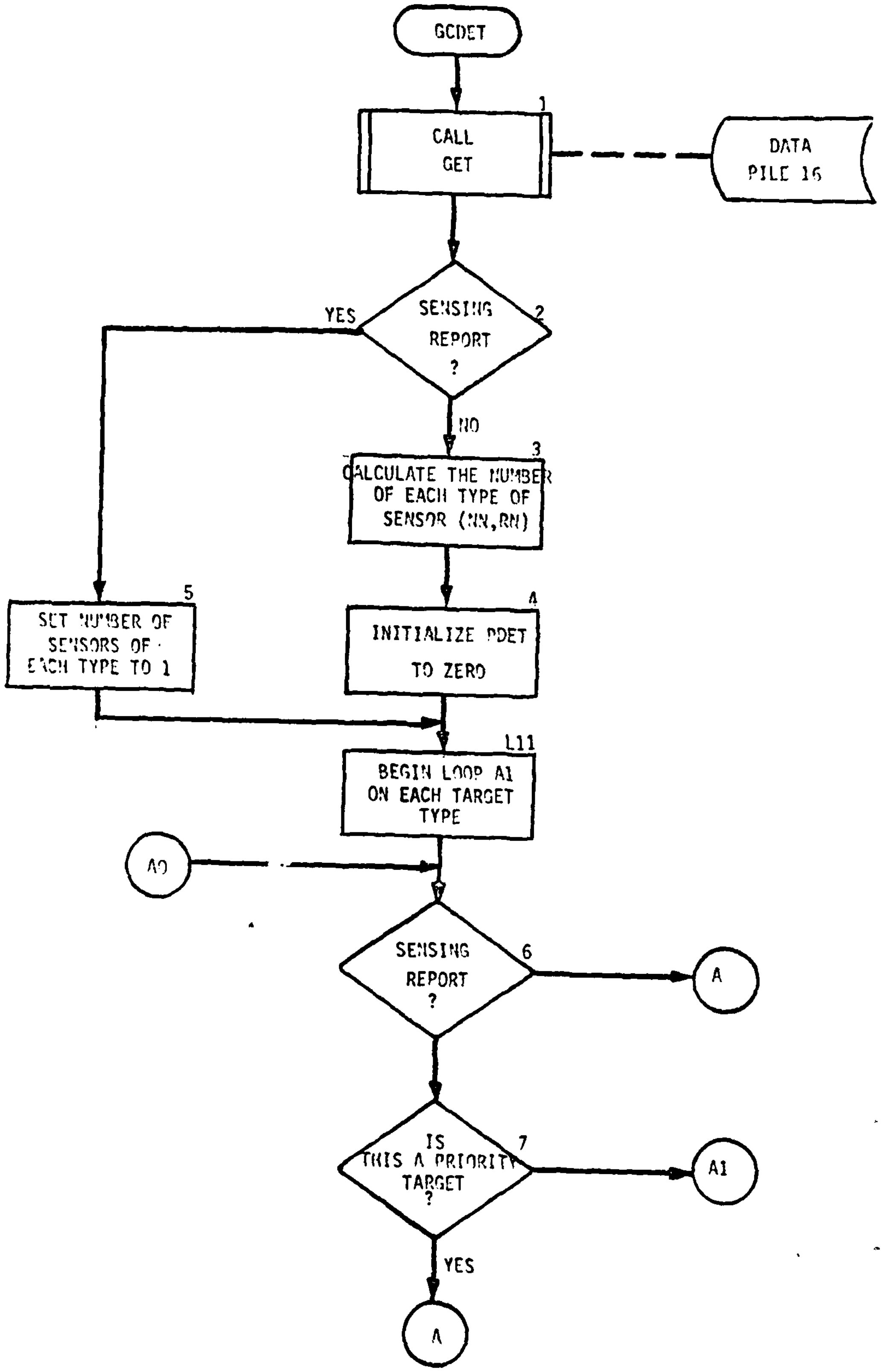
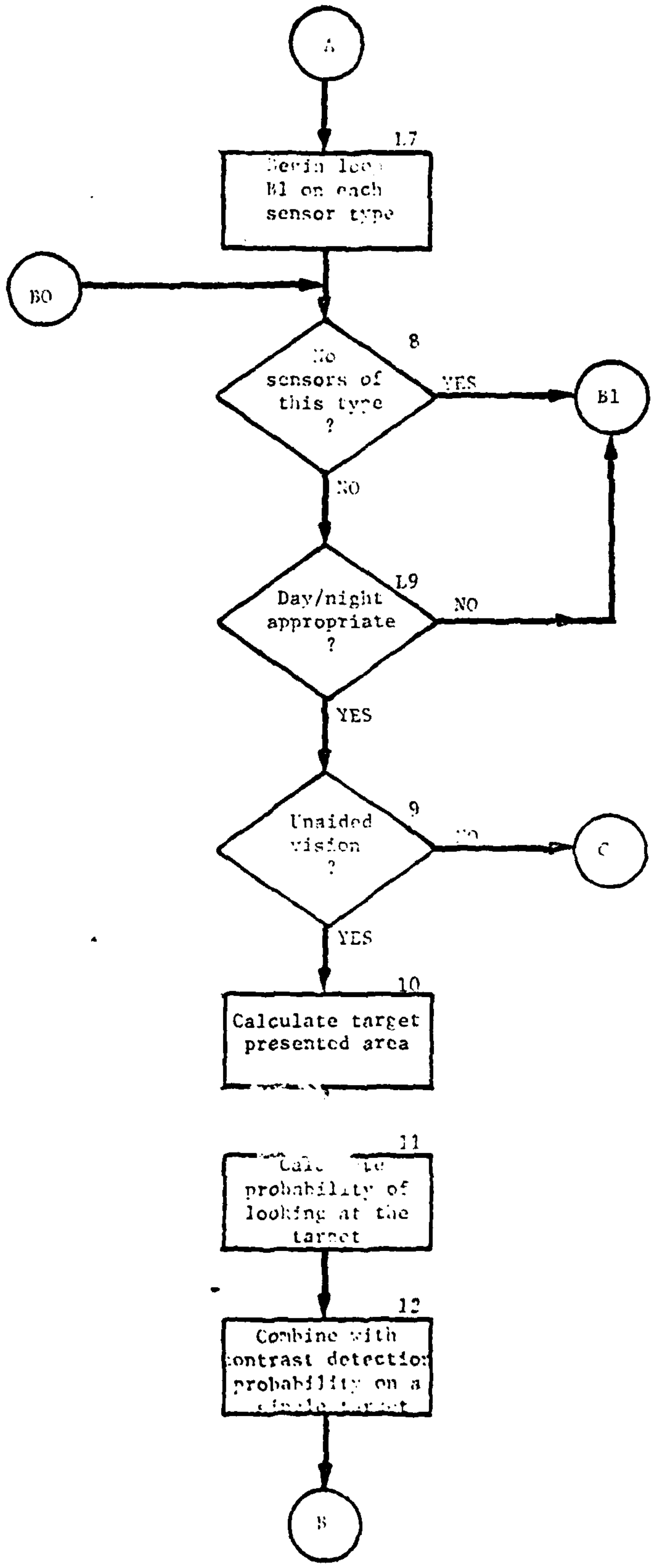
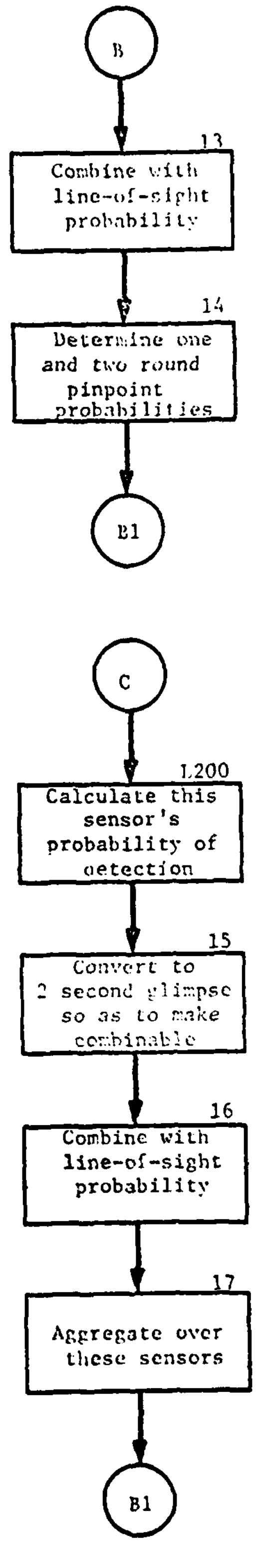
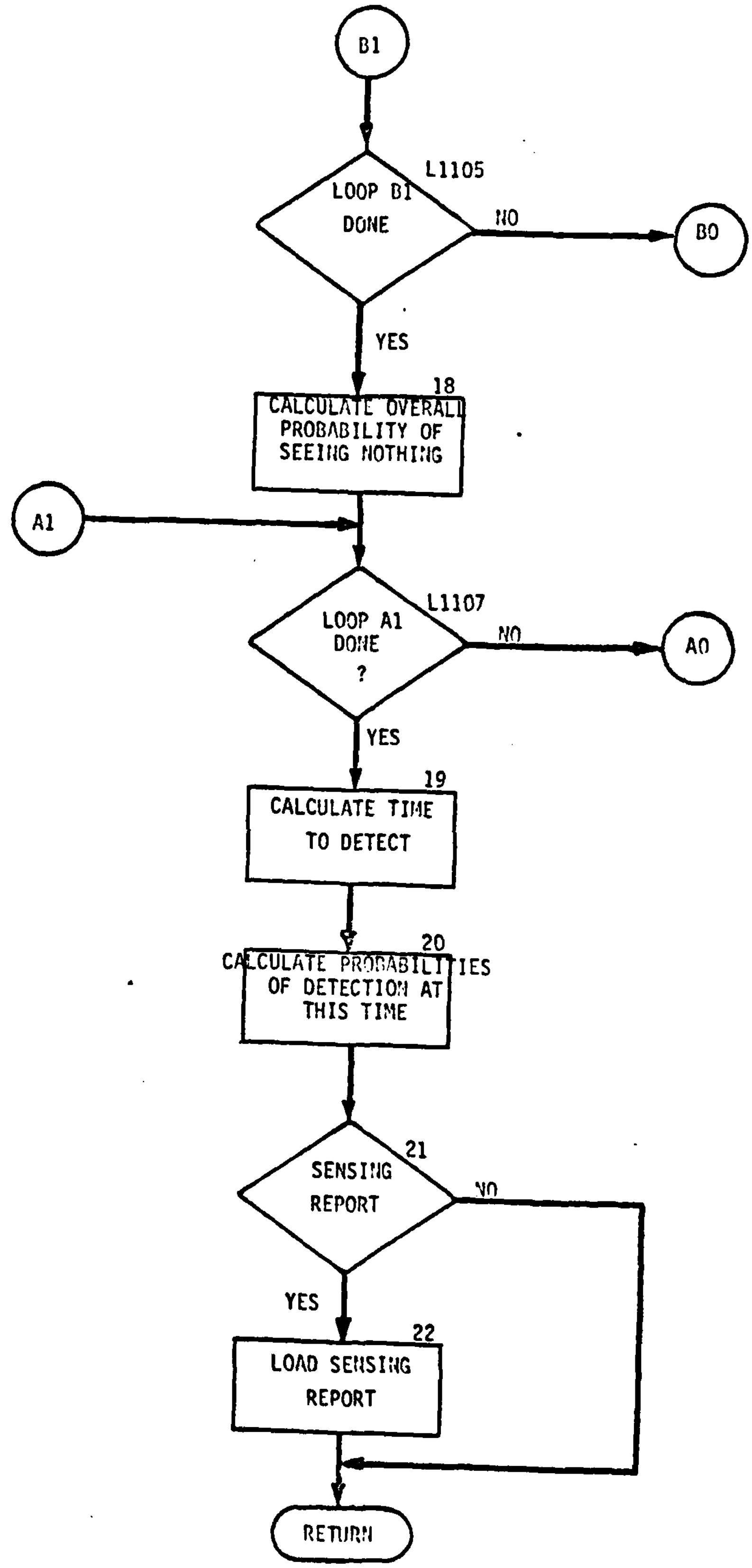


FIGURE IV-7-B-22 ROUTINE GCDET



A
17
Begin loop
B1 on each
sensor type
BO
8
No
sensors of
this type
?
YES
B1
NO
L9
Day/night
appropriate
?
NO
YES
9
Unaided
vision
?
C
YES
10
Calculate target
presented area
11
probability of
looking at the
target
12
Combine with
contrast detection
probability on a
B


B
13
Combine with line-of-sight probability
14
Determine one and two round pinpoint probabilities
B1
C
L200
Calculate this sensor's probability of detection
15
Convert to 2 second glimpse so as to make combinable
16
Combine with line-of-sight probability
17
Aggregate over these sensors
B1


B1
L1105
LOOP B1 DONE
NO
B0
YES
18
CALCULATE OVERALL PROBABILITY OF SEEING NOTHING
A1
L1107
LOOP A1 DONE ?
NO
A0
YES
19
CALCULATE TIME TO DETECT
20
CALCULATE PROBABILITIES OF DETECTION AT THIS TIME
21
SENSING REPORT
NO
YES
22
LOAD SENSING REPORT
RETURN

(16) Block 13. Combine with the line-of-sight probability.

(17) Block 14. Determine the one and two round pin-point probabilities. Transfer to Block L1105.

(18) Block L200. Calculate this sensor's probability of detection.

(19) Block 15. Convert this probability to a 2-second glimpse probability so that is can be combined with other probabilities.

(20) Block 16. Combine this probability with line-of-sight probability.

(21) Block 17. Aggregate over these sensors.

(22) Block L1105. If loop (B1) is not done (more sensors, transfer to Block 8.

(23) Block 18. Calculate the overall probability of seeing nothing (PNODET).

(24) Block L1107. If loop (A1) is not done (more target types), transfer to Block 6.

(25) Block 19. Calculate the time to detect.

(26) Block 20. Convert the probabilities of detection using the time to detect.

(27) Block 21. If the calling routine does not want a sensing report, RETURN to the calling routine.

(28) Block 22. Load the sensing report array with the required data. RETURN to the calling routine.

23. ROUTINE GPKILL.

a. Purpose. GPKILL determines the single round probability of a kill as a function of weapon type, target type, target presented area, and weapon-target range.

b. Input Variables:

Name	Source	Contents
ZAP(16,6)	DF16	NATO hit probabilities for six range values, located at IDUM (2937).
SLOPE(16,8)	DF16	Slope of PK/H line, located at IDUM (3129).
CEPT(16,8)	DF16	Y intercept of PK/H line, located at IDUM (3385).
ICODE	TWO	Flag designating firing unit, located at IDUM (1682).
R(3)	TWO	Range to each type coverage region, located at IDUM (1676).
NTGTT	TWO	Total number of target types, located at IDUM (517).
A(16,8)	TWO	Weapon-target priorities, located at IDUM (323).
BIG(8)	TWO	Fully exposed target presented area, located at IDUM (1).
RMIN(16)	TWO	Weapon's minimum range, located at IDUM (49).
RMAX(16)	TWO	Weapon's maximum range, located at IDUM (17).
PHNATO	Call	Interpolated NATO hit probability.

c. Output Variables:

Name	Destination	Contents
PHTABL(16)	Call	NATO hit probability table for firing weapon, located at IDUM (3993).
PK(3,8,3)	TWO	Kill probabilities for the firing weapon against each range, target, and posture combination, located at IDUM (2793).

d. Logical Flow (Figure IV-7-B-23).

(1) Block 1. If the defender is firing (ICODE=2), transfer to Block L2.

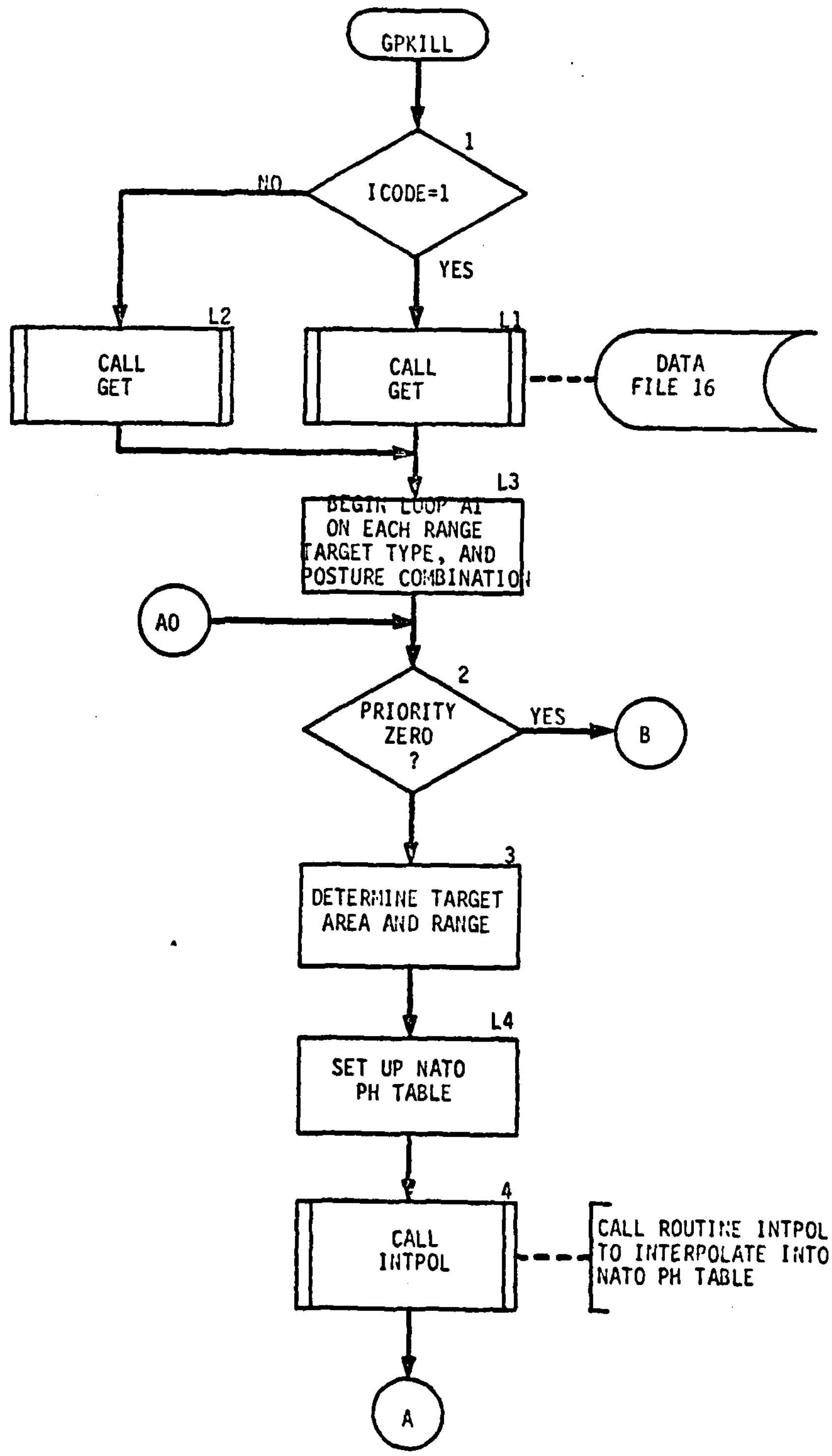
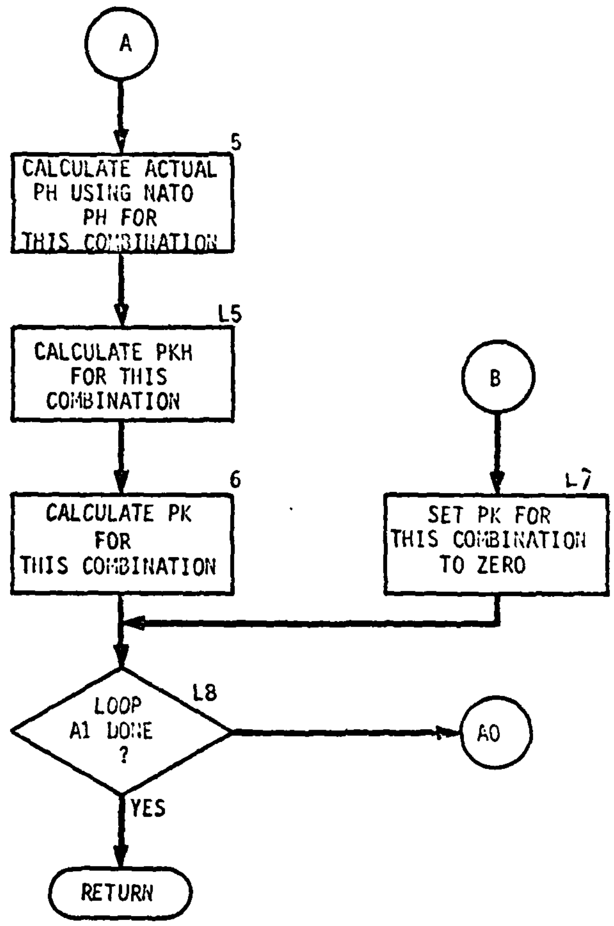


FIGURE IV-7-B-23 ROUTINE GPKILL


A
5
CALCULATE ACTUAL PH USING NATO PH FOR THIS COMBINATION
L5
CALCULATE PKH FOR THIS COMBINATION
B
6
CALCULATE PK FOR THIS COMBINATION
L7
SET PK FOR THIS COMBINATION TO ZERO
LOOP A1 DONE ?
L8
A0
YES
RETURN

(2) Block L1.	Call routine GET to get the data required for attacker firing. Transfer to Bloc '.3.
(3) Block L2.	Call routine GET to get the data required for defender firing.
(4) Block L3.	Begin loop (A1) on each range, target type, and posture combination.
(5) Block 2.	If the weapon priority against this target type is ZERO, transfer to Block L7.
(6) Block 3.	Determine the target presented area and range. (For pinpointed targets, calculate PH as direct fraction of the target presented area.
(7) Block L4.	Set up the NATO probability of hit PH table.
(8) Block 4.	Call routine INTPOL to calculate the exact NATO PH for this target by interpolating into the NATO PH table.
(9) Block 5.	Calculate the actual PH for this target using the NATO PH.
(10) Block L5.	Calculate the probability of kill give.. a hit (PKH) for this target.
(11) Block 6.	Calculate the probability of kill PK for this target. Transfer to Block L8.
(12) Block L7.	Set PK to ZERO.
(13) Block L8.	If loop A1 is not done, transfer to Block 2. Otherwise, RETURN to the calling routine.

24. ROUTINE GBKEEP.

a. Purpose. GBKEEP converts individual weapon conditional kills to weapon system conditional kills and applies a multiplying factor to convert conditional kills and rounds to actual kills and rounds fired.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
IDAT(1024)	DF16	Loss and expenditure data, located at IDUM (1).
LNKA(16)	DF16	Attacker weapon system link table, located at IDUM (2597).
LNKD(16)	DF16	Defender weapon to weapon system link table, located at IDUM (2613).
KDAT(4)	DF16	Number of attacker and defender weapon and weapon system tapes, located at IDUM (2049).
NOTABA(8)	DF16	Number of attacker active targets, located at IDUM (2725).
NOTABD(8)	DF16	Number of defender active targets, located at IDUM (2741).

c. Output Variables:

Name	Destination	Contents
IDAT(1024)	DF16	Converted loss and expenditure data, located at IDUM (1).
ALOSS(8,8)	TWO	Real attacker losses, located at IDUM (2309).
DLOSS(8,8)	TWO	Real defender losses, located at IDUM (2437).
ALOSST(8,8)	TWO	Conditional attacker losses, located at IDUM (2053).
DLOSST(8,8)	TWO	Conditional defender losses, located at IDUM (2181).

d. Logical Flow (Figure IV-7-B-24).

(1) Block 1. Call routine GET to obtain required data from Data File 16.

(2) Block 2. Initialize real losses arrays (ALOSS, DLOSS) to ZERO.

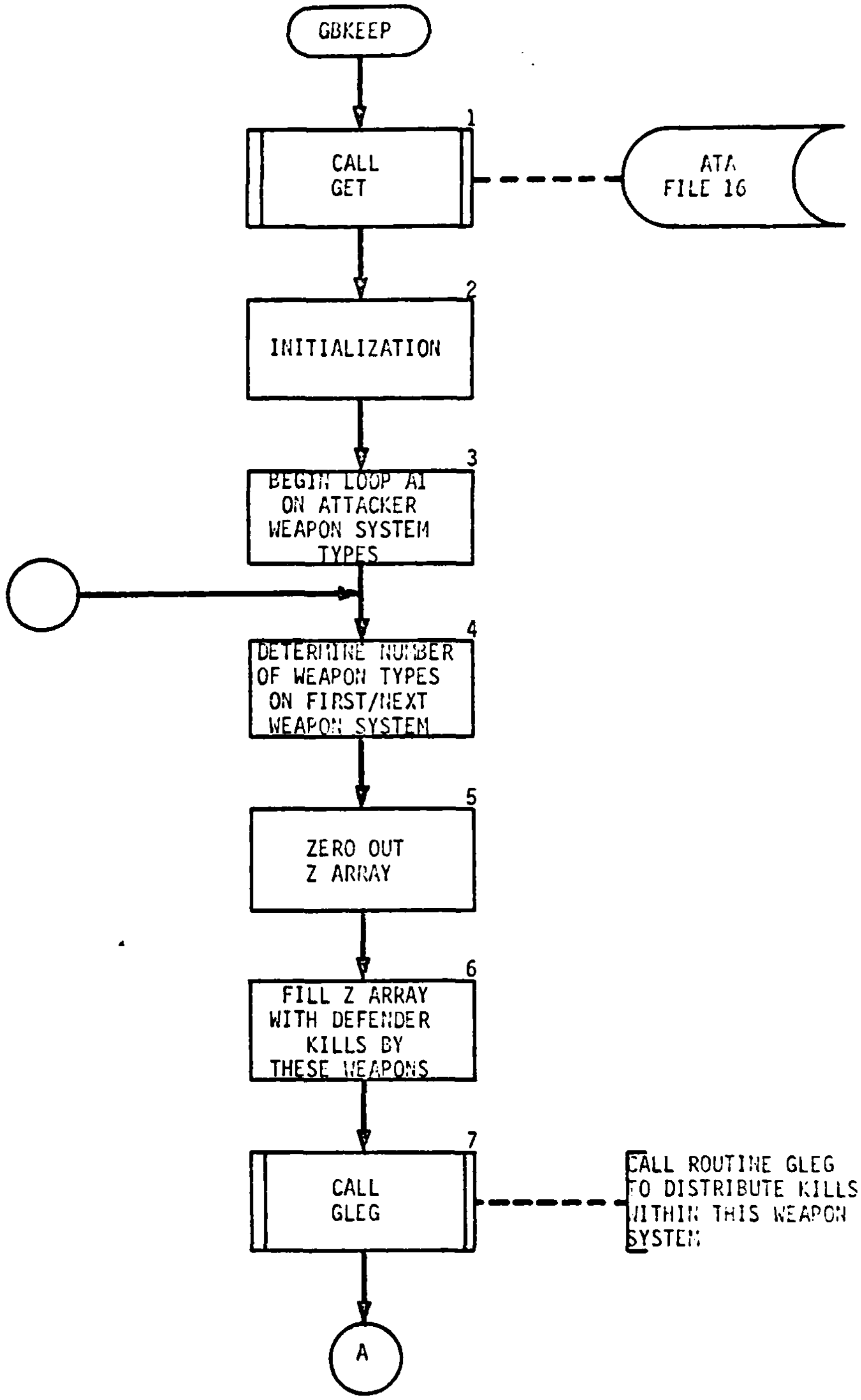
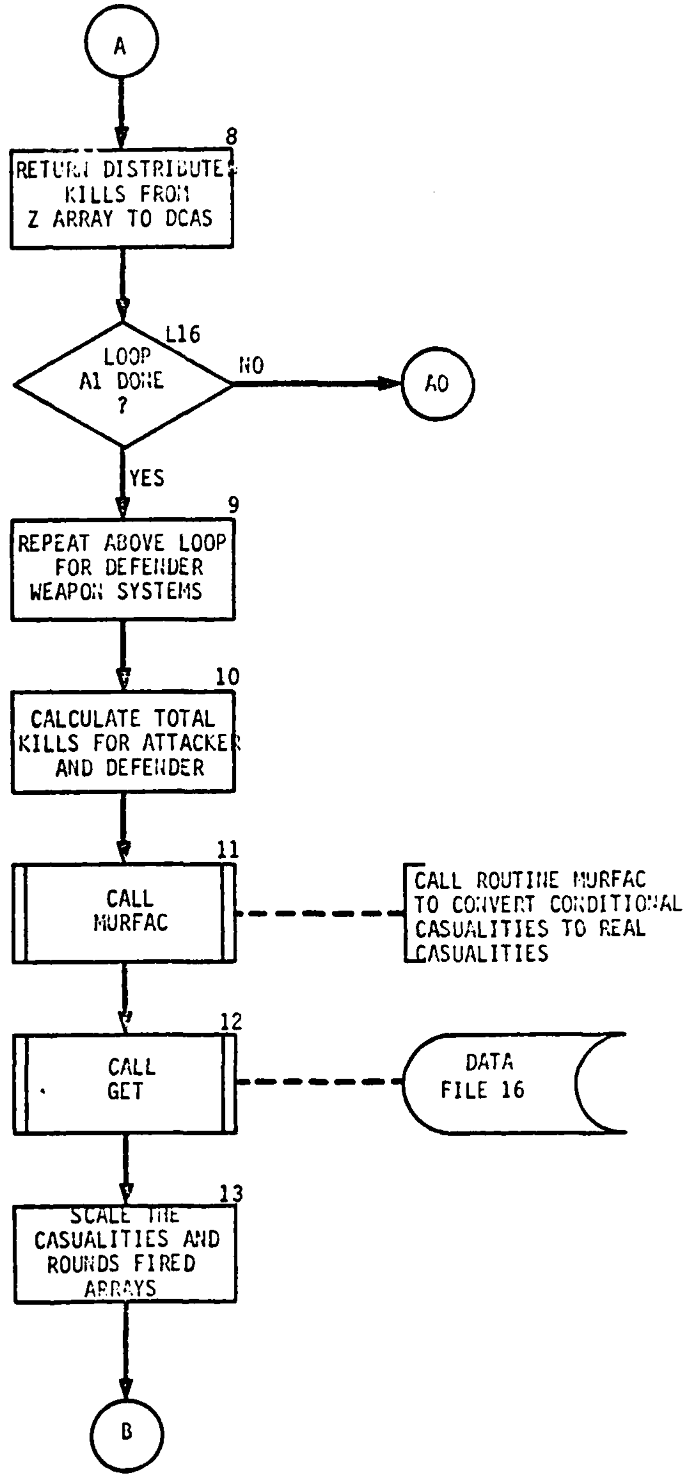
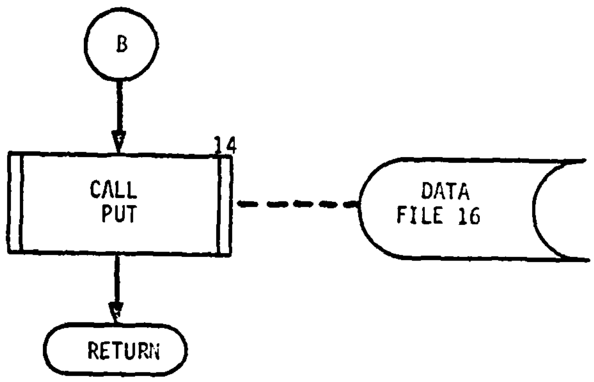


FIGURE IV-7-B-24 ROUTINE GBKEEP


A
8
RETURN DISTRIBUTED KILLS FROM Z ARRAY TO DCAS
L16
LOOP A1 DONE ?
NO
A0
YES
9
REPEAT ABOVE LOOP FOR DEFENDER WEAPON SYSTEMS
10
CALCULATE TOTAL KILLS FOR ATTACKER AND DEFENDER
11
CALL MURFAC
CALL ROUTINE MURFAC TO CONVERT CONDITIONAL CASUALITIES TO REAL CASUALITIES
12
CALL GET
DATA FILE 16
13
SCALE THE CASUALITIES AND ROUNDS FIRED ARRAYS
B


B
14
CALL
PUT
DATA
FILE 16
RETURN

(3)	Block 3.	Begin loop (A1) on attacker's weapon system types.
(4)	Block 4.	Determine the number of weapon types on the first/next weapon system type.
(5)	Block 5.	ZERO out the Z array.
(6)	Block 6.	Fill the appropriate locations of the Z array with the defender kills by the weapon types on this weapon system type.
(7)	Block 7.	Call routine GLEG to distribute the kills by the weapon types on this weapon system type.
(8)	Block 8.	Return these distributed kills from the Z array to IDUM.
(9)	Block L16.	If loop (A1) is not done, transfer to Block 4.
(10)	Block 9.	Repeat the above loop (A1) for the defender weapon system types.
(11)	Block 10.	Calculate the total number of kills for the attacker and the defender.
(12)	Block 11.	Call routine MURFAC to convert these conditional kills to real kills (accounting for return fire, etc).
(13)	Block 12.	Call routine GET to get the number of active targets.
(14)	Block 13.	Scale the kills and rounds fired using the number of active targets.
(15)	Block 14.	Call routine PUT to place the converted loss and expenditure data on Data File 16. RETURN to the calling routine.

25. ROUTINE MURFAC.

a. Purpose. MURFAC uses an exponential averaging technique to find multiplying factors for converting conditional casualties and rounds find to actual casualties and rounds fired.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
NAWT	CALL	Number of attacker weapon system types.
NDWT	CALL	Number of defender weapon system types.
ACAS(8,8)	CALL	Conditional casualties suffered by the attacker.
DCAS(8,8)	CALL	Conditional casualties suffered by the defender.

c. Output Variables:

Name	Destination	Contents
ACAS(8,8)	CALL	Casualties suffered by the attacker.
DCAS(8,8)	CALL	Casualities suffered by the defender.

d. Logical Flow (Figure IV-7-B-25).

(1) Block 1. Initialize the required parameters.

(2) Block 2. Change the conditional kills (ACAS, DCAS) to kill fractions (ABAR, DBAR).

(3) Block 3. Determine the size of the attacking and defending forces (A, D).

(4) Block 4. Store the force sizes used in this iteration (ABARP, DBARP).

(5) Block 5. Determine the new force sizes (ABAR, DBAR).

(6) Block 6. If the old and new force sizes do not converge (not within DEL of each other), transfer to Block 3.

(7) Block 7. Calculate the attacker and defender casualties.

(8) Block 8. Put the defender's actual casualties into the Z array.

(9) Block 9. Call routine GLEG to determine the distribution of kills.

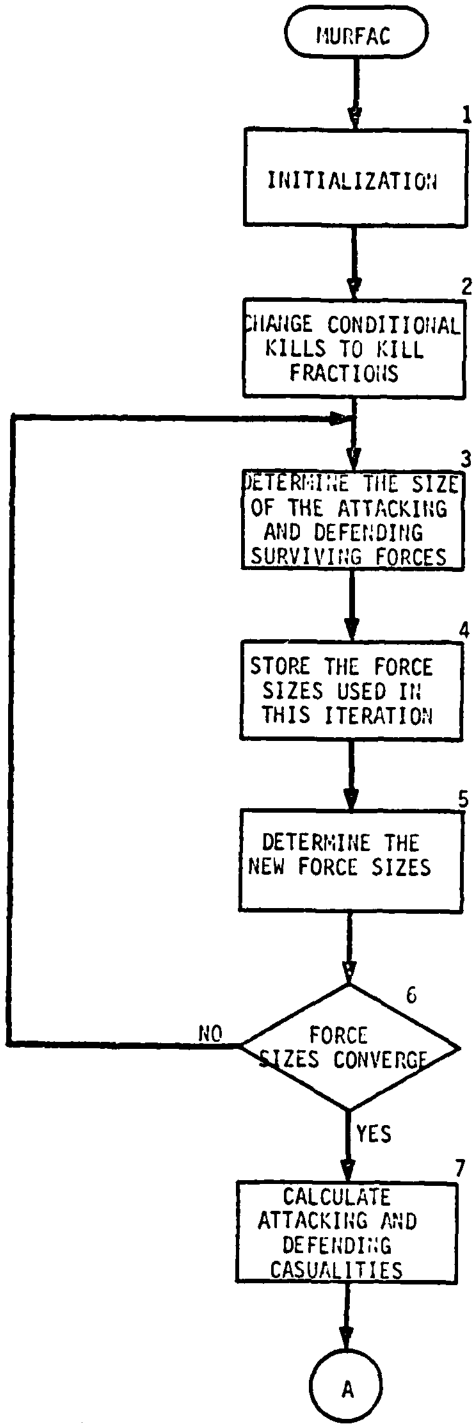
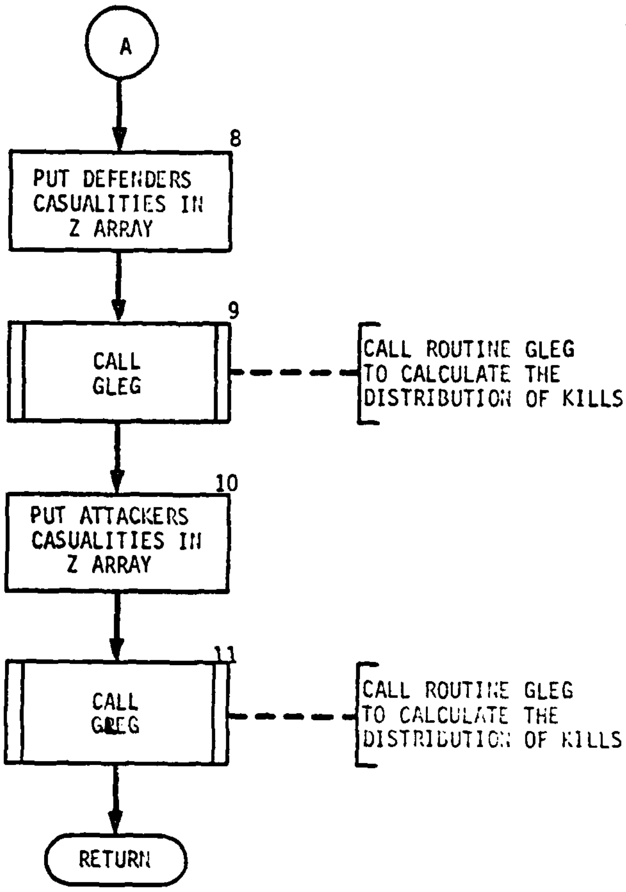


FIGURE IV-7-B-25 ROUTINE MURFAC


A
8
PUT DEFENDERS CASUALITIES IN Z ARRAY
9
CALL GLEG
CALL ROUTINE GLEG TO CALCULATE THE DISTRIBUTION OF KILLS
10
PUT ATTACKERS CASUALITIES IN Z ARRAY
11
CALL GLEG
CALL ROUTINE GLEG TO CALCULATE THE DISTRIBUTION OF KILLS
RETURN

(10) Block 10. Put the attacker's actual casualties into the Z array.

(11) Block 11. Call routine GLEG to determine the distribution of kills, RETURN to the calling routine.

26. ROUTINE GLEG.

a. Purpose. GLEG uses Gauss-Legendre integration to calculate the distribution of kills.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
KROW	CALL	Weapon type kills.
KCOL	CALL	Weapon system type kills.
Z(16,8)	TWO	Casualties.

c. Output Variables:

Name	Destination	Contents
Z(16,8)	TWO	Distributed casualties.

d. Logical Flow (Figure IV-7-B-26).

(1) Block 1. Set ZC equal to the total number of casualties.

(2) Block 2. Initialize the weights and roots.

(3) Block 3. Calculate the functional values using Guass-Legendre integration.

(4) Block 4. Multiply the functional values by weights and sums.

(5) Block 5. Calculate distributed kills.

27. ROUTINE EXECØ.

a. Purpose. EXECØ builds the sensing reports for ground combat and prepares the history records (#s 311, 312, 313, and 333) for output on to the history tape.

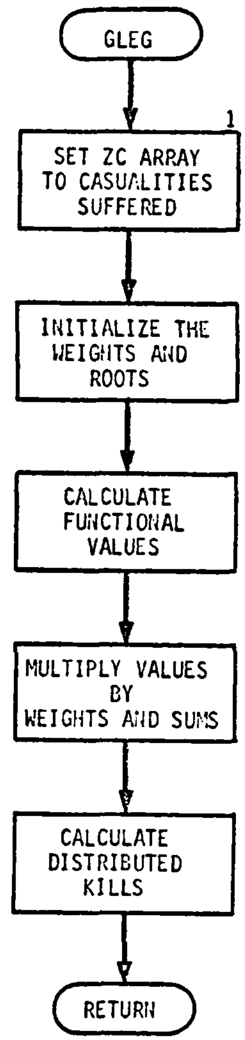


FIGURE IV-7-B-26 ROUTINE GLEG

b. Input Variables:

Name	Source	Contents
IDOM(2001-3244)	DF16	GCM data.
TBCOSA(256)	DF21	Total battle losses for the attacker.
TBLOSD(256)	DF21	Total battle losses for the defender.

c. Output Variables:

Name	Destination	Contents
JOOT(128,2)	ONE	GCM history records.
TBLOSA(256)	DF21	Total battle losses for the attacker, located at IDUM (1001).
TBLOSD(256)	DF21	Total battle losses for the defender, located at IDUM (1257).

d. Logical Flow (Figure IV-7-B-26).

(1) Block 1. Get GCM data from Data File 16 and place in IDUM (2001-3244).

(2) Block 2. Prepare data for construction of history records (operations such as rounding, packing, and unpacking appropriate data).

(3) Block 3. Fill JOUT array for #311 history record for the attacker and defender. Attacker's 311 history record starts at location JOUT (1,1) and the defenders at JOUT (1,2).

(4) Block 4. Call routine PUTOUT to create the attacker's #311 GCM history record. (PUTOUT uses JOUT array).

(5) Block 5. Fill JOUT array for #312 history record for the attacker (JOUT (1,1)). (Defender's 311 record remains in JOUT (1,2).)

(6) Block 6. Call routine PUTOUT to create the attacker's #312 GCM history record.

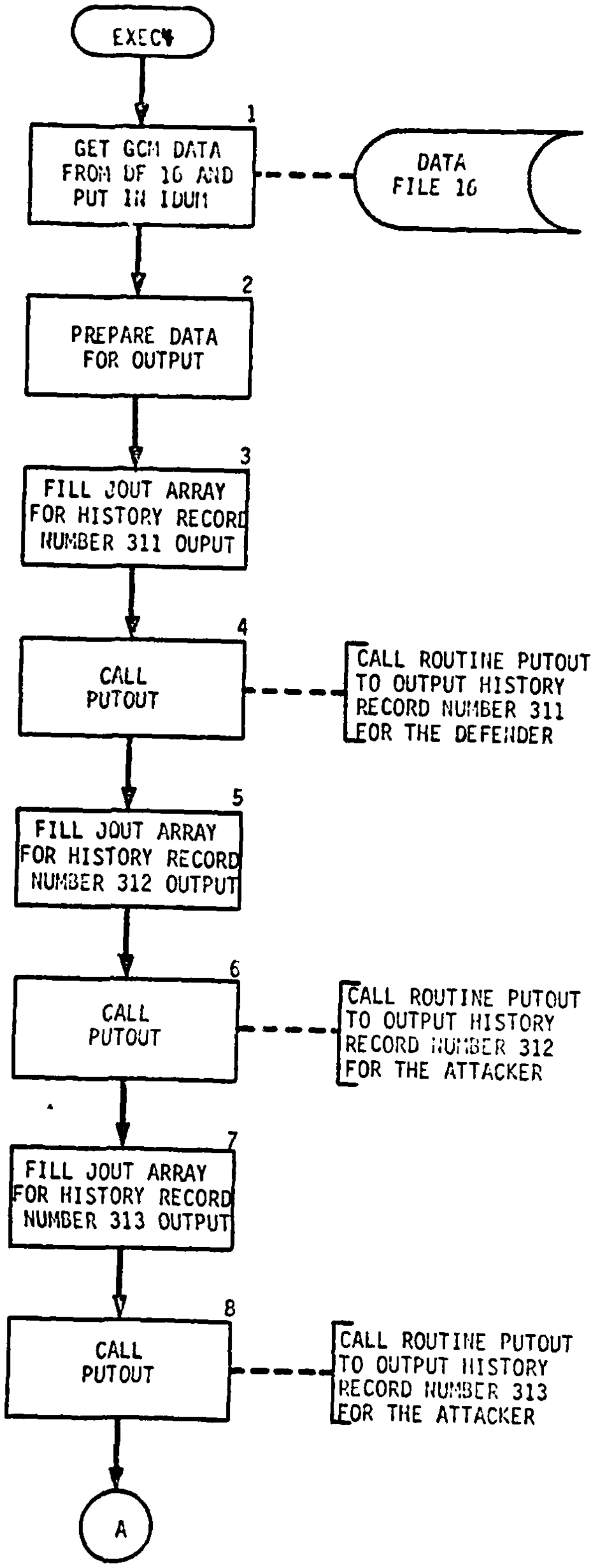
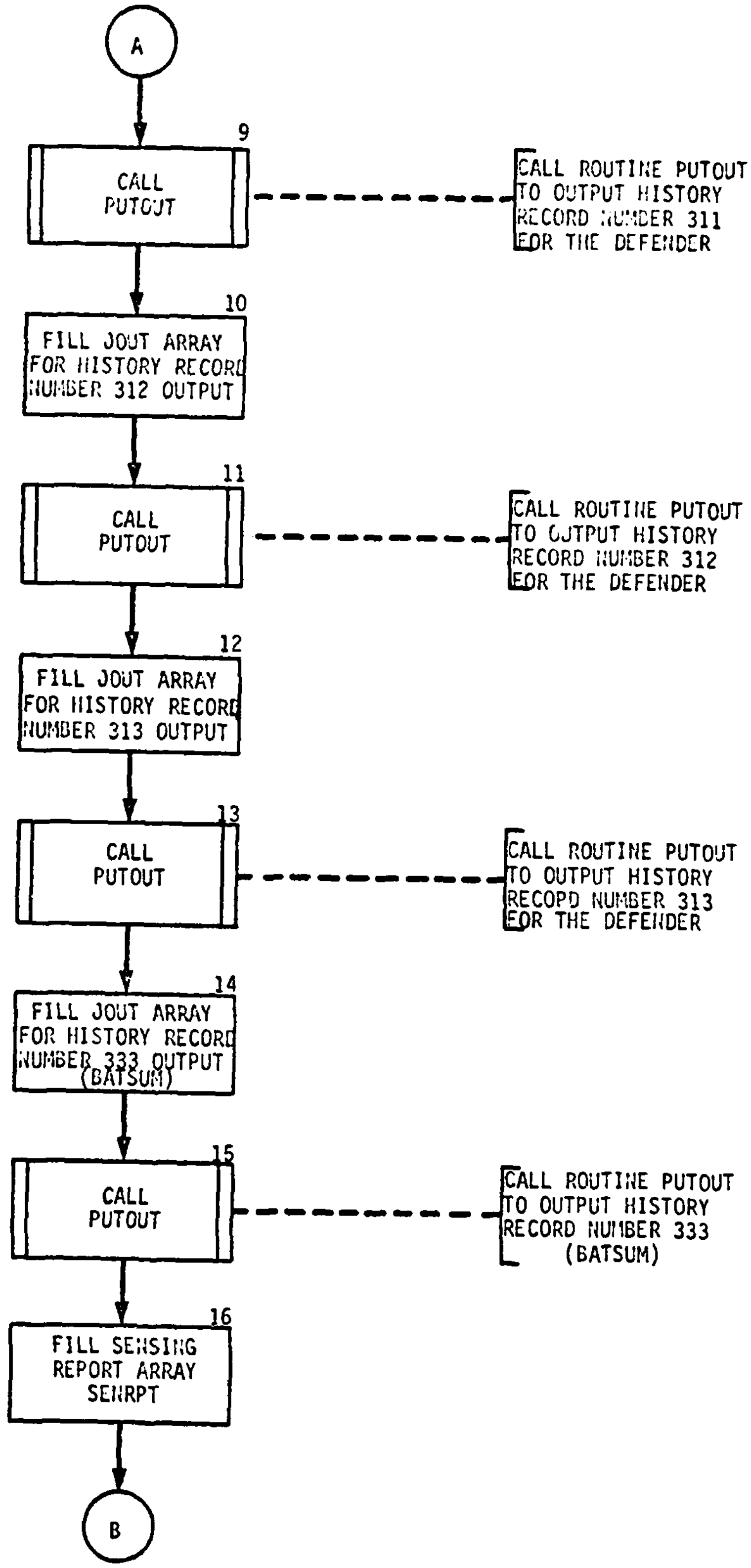
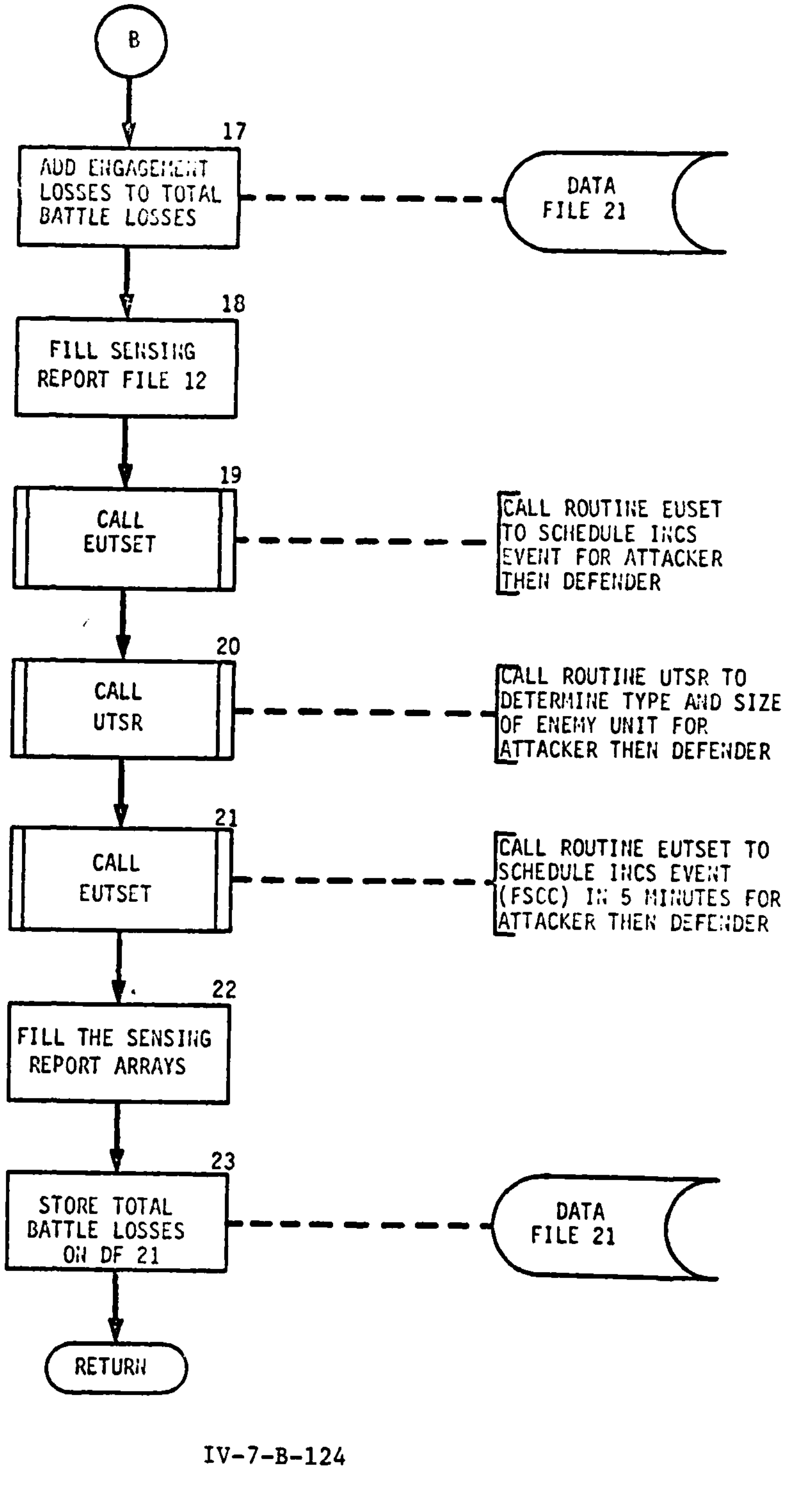


FIGURE IV-7-B-27 ROUTINE EXEC4


A
9
CALL PUTOUT
CALL ROUTINE PUTOUT TO OUTPUT HISTORY RECORD NUMBER 311 FOR THE DEFENDER
10
FILL JOUT ARRAY FOR HISTORY RECORD NUMBER 312 OUTPUT
11
CALL PUTOUT
CALL ROUTINE PUTOUT TO OUTPUT HISTORY RECORD NUMBER 312 FOR THE DEFENDER
12
FILL JOUT ARRAY FOR HISTORY RECORD NUMBER 313 OUTPUT
13
CALL PUTOUT
CALL ROUTINE PUTOUT TO OUTPUT HISTORY RECORD NUMBER 313 FOR THE DEFENDER
14
FILL JOUT ARRAY FOR HISTORY RECORD NUMBER 333 OUTPUT (BATSUM)
15
CALL PUTOUT
CALL ROUTINE PUTOUT TO OUTPUT HISTORY RECORD NUMBER 333 (BATSUM)
16
FILL SENSING REPORT ARRAY SENRPT
B


B
17
ADD ENGAGEMENT LOSSES TO TOTAL BATTLE LOSSES
DATA FILE 21
18
FILL SENSING REPORT FILE 12
19
CALL EUTSET
CALL ROUTINE EUSET TO SCHEDULE INCS EVENT FOR ATTACKER THEN DEFENDER
20
CALL UTSR
CALL ROUTINE UTSR TO DETERMINE TYPE AND SIZE OF ENEMY UNIT FOR ATTACKER THEN DEFENDER
21
CALL EUTSET
CALL ROUTINE EUTSET TO SCHEDULE INCS EVENT (FSCC) IN 5 MINUTES FOR ATTACKER THEN DEFENDER
22
FILL THE SENSING REPORT ARRAYS
23
STORE TOTAL BATTLE LOSSES ON DF 21
DATA FILE 21
RETURN

(7) Block 7. Fill JOUT array for #313 history record for the attacker (JOUT (1,1)). (Defender's 311 record remains in JOUT (1,2).)

(8) Block 8. Call routine PUTOUT to create the attacker's #313 GCM history record.

(9) Block 9. Call routine PUTOUT to create the defender's #311 GCM history record.

(10) Block 10. Fill JOUT array for #312 history record for the defender (JOUT (1,2).)

(11) Block 11. Call routine PUTOUT to create the defender's #312 GCM history record.

(12) Block 12. Fill JOUT array for #313 history record for the defender.

(13) Block 13. Call routine PUTOUT to create the defenders #313 GCM history record.

(14) Block 14. Fill JOUT array for #333 (BATSUM) history record.

(15) Block 15. Call routine PUTOUT to create #333 GCM history record (BATSUM).

(16) Block 16. Create sensing reports on the attacker and the defender.

(17) Block 17. Get the total losses for the attacker and defender which have occurred during this battle and add the attacker and defender losses of this GCM engagement increment.

(18) Block 18. Fill FILE12 before scheduling of INS event for the attacker then for the defender (loop).

(19) Block 19. Call routine EVTSET to schedule an INS event for the attacker then the defender (loop). FILE12(2) equal to 2 will cause INCS creative processing to occur.

(20) Block 20. Call routine UTSR to determine the type and size of the defender then the attacker (loop).

(21) Block 21. Call routine EUTSET to schedule an IN' event for the attacker then the defender (loop). FILE12(2) equal to 12 will cause FSCC (DECIDE) INCS logic to occur.

(22) Block 22. Fill the sensing report arrays (SENSD, SENSA).

(23) Block 23. Put total attacker and defender losses for this battle out on Data File 21, then RETURN to the calling routine.

28. ROUTINE GCOBS.

a. Purpose. GCOBS determines whether a barrier will be encountered during a GCM move segment and, if so, sets up the data files required for the encounter.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
ITMAT (8)	TWO	Attacker's weapon system transport item codes, located at IDUM (4024).
VATTV (8)	TWO	Attacker's weapon system transport velocities, located at IDUM (4016).
MVRATE	ONE	Movement rate.
ITBL (16, 4)	TWO	GCM Control Table, located at IDUM (4035).
IDAT22 (1502)	DF22	Quadrature locations and File 2 indices of barriers, located at IDUM (1001).
IDAT2 (35)	DF2	Barrier information, located at IDUM (2784).
NOT	CALL	Mine intersection flag.
IDXATT	TWO	Attacker's index into GCM Control Table, located at IDUM (4033).

c. Output Variables:

Name	Destination	Contents
BLOC (2)	TWO	Quadrature location of a barrier and its File 2 record number, located at IDUM (2774).
DELT	ONE	Time of move to intersection with barrier.
IGO	TWO	Barrier encounter flag, located at IDUM (4101).

MVRATE ONE Unit movement rate.

d. Logical Flow (Figure IV-7-B-28).

(1) Block 1. Is the unit moving? If not, RETURN to calling program. Units must be moving to hit barriers.

(2) Block 2. Set the movement rate to that of the slowest weapon system transport in the unit.

(3) Block 3. Calculate move segment end points and time of move segment.

(4) Block 4. Call routine CRTQD to create a packed 8-digit quadrature code for this move segment.

(5) Block 5. Call routine PACK28 to unpack the 8-digit quadrature code for this move segment.

(6) Block 6. Call routine OBFIL to obtain the Data File 22 record numbers required to locate barriers along this move segment.

(7) Block 7. Begin loop (A1) on these Data File 22 records.

(8) Block 8. Call routine GETRCD to obtain first/next File 22 record containing quadrature code location and File 2 record number.

(9) Block 9. If this is an empty record, transfer to block L400.

(10) Block 10. Begin loop (B1) on each entry (barrier triplet) in this File 22 record.

(11) Block 11. Get File 2 record number and quadrature code location of the first/next barrier in this File 22 record.

(12) Block 12. Call routine PACK28 to unpack the 8-digit quadrature code location of this barrier.

(13) Block 13. Call routine ISCAN to determine if intersection between the move segment line and barrier line is possible.

(14) Block 14. If intersection is not possible, transfer to block L300.

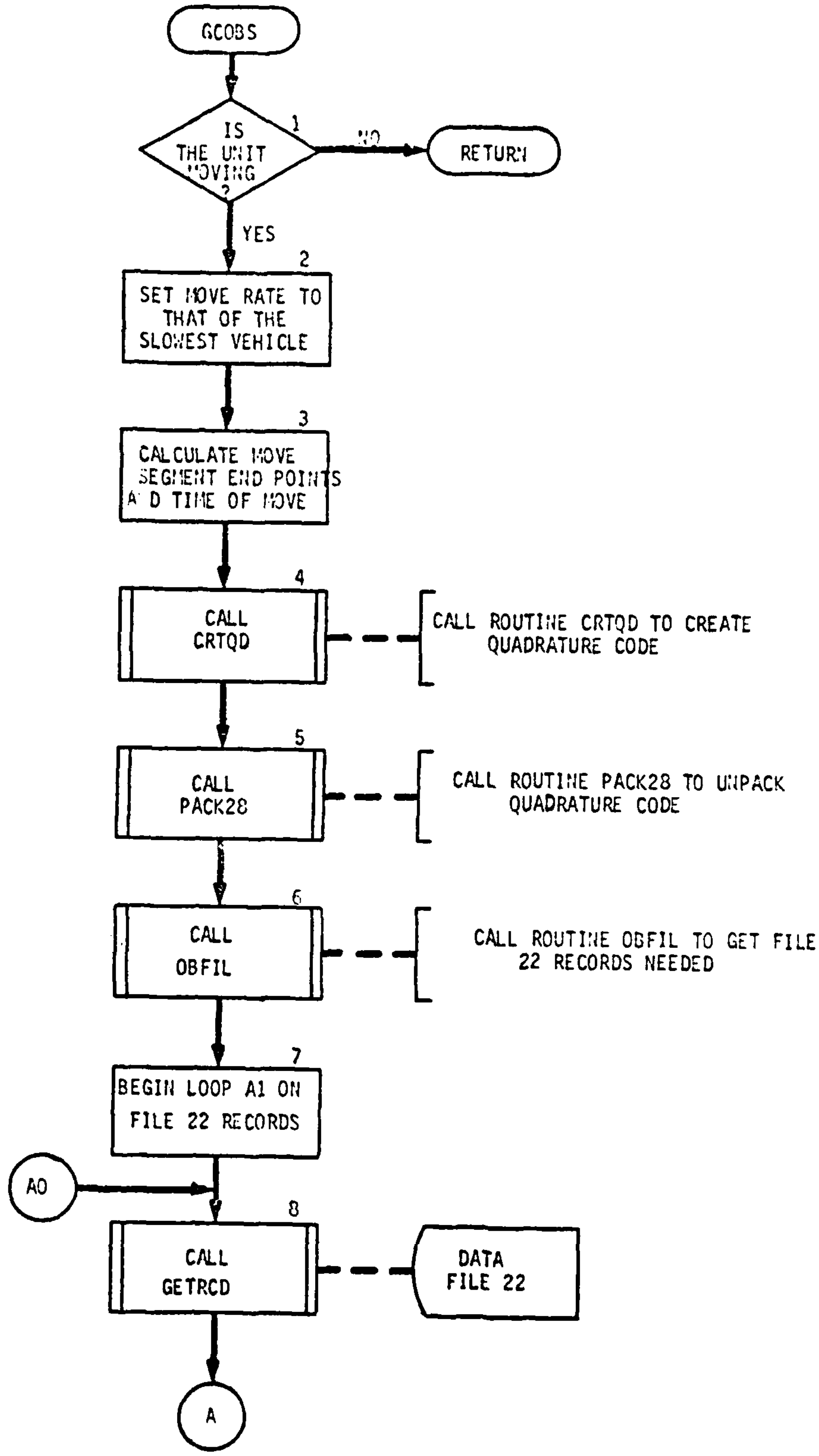
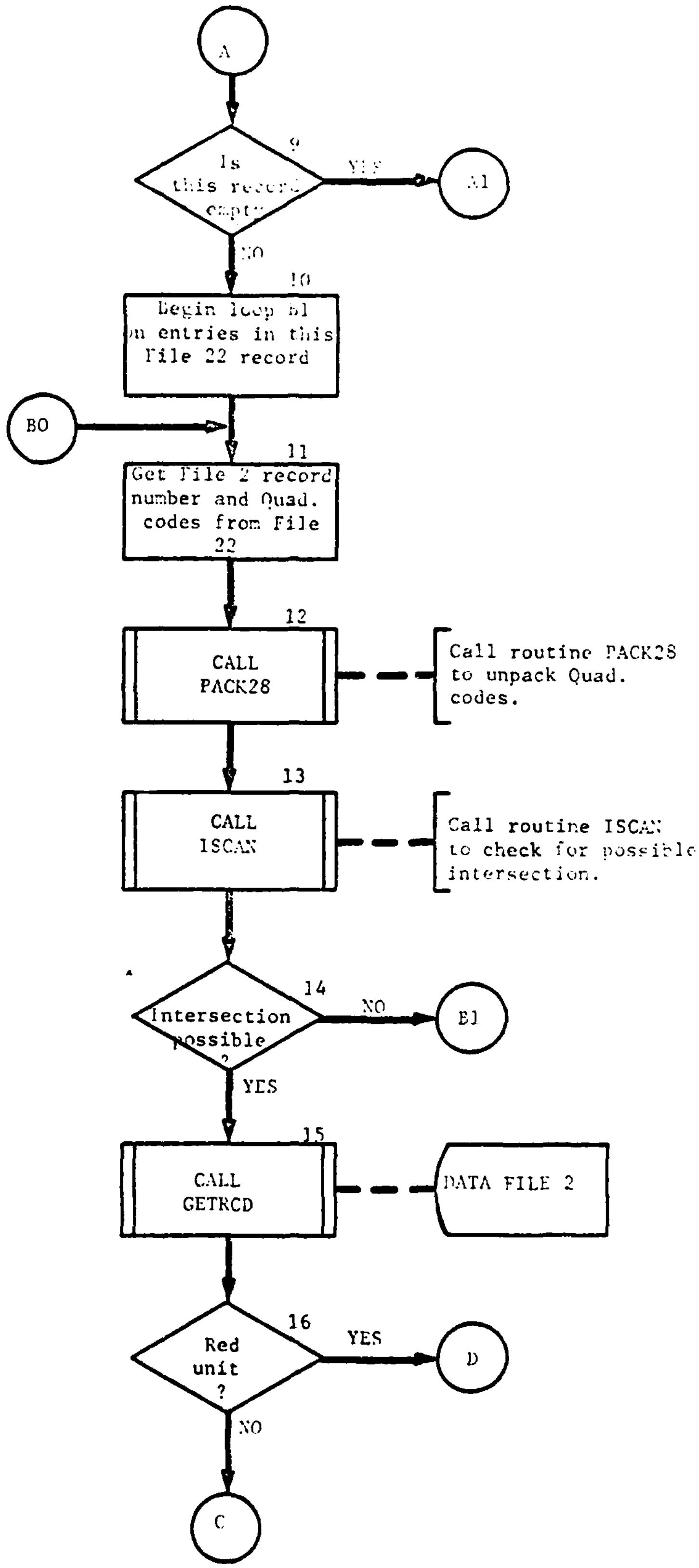
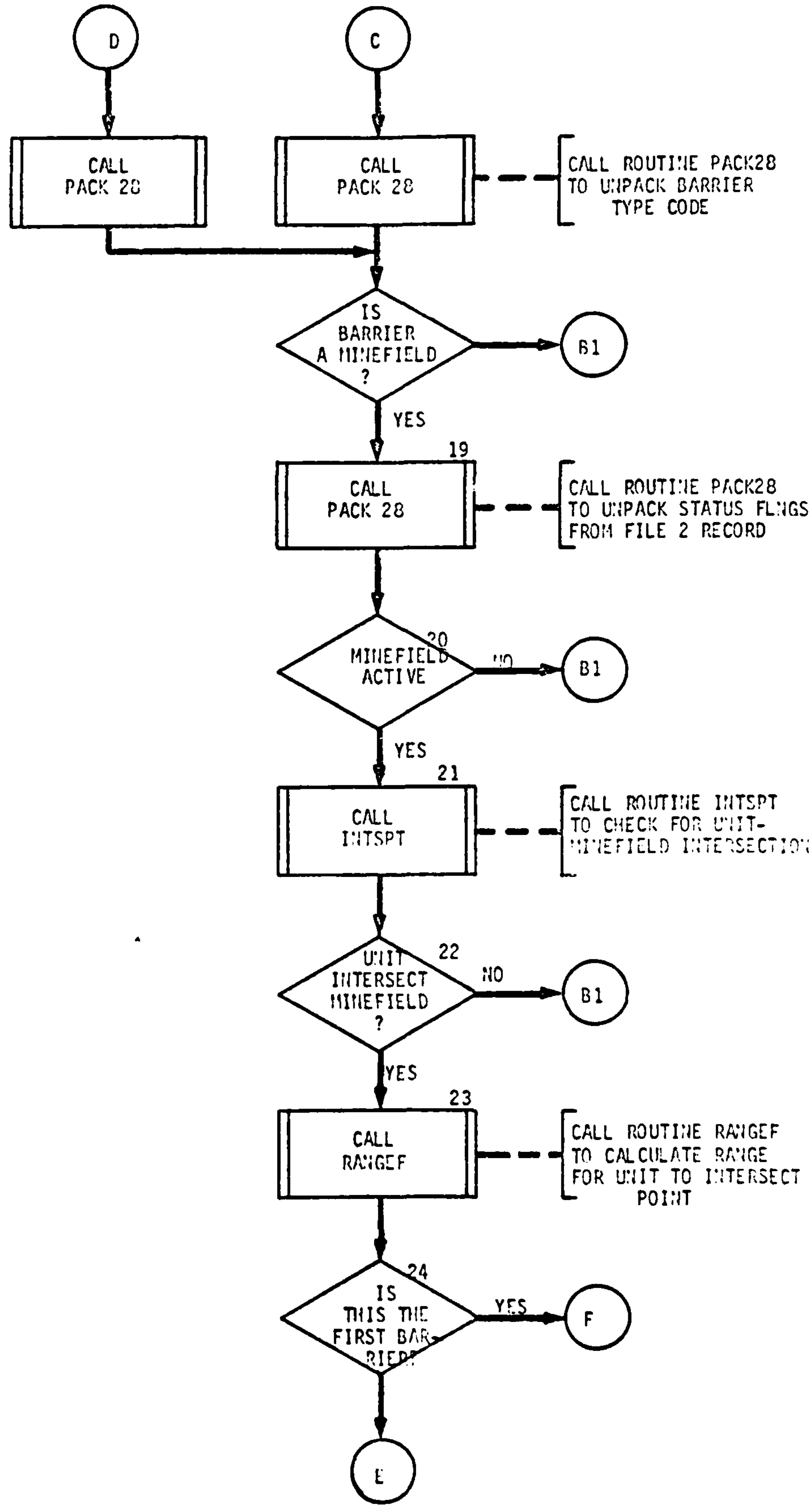
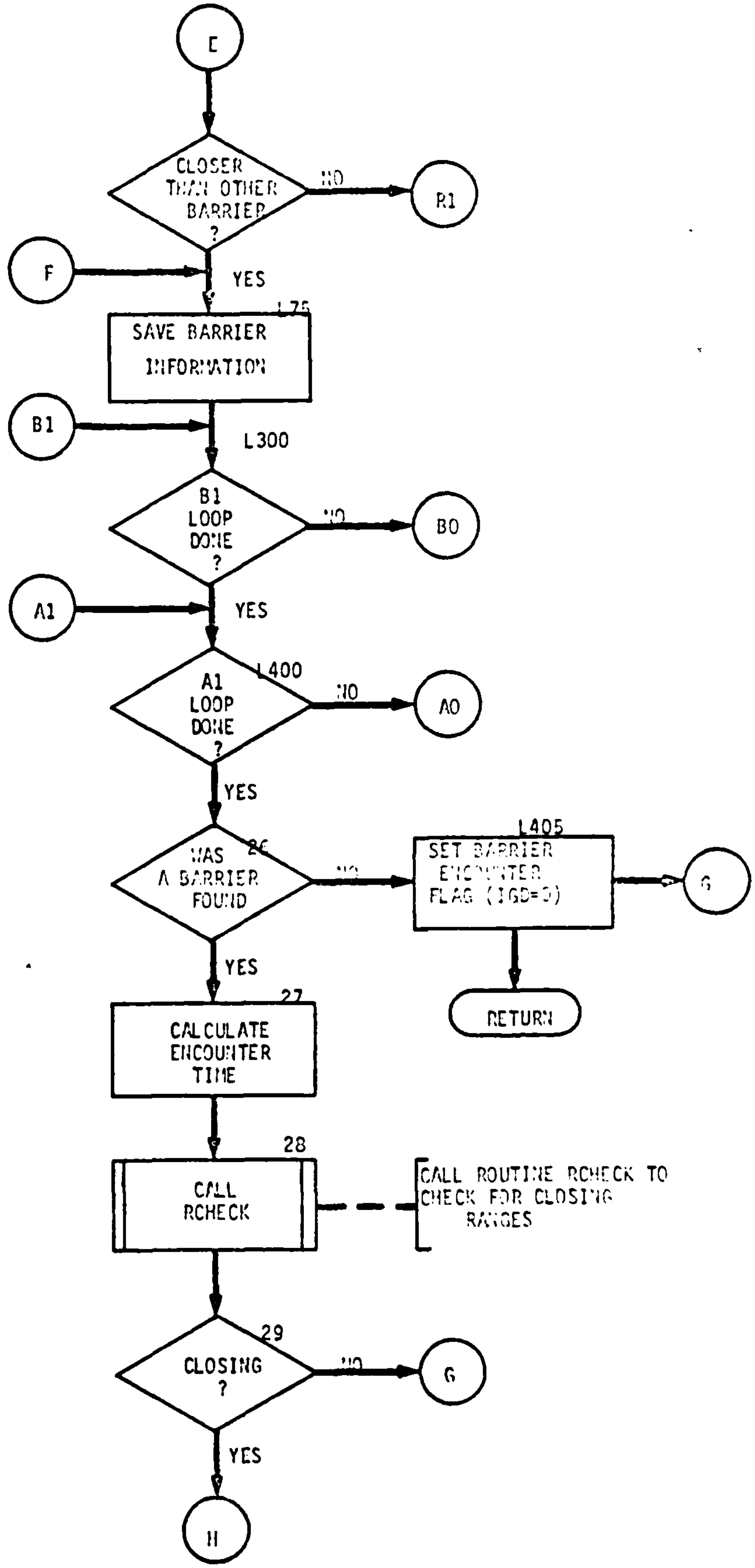
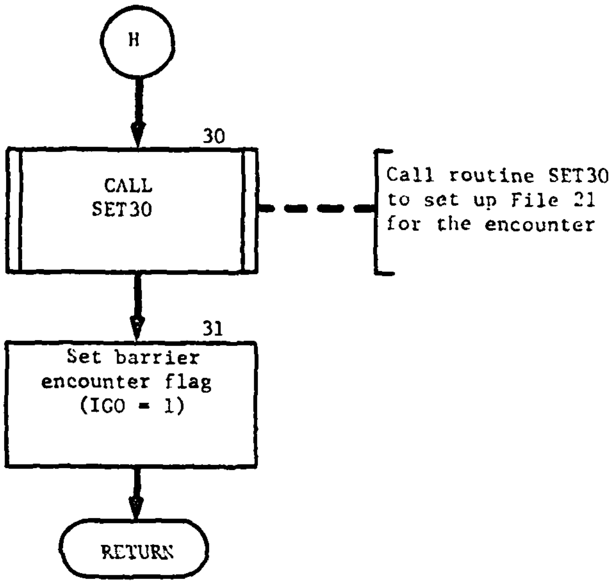


FIGURE IV-7-B-28 ROUTINE GCOBS


A
9
Is
this record
empty
YES
A1
NO
10
Begin loop on entries in this File 22 record
BO
11
Get File 2 record number and Quad. codes from File 22
12
CALL PACK28
Call routine PACK28 to unpack Quad. codes.
13
CALL ISCAN
Call routine ISCAN to check for possible intersection.
14
Intersection possible ?
NO
B1
YES
15
CALL GETRCD
DATA FILE 2
16
Red unit ?
YES
D
NO
C


D
C
CALL PACK 28
CALL PACK 28
CALL ROUTINE PACK28 TO UNPACK BARRIER TYPE CODE
IS BARRIER A MINEFIELD ?
B1
YES
19
CALL PACK 28
CALL ROUTINE PACK28 TO UNPACK STATUS FLAGS FROM FILE 2 RECORD
20
MINEFIELD ACTIVE
NO
B1
YES
21
CALL INTSPT
CALL ROUTINE INTSPT TO CHECK FOR UNIT-MINEFIELD INTERSECTION
22
UNIT INTERSECT MINEFIELD ?
NO
B1
YES
23
CALL RANGEF
CALL ROUTINE RANGEF TO CALCULATE RANGE FOR UNIT TO INTERSECT POINT
24
IS THIS THE FIRST BARRIER
YES
F
E


E
CLOSER THAN OTHER BARRIER ?
NO
R1
F
YES
L75
SAVE BARRIER INFORMATION
B1
L300
B1 LOOP DONE ?
NO
B0
A1
YES
L400
A1 LOOP DONE ?
NO
A0
YES
26
WAS A BARRIER FOUND
NO
L405
SET BARRIER ENCOUNTER FLAG (IGD=0)
G
RETURN
YES
27
CALCULATE ENCOUNTER TIME
28
CALL RCHECK
CALL ROUTINE RCHECK TO CHECK FOR CLOSING RANGES
29
CLOSING ?
NO
G
YES
H


H
30
CALL
SET30
Call routine SET30
to set up File 21
for the encounter
31
Set barrier
encounter flag
(IGO = 1)
RETURN

(15) Block 15. Call routine GETRCD to get barrier information for this barrier from File 2.

(16) Block 16. If encountering unit is Red, transfer to block L50.

(17) Block 17. Call routine PACK28 to unpack barrier type code. Transfer to block 18.

(18) Block L50. Call routine PACK28 to unpack barrier type code.

(19) Block 18. If the barrier is not a minefield, transfer to block L300.

(20) Block 19. Call routine PACK28 to unpack barrier status flag from CHAR2 of File 2 record.

(21) Block 20. If this minefield is not active, transfer to block L300.

(22) Block 21. Call routine INTSPT to determine unit move segment intersection with the minefield.

(23) Block 22. If the unit move segment does not intersect the minefield, transfer to block L300.

(24) Block 23. Call routine RANGEF to compute the range to the intersect point.

(25) Block 24. If this is the first barrier to be hit during this move segment, transfer to block L75.

(26) Block 25. If this barrier intersection range is greater than the range to the other barrier intersection, transfer to block L300.

(27) Block L75. Save information on this barrier.

(28) Block L300. If loop B1 is not done (more entries in this File 22 record), transfer to block 11.

(29) Block L400. If loop A1 is not done (more File 22 records), transfer to block 8.

(30) Block 26. Was a barrier found? If so, transfer to block 27.

(31) Block L405. Set barrier encounter flag (IGO) to ZERO and RETURN to calling program.

(32) Block 27. Calculate time of the move to the intersect point.

(33) Block 28. Call routine RCHECK to check for closing ranges.

(34) Block 29. If ranges are not closing, transfer to block L405.

(35) Block 30. Call routine SET30 to set up File 21 for the barrier encounter.

(36) Block 31. Set barrier encounter flag (IGO) to 1 and RETURN to calling program.

29. ROUTINE OBFIL.

a. Purpose. OBFIL determines the File 22 records required to locate the barriers associated with a particular quadrature code location.

b. Input Variables:

Name	Source	Contents
ALOCC (8)	CALL	Quadrature codes.

c. Output Variables:

Name	Destination	Contents
NFIL	CALL	Number of File 22 records.
JREC (12)	CALL	File 22 record numbers.

d. Logical Flow (Figure IV-7-B-29).

(1) Block 1. Using the first two words of the quadrature codes, fill the JREC array with File 22 record numbers and set NFIL.

30. ROUTINE ISCAN.

a. Purpose. ISCAN scans a pair of quadrature codes to determine if intersection is possible.

b. Input Variables:

Name	Source	Contents
ALOCC (8)	CALL	First set of quadrature codes.

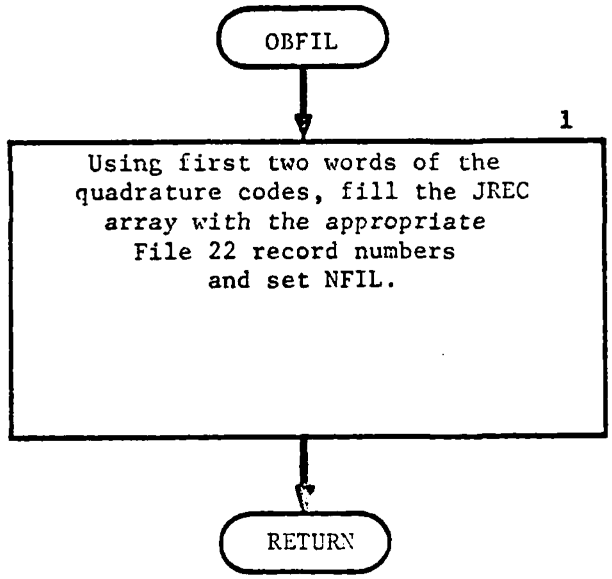


Figure IV-7-B-2[illegible]. Routine OBFIL.

BLOCC (8)	CALL	Second set of quadrature codes.

c. Output Variables:

Name	Destination	Contents
ISCAN	CALL	Possible intersection flag.

d. Logical Flow (Figure IV-7-B-30).

(1) Block 1. Set ISCAN to zero to indicate intersection is not possible.

(2) Block 2. Begin loop (A1) on 8 words in quadrature codes.

(3) Block 3. Set MA to first/next quadrature code word of first set of quadrature codes.

(4) Block 4. If MA is ZERO or 9, transfer to block L30.

(5) Block 5. Set MB to first/next quadrature code word of second set of quadrature codes.

(6) Block 6. If MB is ZERO or 9, transfer to block L30.

(7) Block 7. If MA = MB, transfer to block L20.

(8) Block 8. Search IDATA array for a match between MA and MB.

(9) Block 9. If a match if found, RETURN to calling program with ISCAN=0.

(10) Block L20. If this is not the end of loop (A1), transfer to block 3.

(11) Block L30. Set ISCAN to 1 to indicate intersection is possible. RETURN to calling program.

31. ROUTINE RCHECK.

a. Purpose. RCHECK checks whether the attacker and defender are closing and returns to the calling program a flag indicating such.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables.

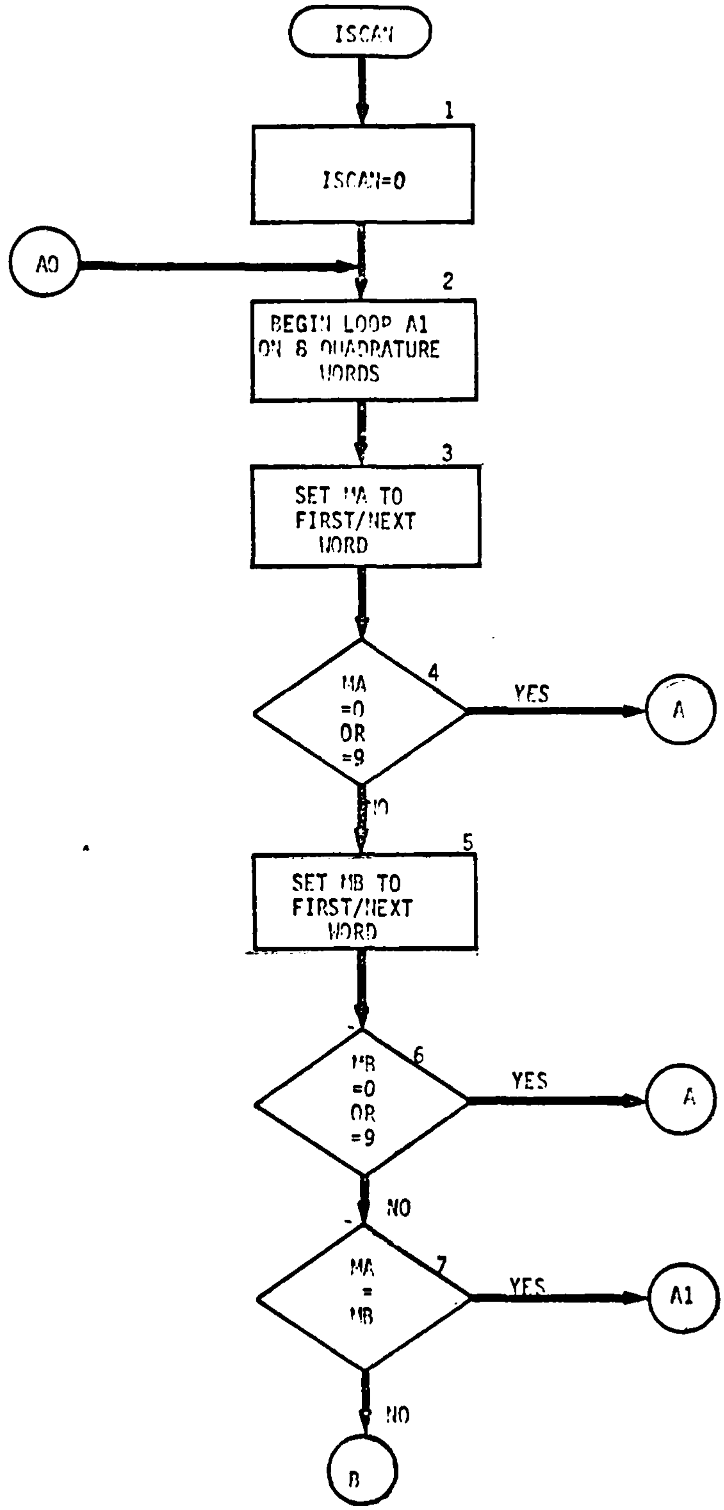
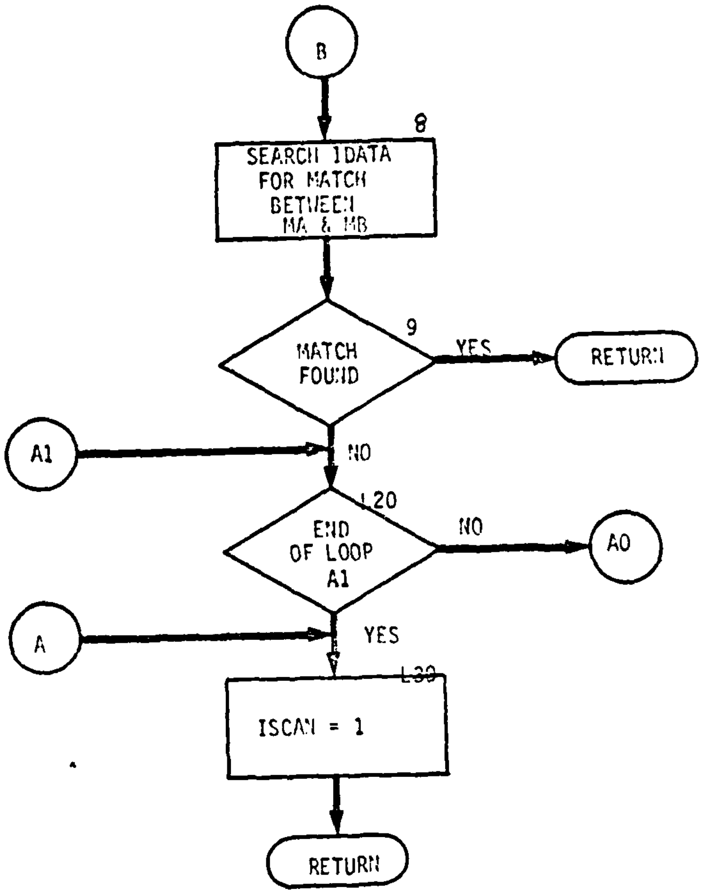


FIGURE IV-7-B-80 ROUTINE ISCAN



B
8
SEARCH IDATA FOR MATCH BETWEEN MA & MB
9
MATCH FOUND
YES
RETURN
A1
NO
L20
END OF LOOP A1
NO
A0
A
YES
L30
ISCAN = 1
RETURN

Name	Source	Contents
ISEP	DF16	Minimum separation distance.
ITBL (16, 4)	TWO	GCM Control Table, located at IDUM (4035).
TIME	CALL	Time to intersect point.

c. Output Variables:

Name	Destination	Contents
RCHECK	CALL	Closing flag.

d. Logical Flow (Figure IV-7-B-31).

(1) Block 1. Set RCHECK to zero indicating no barrier encounter.

(2) Block 2. Call routine GET to obtain the GCM minimum separation distance (ISEP) from Data File 16.

(3) Block 3. Begin loop (A1) on 16 entries in GCM Control Table (ITBL).

(4) Block 4. Is the first/next entry ZERO? If so, transfer to block L100.

(5) Block 5. Unpack ITBL to get the IUID and MODE of the defending unit.

(6) Block 6. If the defender's MODE is ZERO, transfer to block L100.

(7) Block 7. Call routine GETRCD to obtain the defender's Unit Status File from Data File 1.

(8) Block 8. Call routine GRNG to determine the attacker and defender's initial separation distance (SI), final separation distance (SF), and engagement frontage overlap (W).

(9) Block 9. If the attacker and defender do not have overlapping engagement frontage (W=0), transfer to block L100.

(10) Block 10. If the final separation distance is greater than the minimum separation distance, transfer to block L100.

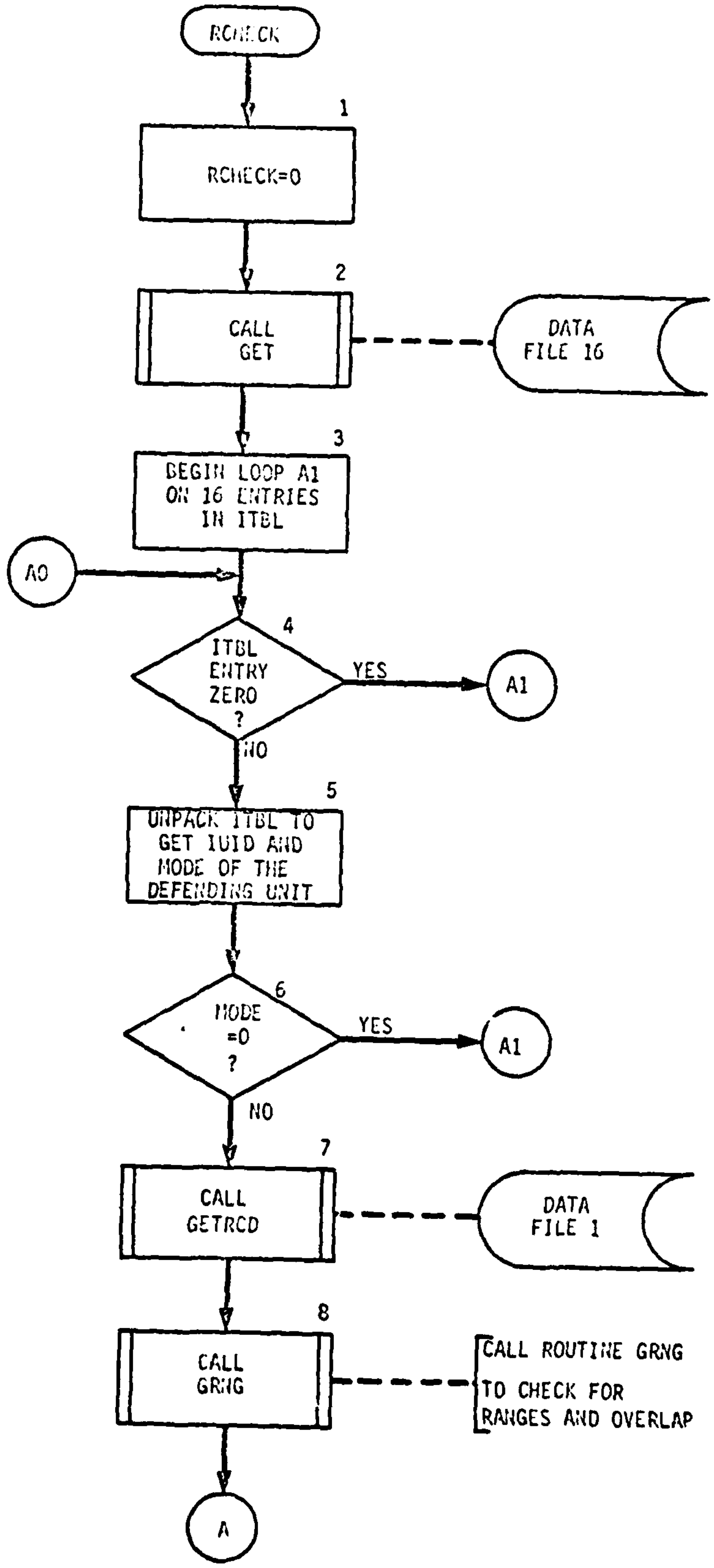
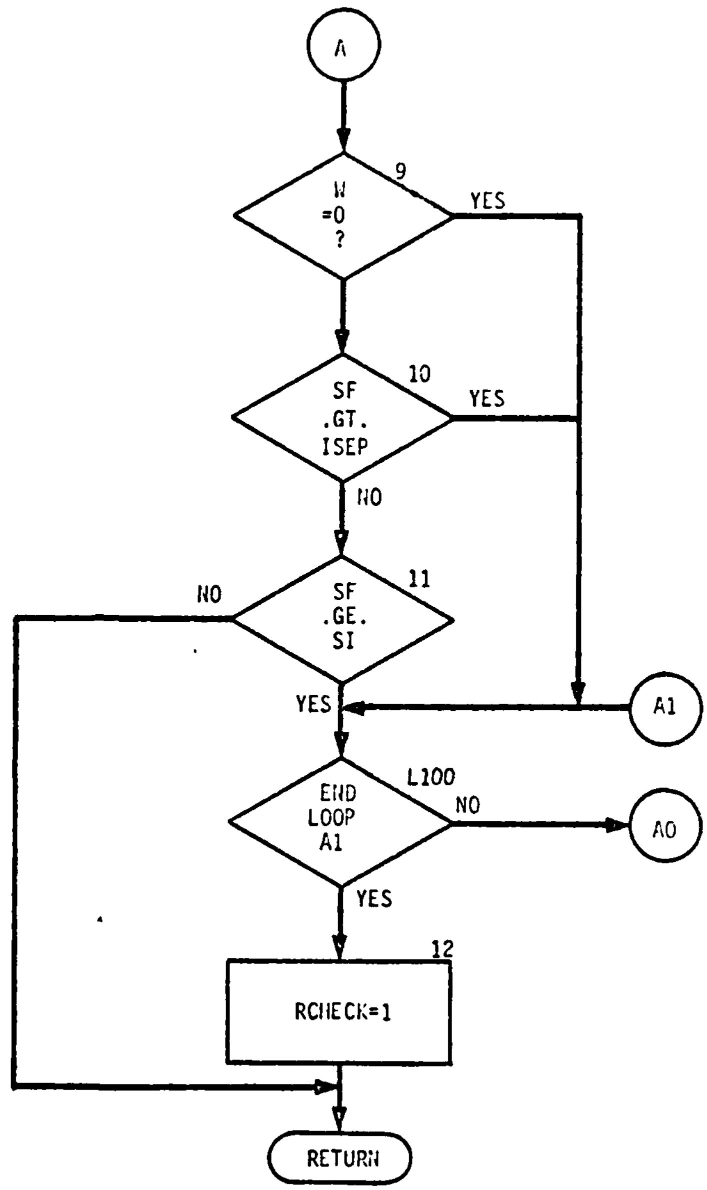


FIGURE IV-7-B-31 ROUTINE RCHECK


A
9
W
=0
?
YES
10
SF
.GT.
ISEP
YES
NO
11
NO
SF
.GE.
SI
YES
A1
L100
END
LOOP
A1
NO
A0
YES
12
RCHECK=1
RETURN

(11) Block 11. If the final separation distance is not greater than or equal to the initial separation distance, RETURN to the calling program.

(12) Block L100. If loop A1 is not done, transfer to block 4.

(13) Block 12. Set RCHECK to 1 indicating that barrier encounter can take place. RETURN to calling program.

32. ROUTINE SET30.

a. Purpose. SET30 sets up Data File 21 data for the barrier encounter.

b. Input Variables:

Name	Source	Contents
IENC	CALL	Time of barrier encounter.
IBAR	CALL	Barrier's File 2 record number.
XSECT	CALL	X coordinate of barrier encounter point.
YSECT	CALL	Y coordinate of barrier encounter point.
IOUT	DF2	Barrier-facility file record.
INDX	DF21	File 21 unit index table.

c. Output Variables:

Name	Destination	Contents
INDX	DF21	File 21 unit index table.
IOUT (128)	DF21	GCM barrier encounter information.

d. Logical Flow (Figure IV-7-B-32).

(1) Block 1. ZERO out IOUT array.

(2) Block 2. Fill part of IOUT array with accounting information (IUID, barrier File 2 record number, encounter point and time).

(3) Block 3. Call routine GETRCD to obtain barrier information.

(4) Block 4. Based on IUID of encountering unit determine type of barrier.

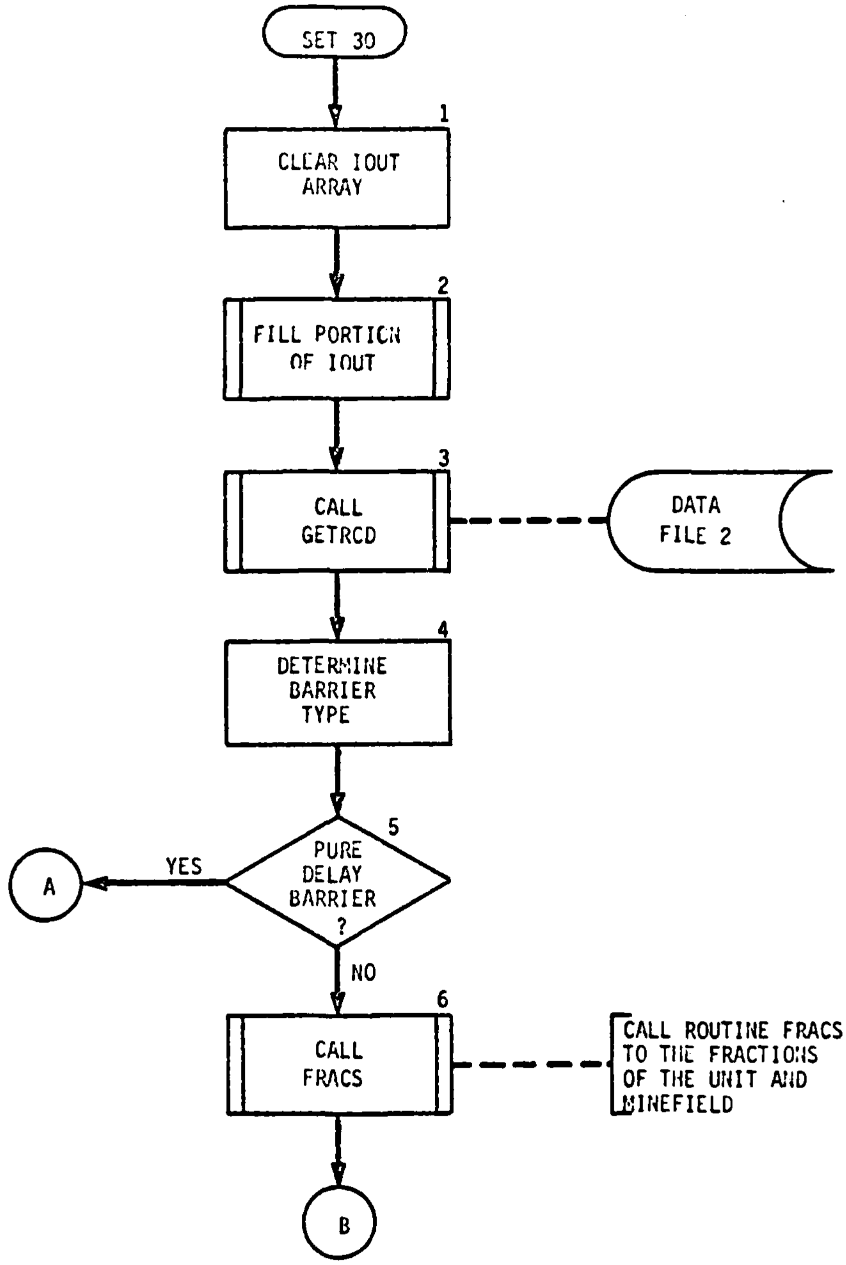
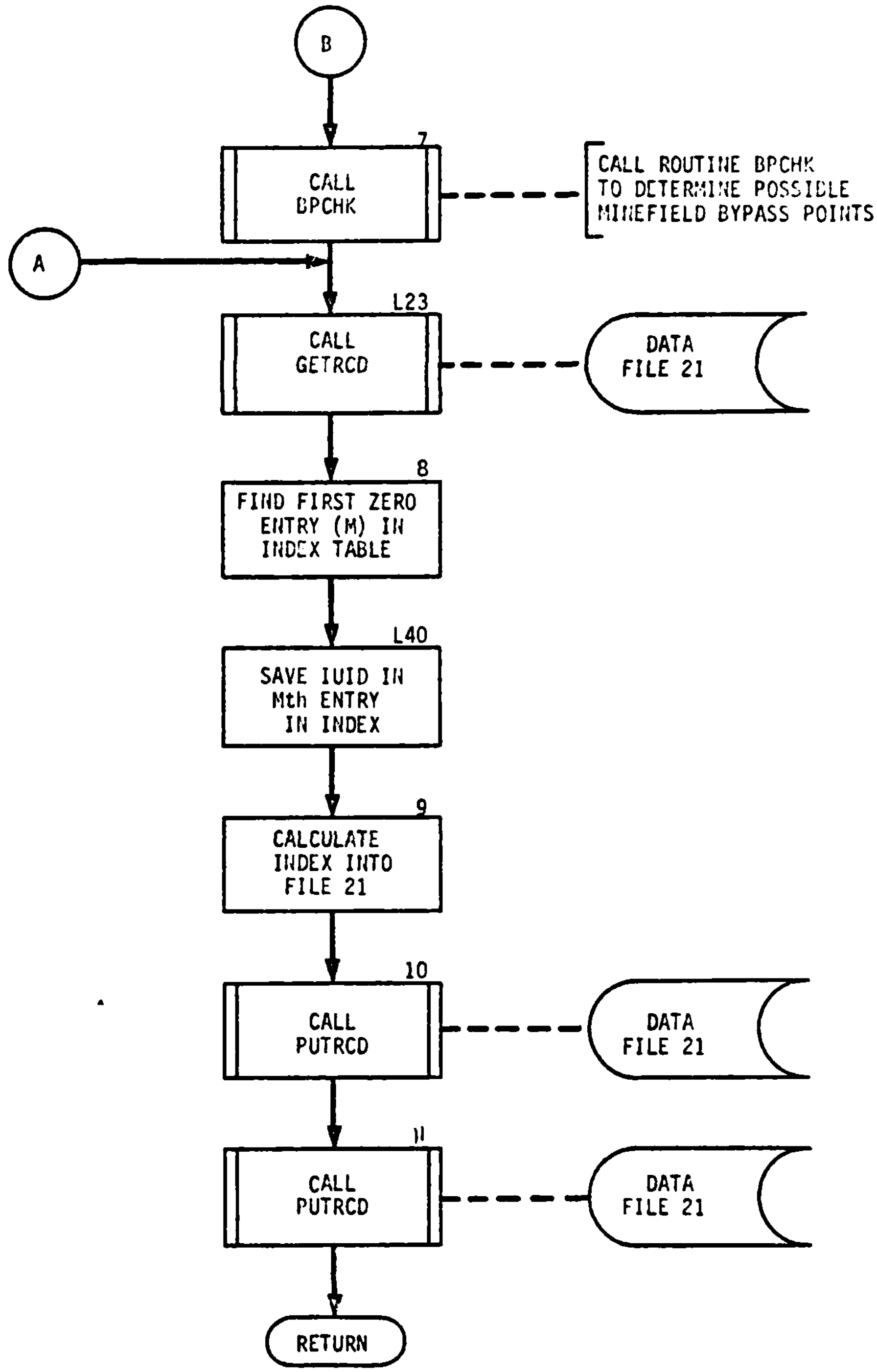


FIGURE IV-7-B-32 ROUTINE SET 30


B
7
CALL
BPCHK
CALL ROUTINE BPCHK
TO DETERMINE POSSIBLE
MINEFIELD BYPASS POINTS
A
L23
CALL
GETRCD
DATA
FILE 21
8
FIND FIRST ZERO
ENTRY (M) IN
INDEX TABLE
L40
SAVE IUID IN
Mth ENTRY
IN INDEX
9
CALCULATE
INDEX INTO
FILE 21
10
CALL
PUTRCD
DATA
FILE 21
11
CALL
PUTRCD
DATA
FILE 21
RETURN

(5) Block 5. If this barrier is a pure delay barrier, transfer to block L23.

(6) Block 6. Call routine FRACS to determine the fraction of the encountering unit's frontage that is covered by the minefield, and the fraction of the minefield that is encountered by the unit.

(7) Block 7. Call routine BPCHK to set the potential bypass points for this minefield.

(8) Block L23. Call routine GETRCD to obtain from Data File 21 the unit index table into File 21 (INDX).

(9) Block 8. Find the first available (ZERO) entry (m) in the unit index table (INDX).

(10) Block L40. Save the IUID of the encountering unit in the mth entry of INDX.

(11) Block 9. Calculate this unit's index into File 21.

(12) Block 10. Call routine PUTRCD to return update INDX table to File 21.

(13) Block 11. Call routine PUTRCD to put IOUT array (containing data for this barrier encounter) into Data File 21. RETURN to calling program.

33. ROUTINE GRNG.

a. Purpose. GRNG calculates initial and final separation distances, and amount of overlapping engagement frontage between the attacker and defender.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
TIME	CALL	Time of move to intersect point.

c. Output Variables:

Name	Destination	Contents
SI	CALL	Initial separation distance between attacker and defender.
SF	CALL	Final separation distance between attacker and defender.
W	CALL	Amount of overlapping engagement frontage between attacker and defender.

d. Logical Flow (Figure IV-7-B-33).

(1) Block 1. Initialize coordinates from COMMON areas.

(2) Block 2. Calculate the speed at which the attacker is moving in the X direction (U) and the Y direction (V).

(3) Block 3. Does the defender have a PREPARE order? If so, transfer to block L25.

(4) Block 4. Calculate the speed at which the defender is moving in the X direction (W) and the Y direction (Z).

(5) Block 5. Do the attacker and defender have the same type order? If not, transfer to block L30.

(6) Block 6. Calculate intermediate value (B) by subtracting attacker and defender speeds. Transfer to block L40.

(7) Block L25. Set defender's speed in the X direction (W) and the Y direction (Z) to ZERO.

(8) Block L30. Calculate intermediate value (B) by adding attacker and defender speeds.

(9) Block L40. Calculate other required intermediate values.

(10) Block 7. Calculate initial separation distance (SI).

(11) Block 8. Calculate final separation distance (SF).

(12) Block 9. Calculate engagement frontage overlap between attacker and defender. RETURN to calling routine.

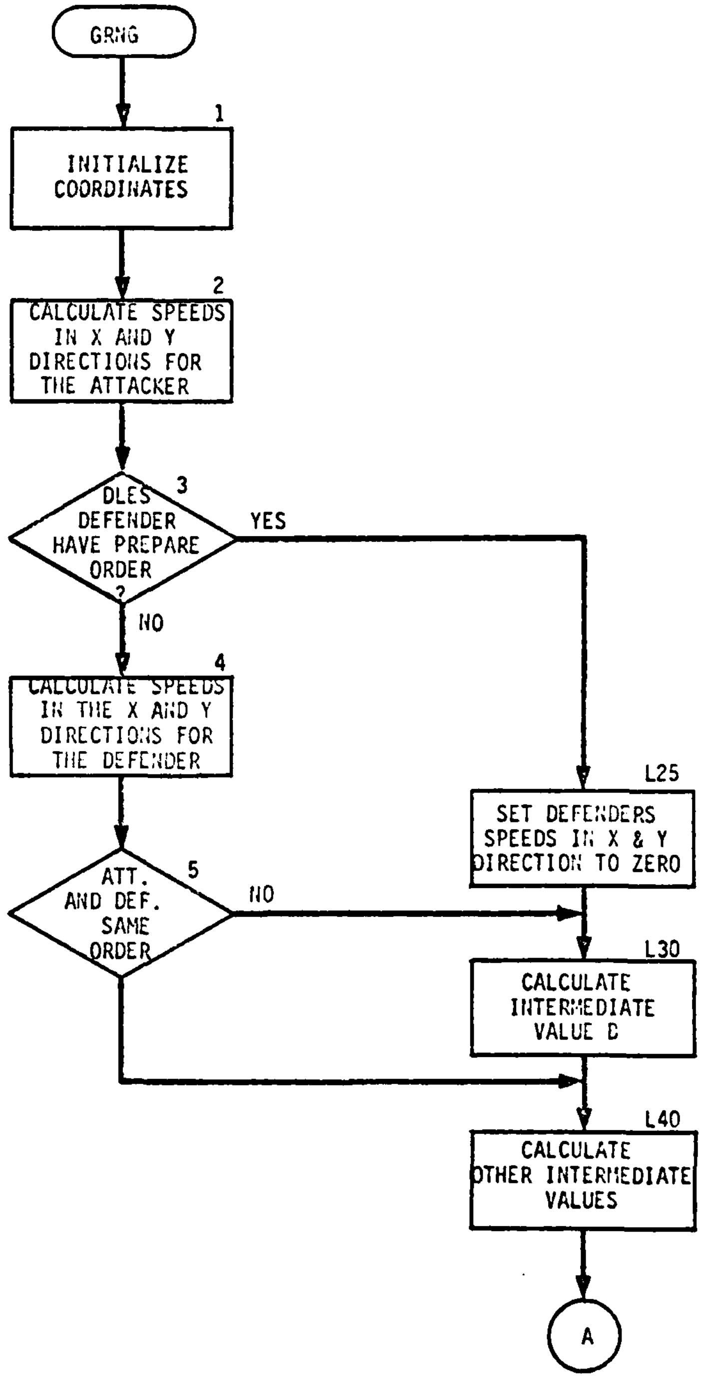
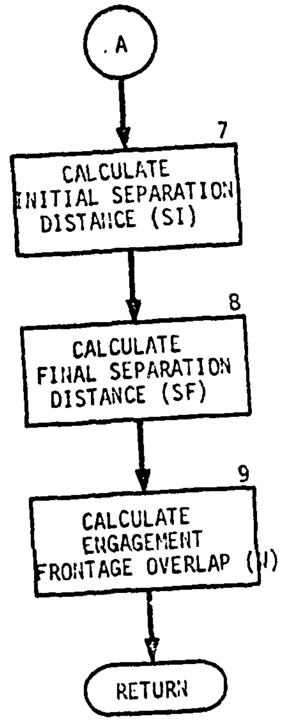


FIGURE IV-7-B-33 ROUTINE GRNG


A
7
CALCULATE INITIAL SEPARATION DISTANCE (SI)
8
CALCULATE FINAL SEPARATION DISTANCE (SF)
9
CALCULATE ENGAGEMENT FRONTAGE OVERLAP (W)
RETURN

34. ROUTINE FRACS.

a. Purpose. FRACS computes what fraction of the total minefield length and what fraction of the total unit frontage encounter one another.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
ROF	CALL	Barrier-facility file (Data File 2) record.

c. Output Variables:

Name	Destination	Contents
FRACOV	CALL	Fraction of the unit's frontage which encounters the minefield.
FRAENC	CALL	Fraction of the minefield's length which is encountered by the unit.

d. Logical Flow (Figure IV-7-B-34).

(1) Block 1. Calculate the side (ends of frontage) points of the encountering unit.

(2) Block 2. Call routine PONTLN to calculate where the minefield end points fall within the unit frontage.

(3) Block 3. Calculate the fraction of the unit's frontage which will encounter the minefield (FRACOV).

(4) Block 4. Do both end points of the minefield fall within end points of the unit frontage? If not, transfer to block L25.

(5) Block 5. Set the fraction of the minefield encountered by the unit (FRAENC) to 1. RETURN control to calling routine.

(6) Block L25. Calculate the unit's side point traces.

(7) Block 6. Call routine INTSPT to determine intersection points between the unit and the minefield.

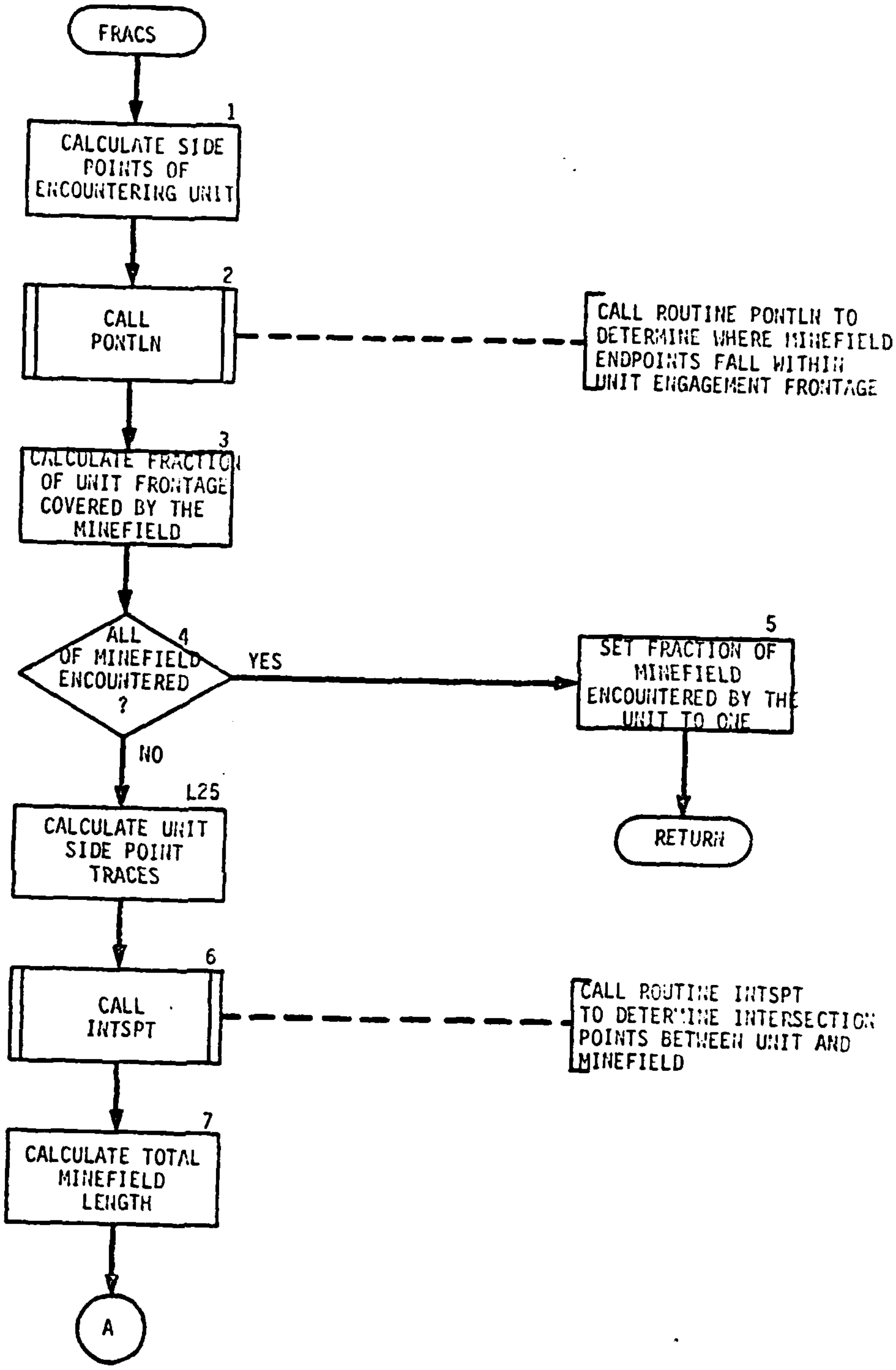
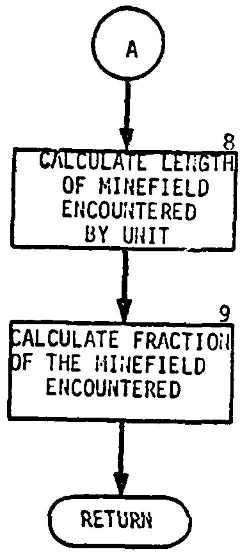


FIGURE IV-7-B-34 ROUTINE FRACS


A
8
CALCULATE LENGTH OF MINEFIELD ENCOUNTERED BY UNIT
9
CALCULATE FRACTION OF THE MINEFIELD ENCOUNTERED
RETURN

(8) Block 7. Calculate the total length of the minefield.

(9) Block 8. Calculate the length of the minefield encountered by the unit.

(10) Block 9. Calculate the fraction of the minefield encountered by the unit (FRAENC). RETURN to calling routine.

35. ROUTINE BPCHK.

a. Purpose. BPCHK determines potential minefield bypass points.

b. Input Variables:

Name	Source	Contents
IOF (35)	CALL	Barrier-facility file (File 2) record.
ROUT (256)	CALL	Barrier encounter data.
IBF (35)	DF2	New Barrier-facility file (File 2) record.

c. Output Variables:

Name	Destination	Contents
ROUT (256)	CALL	Barrier encounter data.

d. Logical Flow (Figure IV-7-B-35).

(1) Block 1. Begin loop (A1) on two end points of the barrier encountered.

(2) Block 2. Move File 2 record of barrier encountered (IOF) to array IBF.

(3) Block L25. Get the barrier record number (JREC) of the following/previous barrier in this barrier line (if any).

(4) Block 3. Is there a following/previous barrier (JREC≠0)? If so, transfer to block 4.

(5) Block L50. Put encountered barrier's end points (original bypass points) in array ROUT. Transfer to block L200.

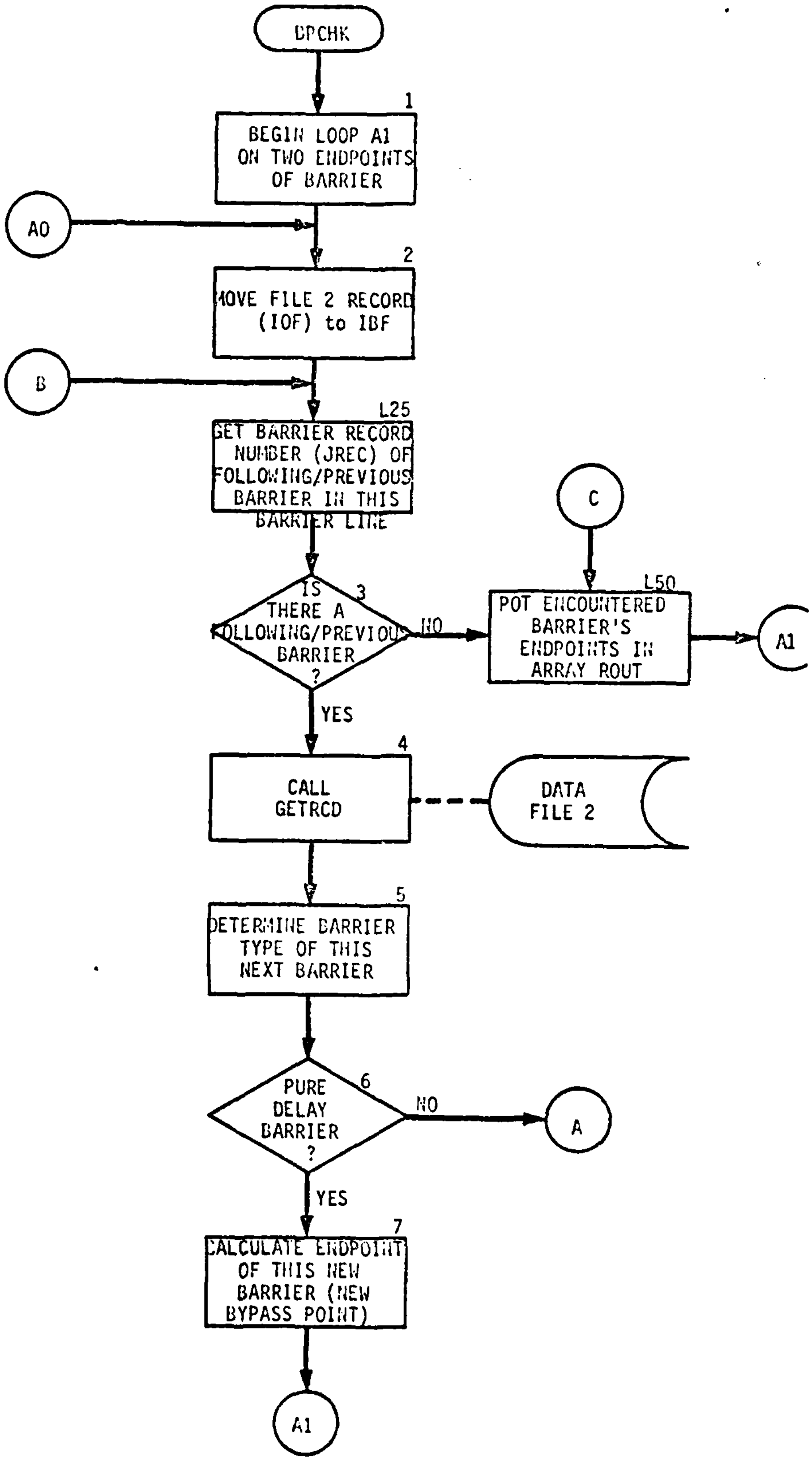
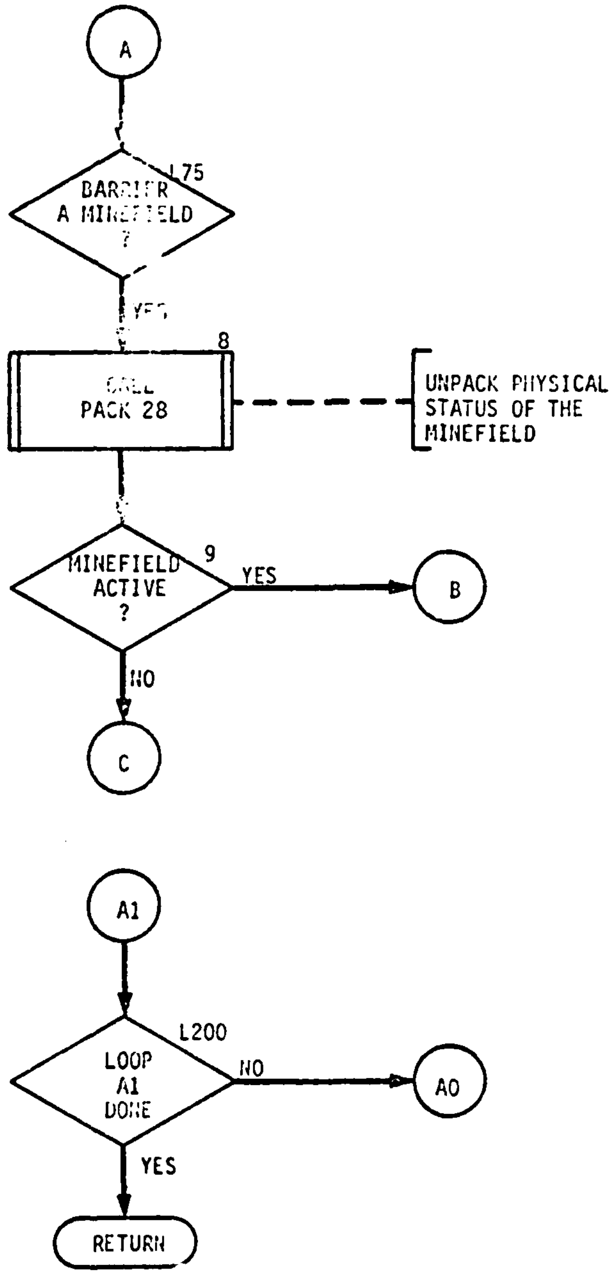


FIGURE IV-7-B-35 ROUTINE BPCHK


A
L75
BARRIER
A MINEFIELD
?
YES
8
CALL
PACK 28
UNPACK PHYSICAL
STATUS OF THE
MINEFIELD
MINEFIELD
ACTIVE
?
9
YES
B
NO
C
A1
L200
LOOP
A1
DONE
NO
A0
YES
RETURN

(6) Block 4. Call routine GETRCD to get the following/previous barrier record (IBF) from Data File 2.

(7) Block 5. Determine barrier type of this barrier.

(8) Block 6. If this is not a pure delay barrier, transfer to block L75.

(9) Block 7. Calculate the end points of the previous/following barrier and place in array ROUT. This is the new bypass point.

(10) Block L75. If the barrier is not a minefield, transfer to block L50.

(11) Block 8. Call routine PACK28 to unpack the physical status of this minefield.

(12) Block 9. Is the minefield active? If so, transfer to block L25. If not, transfer to block L50.

(13) Block L200. If loop (A1) is not done, transfer to block 2, otherwise RETURN to calling program.

36. ROUTINE EXEC6.

a. Purpose. EXEC6 is the controlling routine for segment 6 of the GCM overlay which handles minefield encounter reactions.

b. Input Variables.

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
IOUT (256)	DF21	GCM minefield encounter data.
INRUPT	TWO	Interrupted actions flag, located at IDUM (4100).
IDXATT	TWO	Attacker's GCM Control Table index, located at IDUM (4033).
BTL (64)	DF21	GCM battle record.
ITBL (16, 4)	TWO	GCM Control Table, located at IDUM (4035).
ITMAT (8)	TWO	Attacker's weapon system's item codes, located at IDUM (4024).
DTBL (5, 10)	DF39	Countermeasure index table, located at IDUM (151).
CMDTA (20, 20)	DF39	Countermeasure mode table, located at IDUM (201).

c. Output Variables:

Name	Destination	Contents
IOUT (256)	TWO	GCM minefield encounter data.

d. Logical Flow (Figure IV-7-B-36).

(1) Block 1. Call routine GETRCD to get GCM minefield encounter data from Data File 21.

(2) Block 2. Copy IOUT array to IDUM.

(3) Block 3. If IFORM flag is not equal to 40, transfer to block L12.

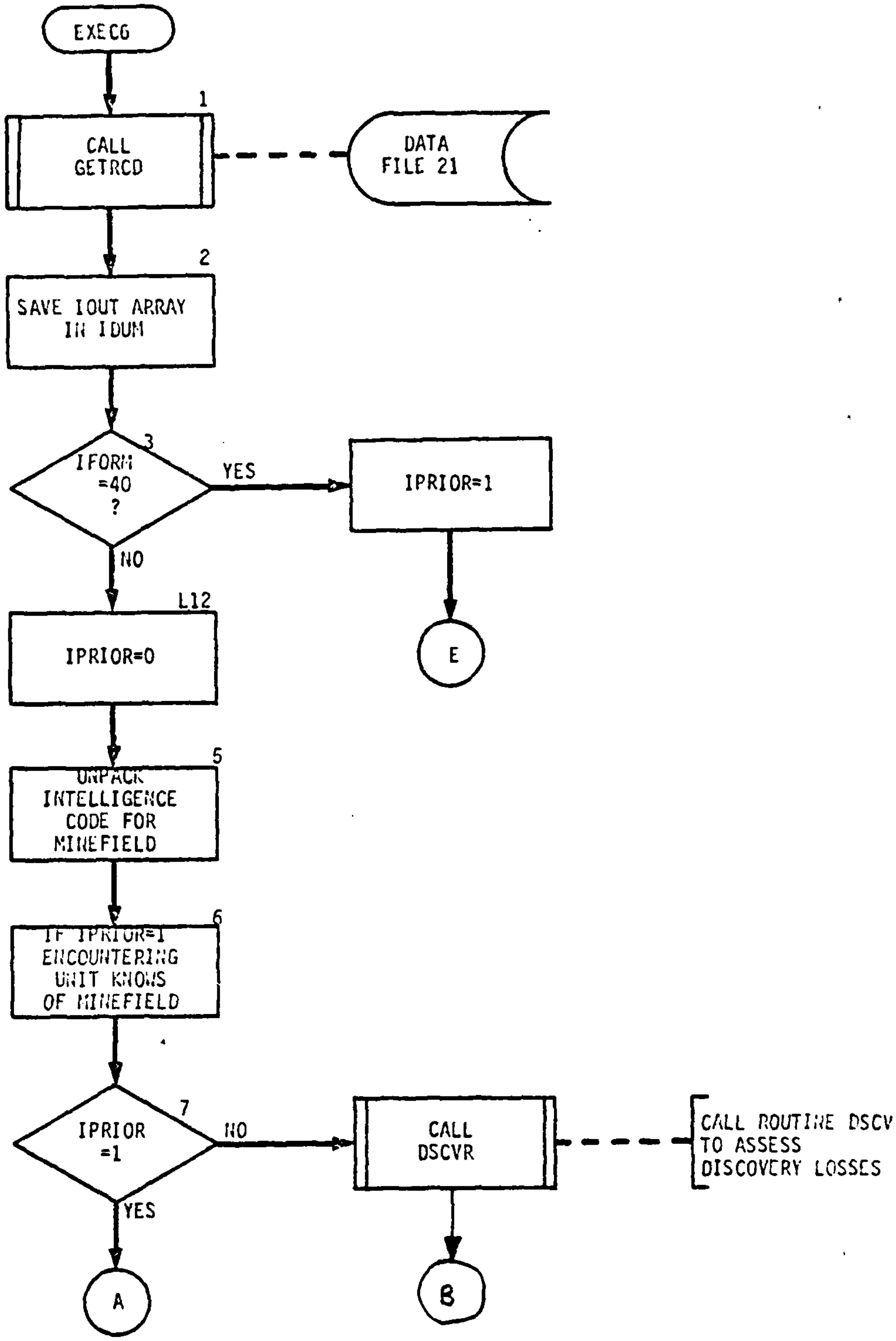
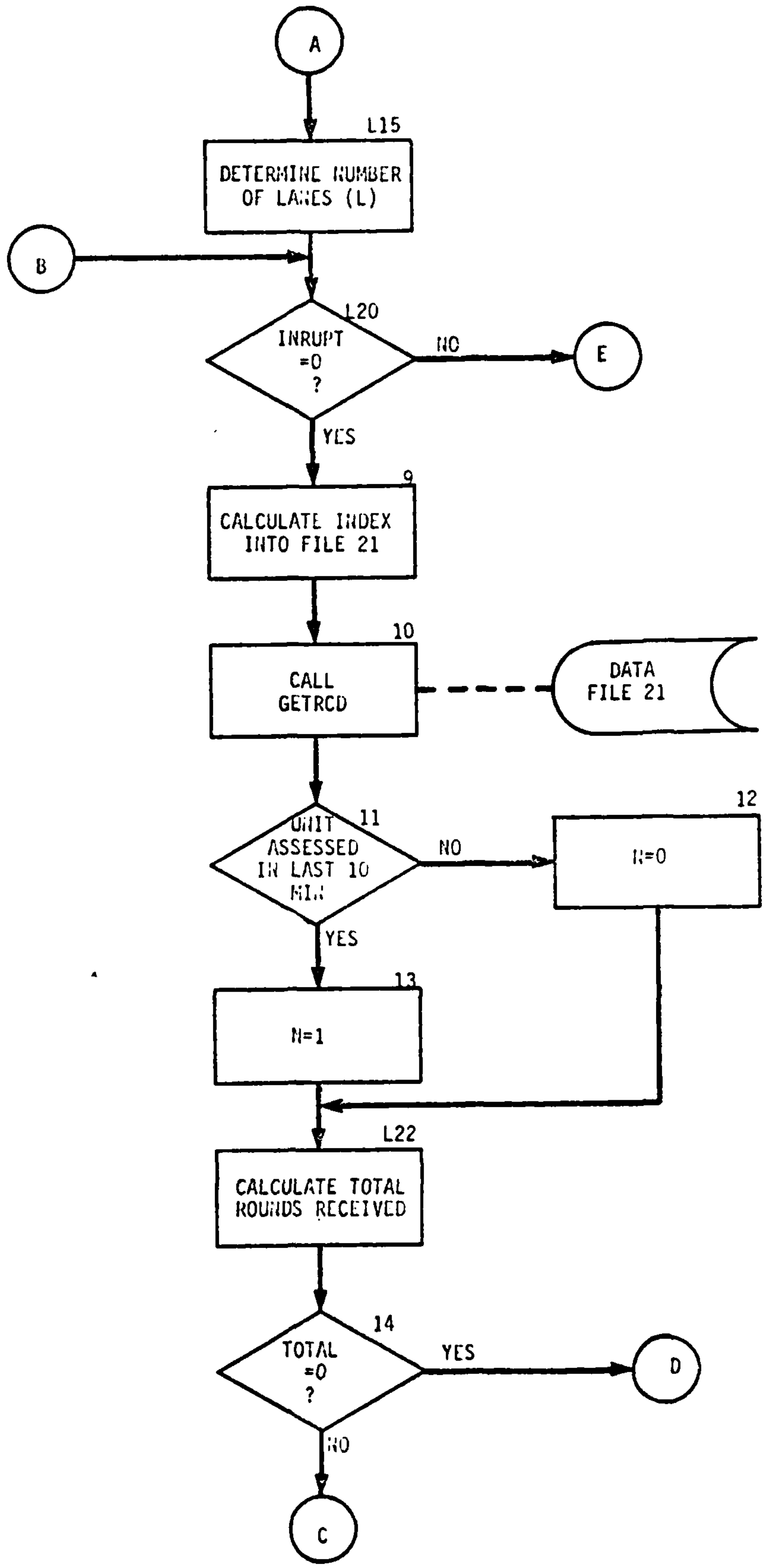
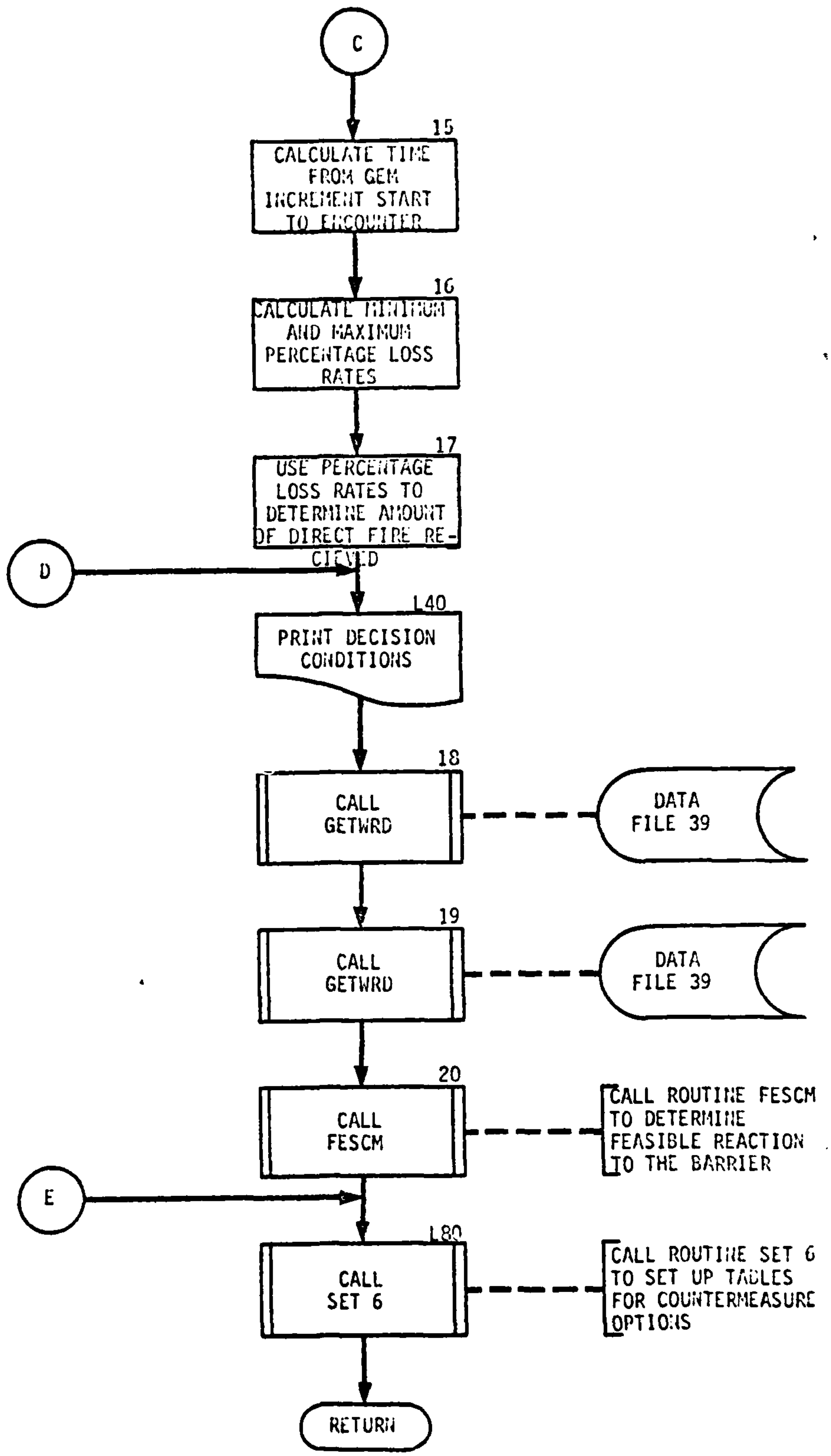


FIGURE IV-7-B-36 ROUTINE EXEC6


A
L15
DETERMINE NUMBER OF LANES (L)
B
L20
INRUPT =0 ?
NO
E
YES
9
CALCULATE INDEX INTO FILE 21
10
CALL GETRCD
DATA FILE 21
11
UNIT ASSESSED IN LAST 10 MIN
NO
12
N=0
YES
13
N=1
L22
CALCULATE TOTAL ROUNDS RECEIVED
14
TOTAL =0 ?
YES
D
NO
C


C
15
CALCULATE TIME FROM GEM INCREMENT START TO ENCOUNTER
16
CALCULATE MINIMUM AND MAXIMUM PERCENTAGE LOSS RATES
17
USE PERCENTAGE LOSS RATES TO DETERMINE AMOUNT OF DIRECT FIRE RE-CIEVED
D
L40
PRINT DECISION CONDITIONS
18
CALL GETWRD
DATA FILE 39
19
CALL GETWRD
DATA FILE 39
20
CALL FESCM
CALL ROUTINE FESCM TO DETERMINE FEASIBLE REACTION TO THE BARRIER
E
L80
CALL SET 6
CALL ROUTINE SET 6 TO SET UP TABLES FOR COUNTERMEASURE OPTIONS
RETURN

(4) Block 4. Set IPRIOR to 1. (Minefield is known to encountering unit.) Transfer to block L80.

(5) Block L12. Set IPRIOR initially to ZERO. (Minefield is unknown to encountering unit.)

(6) Block 5. Unpack the intelligence code for this minefield.

(7) Block 6. Set IPRIOR to 1 if encountering unit has prior knowledge of this minefield based on intelligence code.

(8) Block 7. If encountering unit has prior knowledge of this minefield, transfer to block L15.

(9) Block 8. Call routine DSCUR to assess discovery losses to the encountering unit. Transfer to block L20.

(10) Block L15. Determine number of lanes through the minefield.

(11) Block L20. If interrupted actions flag is not ZERO, transfer to block L80.

(12) Block 9. Calculate appropriate index into Data File 21.

(13) Block 10. Call routine GETRCD to get the GCM battle record (BTL) from Data File 21.

(14) Block 11. Has the encountering unit had an artillery assessment in the last 10 minutes? If so, transfer to block 13.

(15) Block 12. Set N=0 (no artillery assessment). Transfer to block L22.

(16) Block 13. Set N=1 (artillery assessment).

(17) Block L22. Calculate total rounds the encountering unit has received.

(18) Block 14. If the encountering unit has received no rounds, transfer to block L40.

(19) Block 15. Calculate time elapsed from start of GCM battle increment to minefield encounter.

(20) Block 16. Calculate the encountering unit's weapon systems maximum and minimum percentage loss rates for this GCM battle increment.

(21) Block 17. Use these percentage loss rates to determine a measure of the amount of direct fire received by this unit.

(22) Block L40. Save and print the decision conditions determined (level of artillery and direct fire received by the encountering unit this GCM battle increment).

(23) Block 18. Call routine GETWRD to get the minefield encounter countermeasure index table from Data File 39.

(24) Block 19. Call routine GETWRD to get the minefield encounter countermeasure mode table from Data File 39.

(25) Block 20. Call routine FESCM to determine the feasibility reaction to the minefield encountered.

(26) Block L80. Call routine SET6 to set up the tables required for the countermeasure options logic. RETURN to calling program.

37. ROUTINE CONGET.

a. Purpose. CONGET transfers the entire amount of a specified item of equipment from trains to the unit status file for either the attacker or the defender.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
I	CALL	Attacker (UMAIN) or Defender (UCOOP) flag.
ITCD	CALL	Item code of equipment to be transferred.
INFL (10, 20)	DF31	Combat Service Support records (10 words per record).

c. Output Variables:

Name	Destination	Contents
INFL (10, 20)	DF31	Combat Service Support records.
EOH (200)	ONE	Unit Status File equipment on hand.

d. Logical Flow (Figure IV-7-B-37).

(1) Block 1. ZERO out INFL array to be used for File 31 records.

(2) Block 2. Determine the first and last File 31 record numbers for this unit by checking appropriate entry in his Unit Status File.

(3) Block 3. If either of these record numbers are illegal (=0), RETURN to calling routine.

(4) Block 4. Begin loop A1 on File 31 records.

(5) Block 5. Call routine GETRCD to get up to 20 File 31 records for this unit.

(6) Block 6. Is the item code for the equipment to be moved from trains to the USF in this group of File 31 records? If not, transfer to block L200.

(7) Block L110. If there is none of this item of equipment in trains, RETURN to the calling routine.

(8) Block 7. Add the amount of the item of equipment in trains to the amount in the Unit Status File of this unit.

(9) Block 8. Set amount of this equipment in trains to ZERO.

(10) Block 9. Call routine PUTRCD to put updated File 31 records back on File 31.

(11) Block L200. If loop (A1) is not done, transfer to block 5; otherwise RETURN to calling routine.

38. ROUTINE DSCVR.

a. Purpose. DSCVR assesses the discovery losses associated with the minefield encounter.

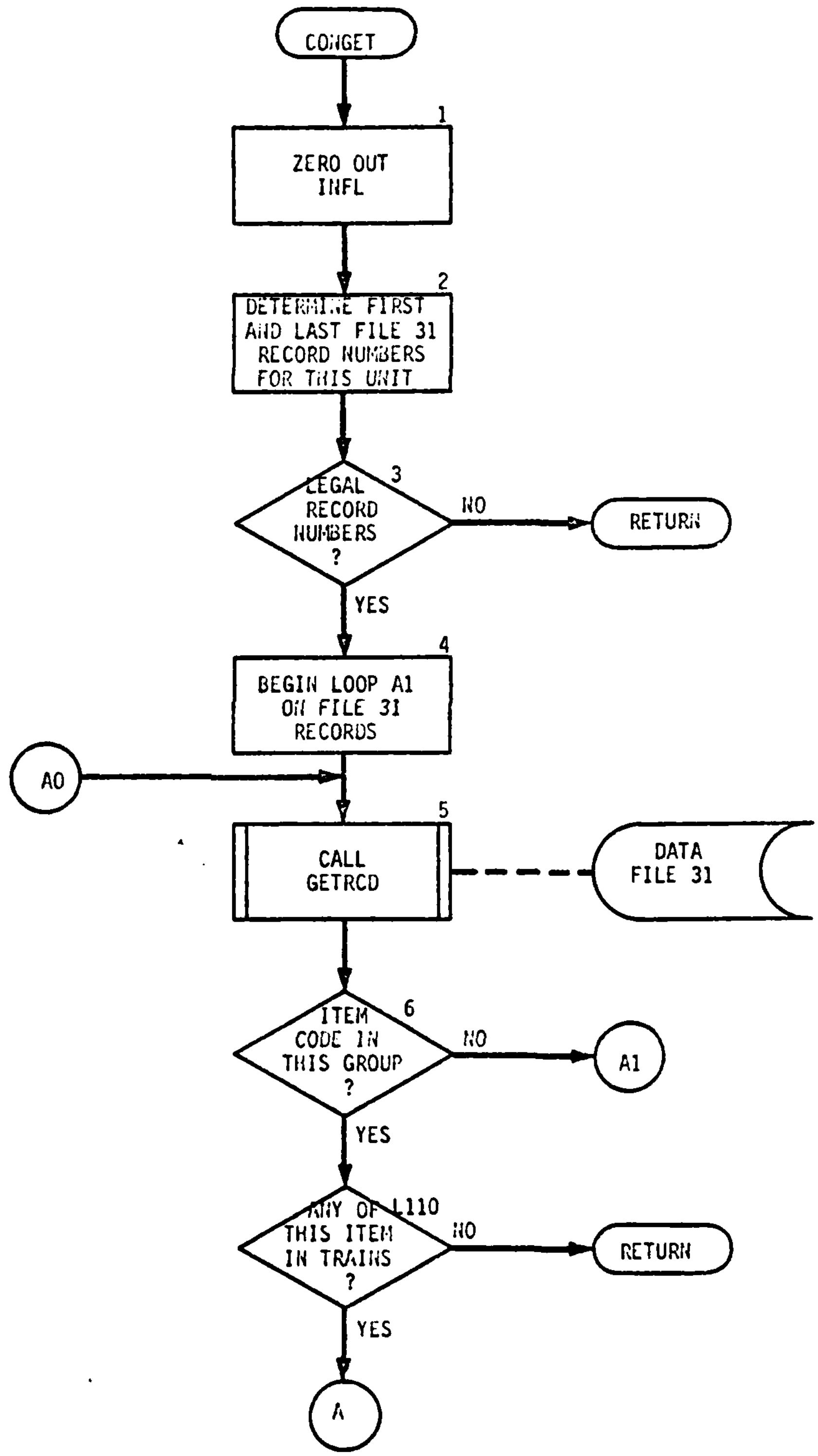
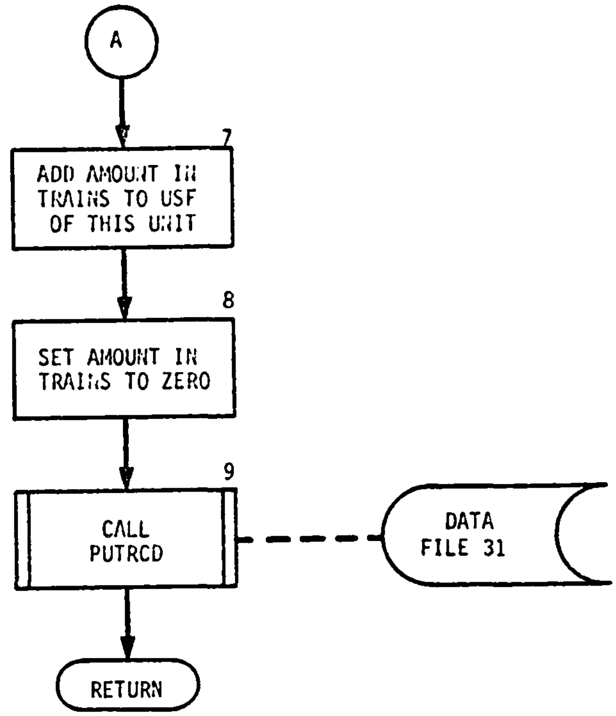
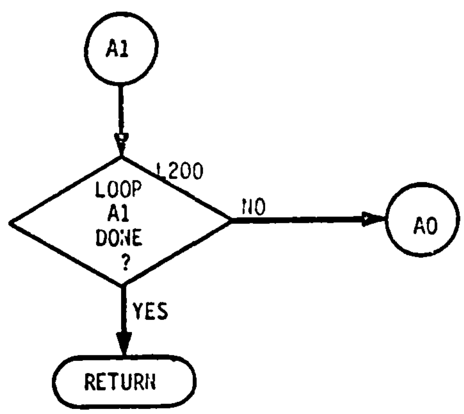


FIGURE IV-7-B-37 ROUTINE CONGET


A
7
ADD AMOUNT IN TRAINS TO USF OF THIS UNIT
8
SET AMOUNT IN TRAINS TO ZERO
9
CALL PUTRCD
DATA FILE 31
RETURN


A1
L200
LOOP A1 DONE ?
NO
A0
YES
RETURN

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
IVEH	DF39	Item code of the encountering vehicle.
MNDTA (20, 10)	DF33	Countermine data, located at IDUM (1001).
SZE (20, 3)	DF33	Track width and belly width of encountering and breaching vehicles, located at IDUM (1201).
VVUL (20, 30)	DF33	Probabilities of kill given detonation at the belly and given detonation at the track for encountering and breaching vehicles, located at IDUM (1261).
FRACOV	TWO	Fraction of the encountering unit's frontage which encounters the minefield, located at IDUM (14).
SECEQP((2, 5)	DF6	Secondary equipment file, located at IDUM (1861).
ANPERS (8)	DF16	Personnel strength associated with each of the 8 weapon system transports of the attacker.

c. Output Variables:

Name	Destination	Contents
UMAIN (500)	DF1	Updated encountering unit's Unit Status File.

d. Logical Flow (Figure IV-7-B-38).

(1) Block 1. Determine encountering unit's side (IFORCE).

(2) Block 2. Call routine GETRCD to get this force's typical lead vehicle (item code of encountering vehicle).

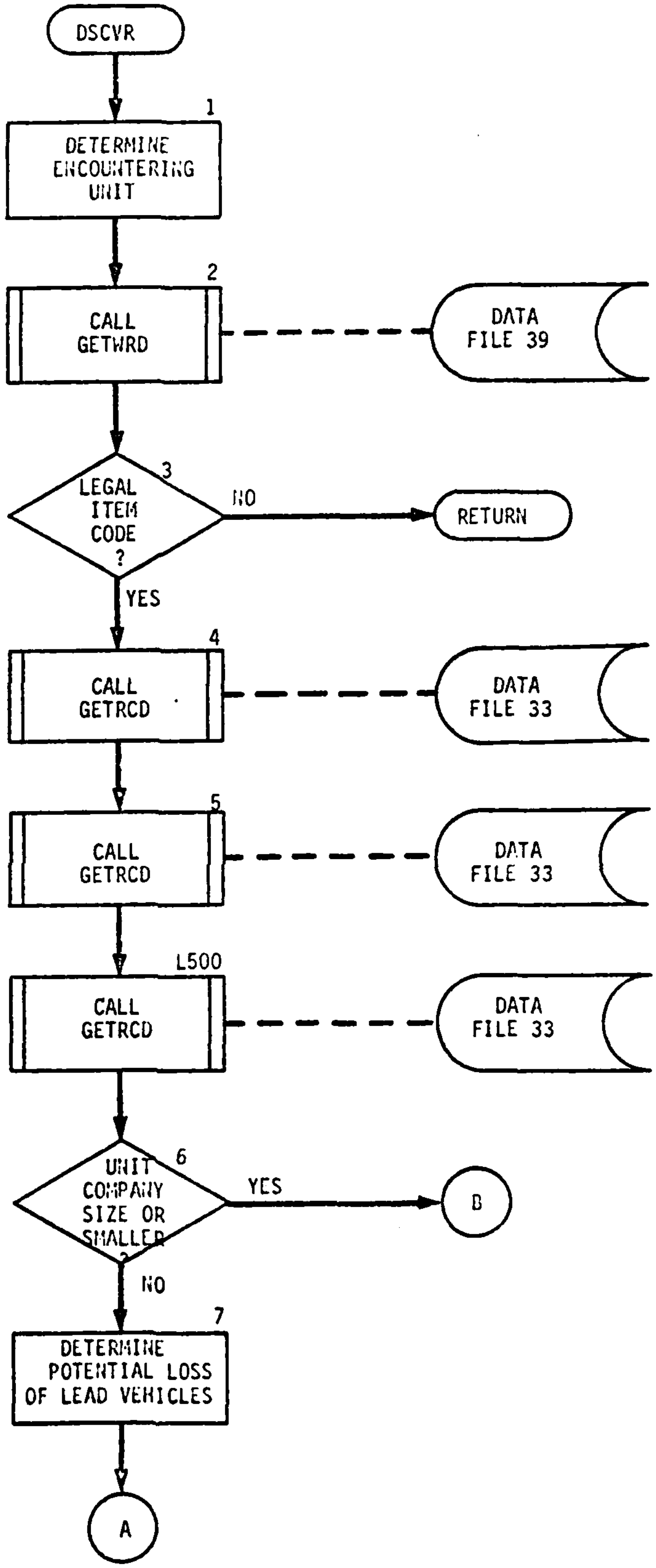
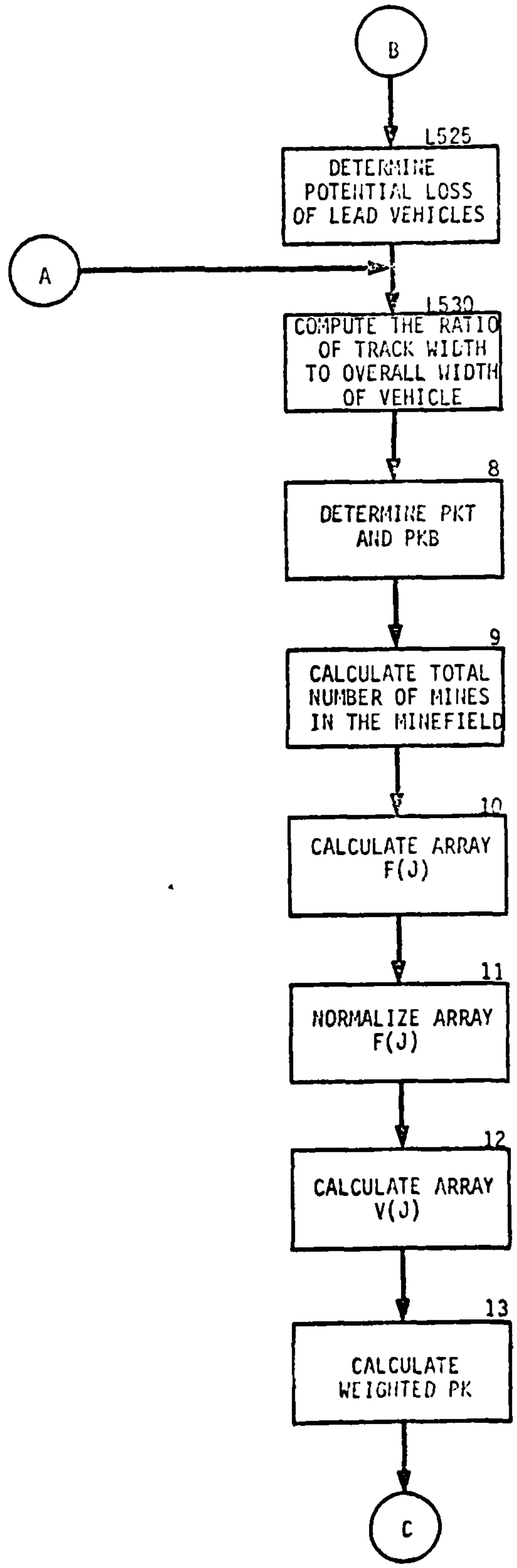
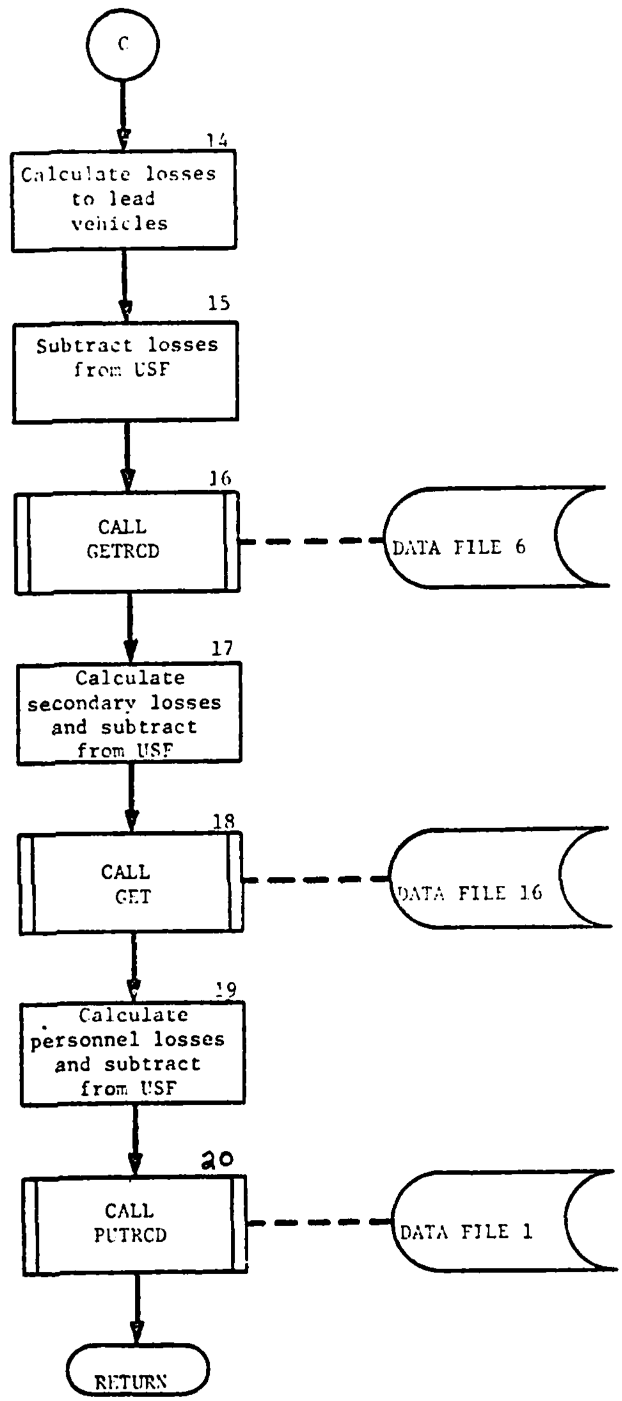


FIGURE IV-7-B-38 ROUTINE DSCVR


B
L525
DETERMINE POTENTIAL LOSS OF LEAD VEHICLES
A
L530
COMPUTE THE RATIO OF TRACK WIDTH TO OVERALL WIDTH OF VEHICLE
8
DETERMINE PKT AND PKB
9
CALCULATE TOTAL NUMBER OF MINES IN THE MINEFIELD
10
CALCULATE ARRAY F(J)
11
NORMALIZE ARRAY F(J)
12
CALCULATE ARRAY V(J)
13
CALCULATE WEIGHTED PK
C


C
14
Calculate losses to lead vehicles
15
Subtract losses from USF
16
CALL GETRCD
DATA FILE 6
17
Calculate secondary losses and subtract from USF
18
CALL GET
DATA FILE 16
19
Calculate personnel losses and subtract from USF
20
CALL PUTRCD
DATA FILE 1
RETURN

(3) Block 3. If item code is not legal (from 1 to 200), RETURN to calling routine.

(4) Block 4. Call routine GETRCD to get countermine data from File 33.

(5) Block 5. Call routine GETRCD to get the track width and belly width table (SZE) of lead (encountering) vehicles and breaching vehicles.

(6) Block L500. Call routine GETRCD to get the probability of a kill given detonation at the belly and given detonation at the track for lead and breaching vehicles (VVUL).

(7) Block 6. If the encountering unit is company size or smaller, transfer to block L525.

(8) Block 7. Determine the potential losses to lead vehicles based on the fraction of the unit frontage encountering the minefield; 1 potential loss for 0-25% of unit front, 2 for 25-50%, 3 for 50-75%, and 4 for 75-100%.

(9) Block L525. Determine the potential losses to lead vehicles based on the fraction of the company size, or smaller unit frontage encountering the minefield; 1 potential loss for 0-50%, 2 potential losses for 50-100%.

(10) Block L530. If the track width and belly width of the lead vehicle is in the table SZE, compute the ratio of track width to overall width.

(11) Block 8. Determine the probability of a kill given detonation at the belly (PKB) and given detonation at the track (PKT) by look-up procedure into VVUL table.

(12) Block 9. Calculate total number of mines in the minefield.

(13) Block 10. Calculate the array F(J) which represents the probabilities that the first mine to detonate will be of type J.

(14) Block 11. Normalize array F(J).

(15) Block 12. Calculate array V(J) which represents the probability of kill given detonation for mines of either pressure fuzed or other than pressure fuzed.

(16) Block 13. Using arrays F(J) and V(J), calculate the weighted probability of kill (PK).

(17) Block 14. Calculate actual losses to the lead vehicles as the weighted probability of kill (PK) times the number of potential lead vehicle losses calculated previously.

(18) Block 15. Subtract these losses to the lead vehicles (primary items) from the unit's Unit Status File. Do not subtract more than is currently on hand.

(19) Block 16. Call routine GETRCD to get the secondary equipment file from Data File 6.

(20) Block 17. Calculate the secondary equipment losses and subtract them from the unit's Unit Status File.

(21) Block 18. Call routine GET to obtain the personnel strength of each weapon system transport.

(22) Block 19. Calculate personnel losses and subtract them from the unit's Unit Status File.

(23) Block 20. Call routine PUTRCD to return the updated Unit Status File to Data File 1. RETURN to the calling routine.

39. ROUTINE FESCM

a. Purpose. FESCM determines the feasible reaction to a minefield encounter.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
IOUT (256)	ONE	GCM minefield encounter data.

DTBL (5, 10)	TWO	Countermeasure index table, located at IDUM (151).
CMDTA (20, 20)	TWO	Countermeasure mode table, located at IDUM (201).
IPRIOR	CALL	Minefield intelligence flag.

c. Output Variables:

Name	Destination	Contents
IDUM	TWO	GCM minefield encounter data.

d. Logical Flow (Figure IV-7-B-39).

(1) Block 1. Initialize control variable J (countermeasure index).

(2) Block L20. Increment J and IDBP.

(3) Block 2. Save IOUT array in IDUM.

(4) Block 3. If index J is not 11, transfer to block L30.

(5) Block L25. Set IFORM flag to 100 and RETURN to calling routine.

(6) Block L30. Determine countermeasure index (ICM) based on value of J.

(7) Block 4. If the index is ZERO, transfer to block L25.

(8) Block 5. Determine the countermeasure mode (MODCM) using the countermeasure index (ICM).

(9) Block 6. Determine the size of the encountering unit.

(10) Block 7. If the countermeasure mode is not 5, transfer to block 12.

(11) Block 8. Get the zone of action and allowable compaction variables from RDTBL.

(12) Block 9. Call routine BPFES to determine if bypass is feasible. Bypass will be considered feasible if the unit can pass around the barrier while remaining in the zone of action at the maximum allowable compaction.

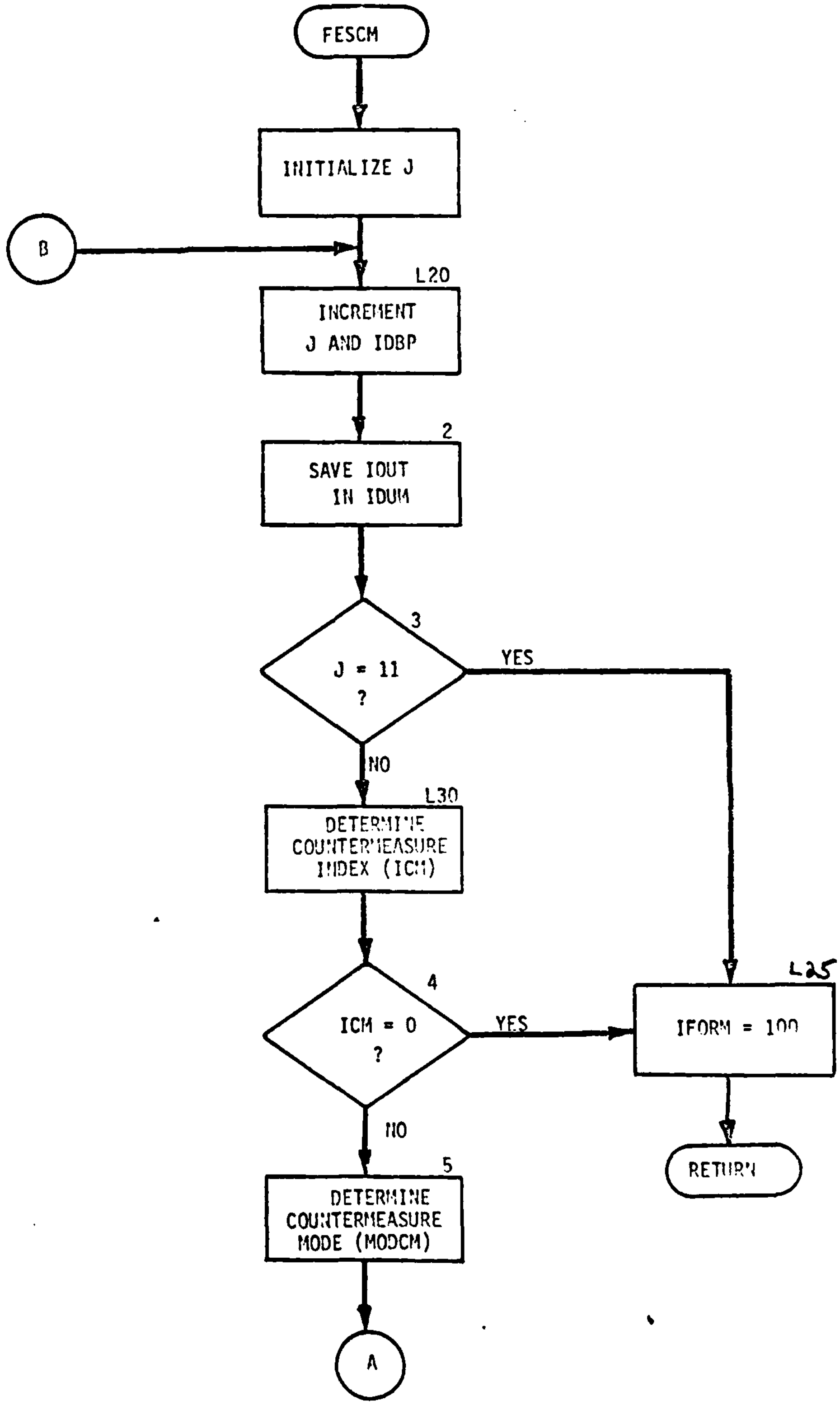
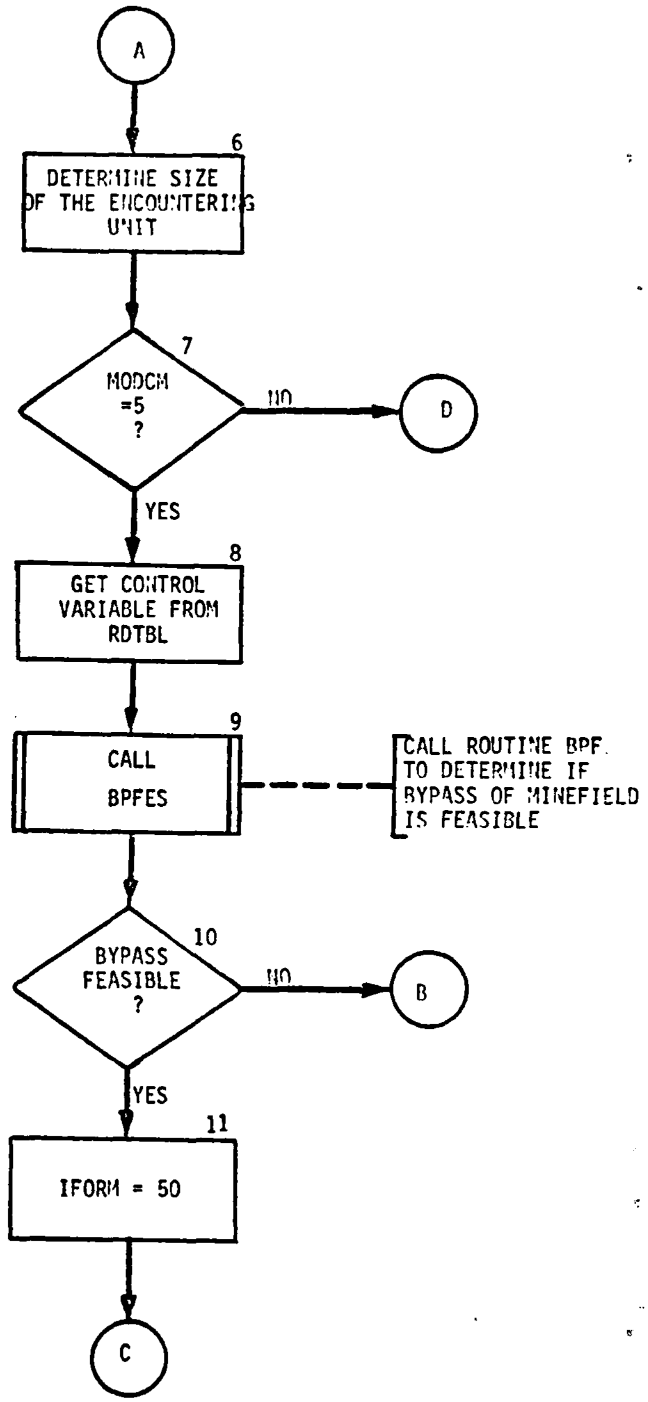
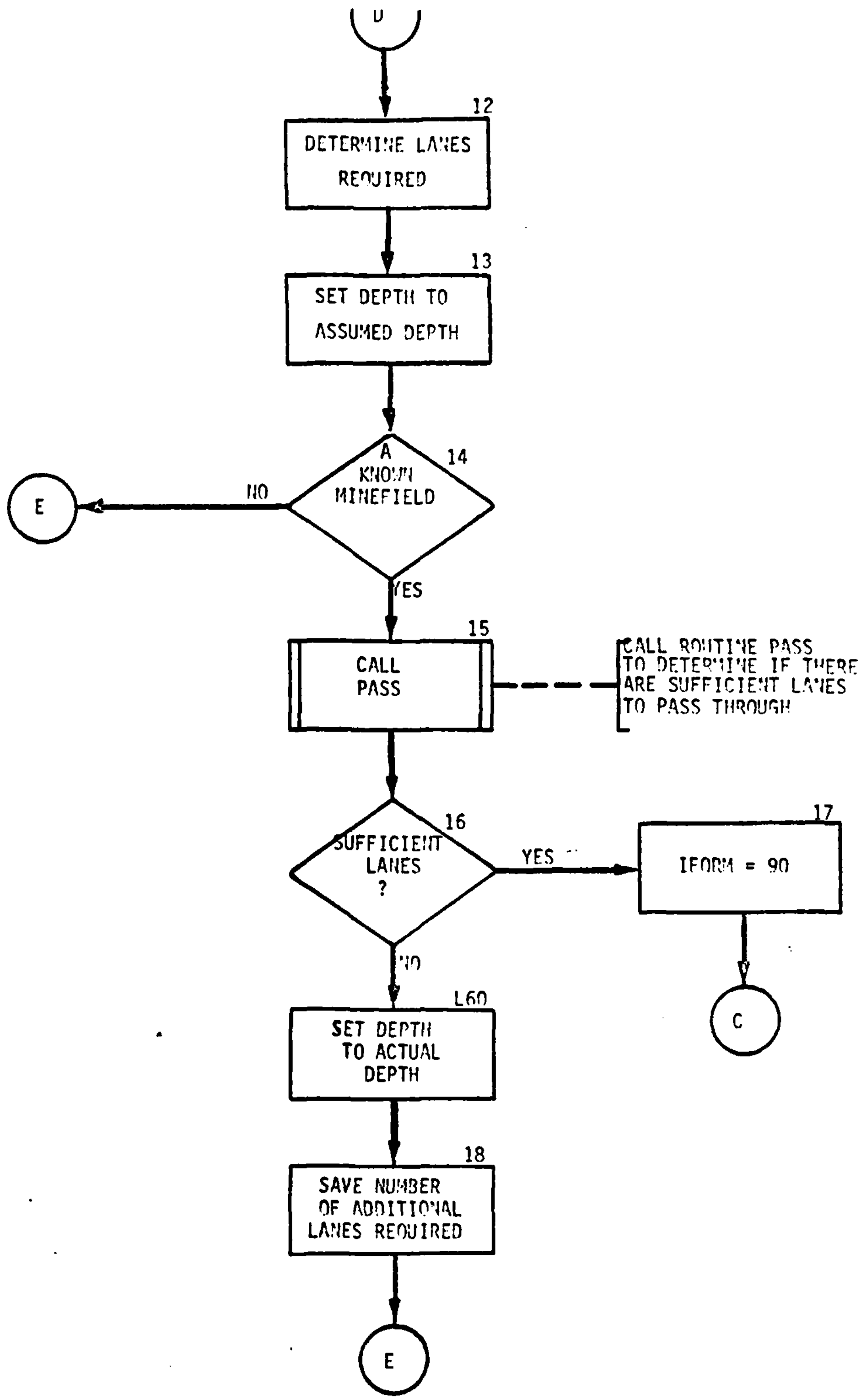
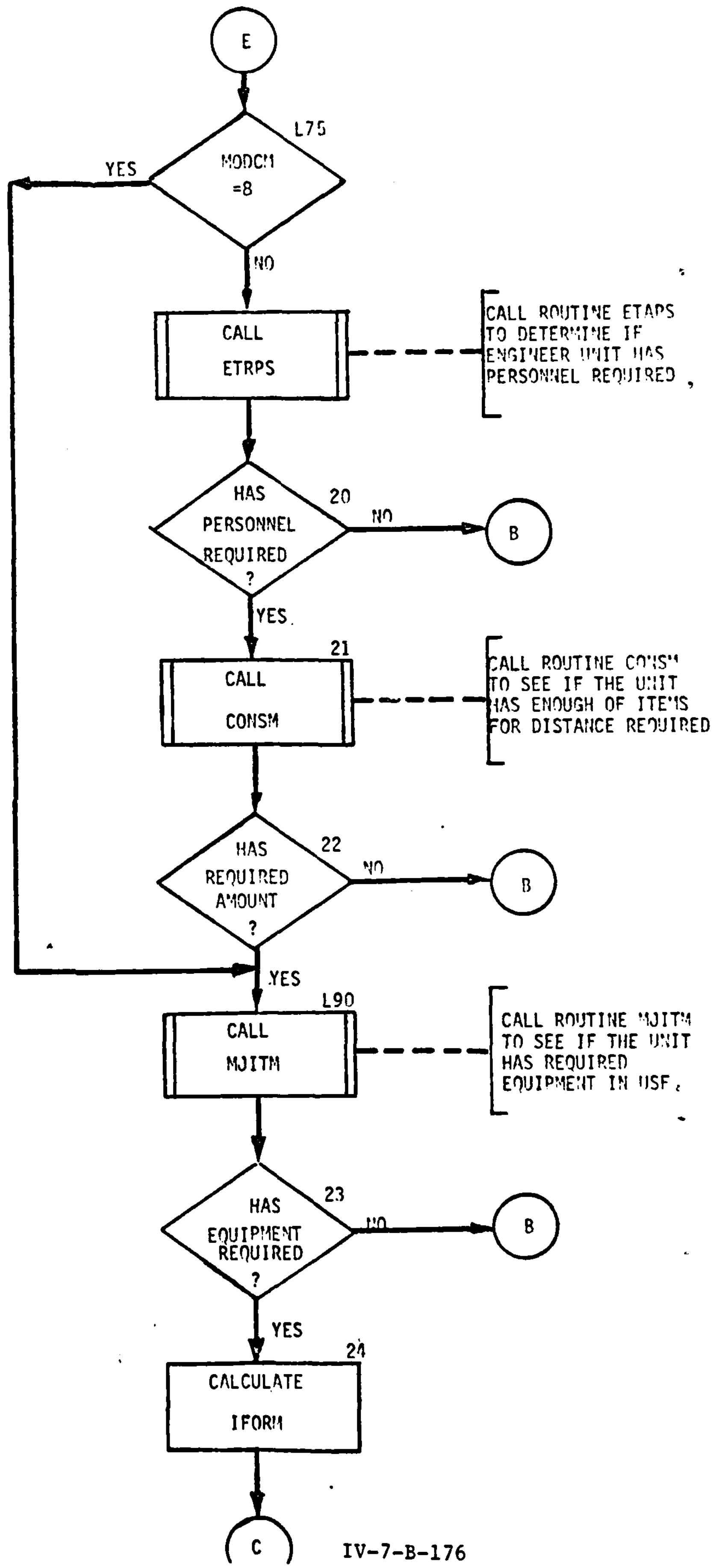
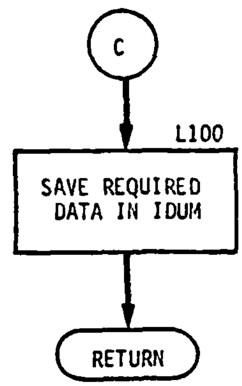


FIGURE IV-7-B-39 ROUTINE FESCM


A
6
DETERMINE SIZE
OF THE ENCOUNTERING
UNIT
7
MODCM
=5
?
NO
D
YES
8
GET CONTROL
VARIABLE FROM
RDTBL
9
CALL
BPFES
CALL ROUTINE BPF
TO DETERMINE IF
BYPASS OF MINEFIELD
IS FEASIBLE
10
BYPASS
FEASIBLE
?
NO
B
YES
11
IFORM = 50
C


D
12
DETERMINE LANES REQUIRED
13
SET DEPTH TO ASSUMED DEPTH
A KNOWN MINEFIELD
14
NO
E
YES
15
CALL PASS
CALL ROUTINE PASS TO DETERMINE IF THERE ARE SUFFICIENT LANES TO PASS THROUGH
SUFFICIENT LANES ?
16
YES
17
IFORM = 90
C
NO
L60
SET DEPTH TO ACTUAL DEPTH
18
SAVE NUMBER OF ADDITIONAL LANES REQUIRED
E


E
L75
MODCM
=8
YES
NO
CALL
ETRPS
CALL ROUTINE ETAPS
TO DETERMINE IF
ENGINEER UNIT HAS
PERSONNEL REQUIRED
HAS
PERSONNEL
REQUIRED
?
20
NO
B
YES
21
CALL
CONSM
CALL ROUTINE CONSM
TO SEE IF THE UNIT
HAS ENOUGH OF ITEMS
FOR DISTANCE REQUIRED
HAS
REQUIRED
AMOUNT
?
22
NO
B
YES
L90
CALL
MJITM
CALL ROUTINE MJITM
TO SEE IF THE UNIT
HAS REQUIRED
EQUIPMENT IN USF
HAS
EQUIPMENT
REQUIRED
?
23
NO
B
YES
24
CALCULATE
IFORM
C


C
L100
SAVE REQUIRED DATA IN IDUM
RETURN

(13) Block 10. If the bypass is not feasible, transfer to block L20.

(14) Block 11. Set IFORM flag to 50, and transfer to block L100.

(15) Block 12. Determine the number of lanes required to pass through.

(16) Block 13. Set the depth of the minefield to the assumed depth from the data load.

(17) Block 14. If this minefield is unknown to the encountering unit, transfer to block L75.

(18) Block 15. Call routine PASS to determine if there are sufficient lanes for the unit to pass through the barrier.

(19) Block 16. If there are not sufficient lanes, transfer to block L60.

(20) Block 17. Set IFORM flag to 90, and transfer to block L100.

(21) Block L60. Set depth of the minefield to actual depth.

(22) Block 18. Save the number of additional lanes required to pass through the minefield (INSUFF).

(23) Block L75. If the countermeasure mode is 8, transfer to block L90.

(24) Block 19. Call routine ETRPS to determine whether an engineer unit has the personnel required.

(25) Block 20. If the engineer unit does not have the personnel required, transfer to block L20.

(26) Block 21. Call routine CONSM to see if the unit has enough of the listed items for the distance required.

(27) Block 22. If the unit does not have the amount required, transfer to block L20.

(28) Block L90. Call routine MJITM to determine if the unit has the required items on its USF.

(29) Block 23. If the unit does not have the required items, transfer to block L20.

(30) Block 24. Calculate IFORM flag.

(31) Block L100. Save the required data in IDUM and RETURN to calling routine.

40. ROUTINE BPFES.

a. Purpose. BPFES determines whether bypass is feasible. Bypass is considered feasible if the unit can pass around the barrier while remaining in the zone of action at the maximum allowable unit compaction.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
ZA	CALL	Unit zone of action in terms of unit width.
CMP	CALL	Maximum allowable unit compaction (shrinkage).
RDUM (1000)	TWO	Barrier encounter data.

c. Output Variables:

Name	Destination	Contents
BPX	CALL	X coordinate of potential bypass point.
BPY	CALL	Y coordinate of potential bypass point.
BPFES	CALL	Flag indicating if bypass is feasible. (1=feasible; 0=unfeasible.)

d. Logical Flow (Figure IV-7-B-40).

(1) Block 1. Initialize bypass flag and bypass points to ZERO indicating that bypass is unfeasible.

(2) Block 2. Calculate the distance (W1) from the center of the unit to the border of the zone of action.

(3) Block 3. Calculate the minimum allowable unit width (W2) using the maximum allowable unit compaction (CMP).

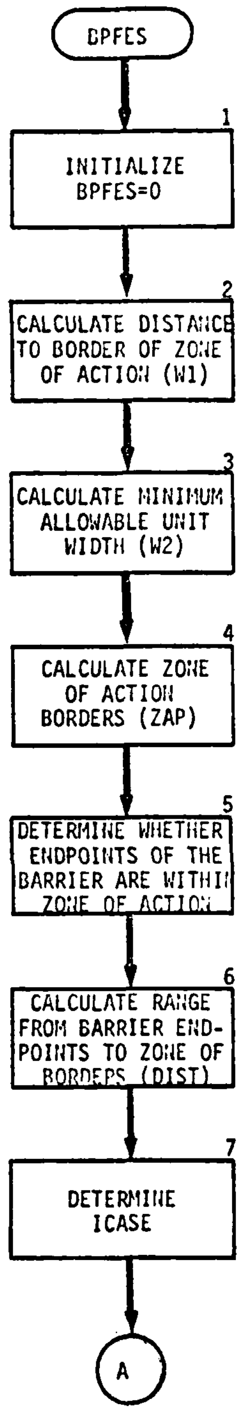
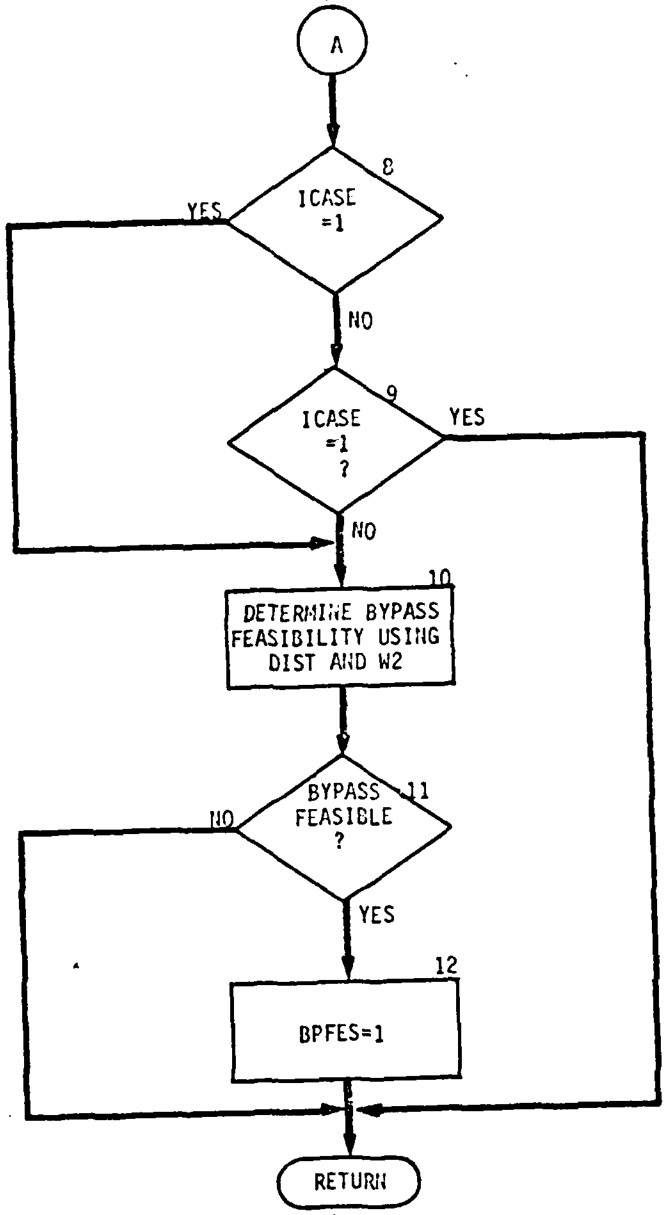


FIGURE IV-7-B-40 ROUTINE BPFES


A
8
ICASE
=1
YES
NO
9
ICASE
=1
?
YES
NO
10
DETERMINE BYPASS
FEASIBILITY USING
DIST AND W2
BYPASS
FEASIBLE
?
11
NO
YES
12
BPFES=1
RETURN

(4) Block 4. Using the unit's orientation angle, calculate the borders of the zone of action (ZAP).

(5) Block 5. Determine whether the end points of the barrier are within the zone of action borders.

(6) Block 6. Calculate the range from the barrier end points to the zone of action border (DIST).

(7) Block 7. Determine ICASE:

ICASE=1 - both barrier end points are in zone of action.
ICASE=2 - only first end point in zone of action.
ICASE=3 - only second end point in zone of action.
ICASE=4 - neither barrier end point in zone of action.

(8) Block 8. If ICASE=1, transfer to block 10.

(9) Block 9. If ICASE=4, RETURN to calling routine with bypass unfeasible.

(10) Block 10. Determine bypass feasibility. When only one barrier end point is within the zone of action, feasibility depends on whether the unit (when at maximum compaction) can bypass without crossing the zone of action border.

(11) Block 11. If bypass has been determined to be unfeasible, RETURN to the calling routine with BPFES=0.

(12) Block 12. Set BPFES=1 (bypass feasible) and RETURN to calling routine.

41. ROUTINE ETRPS.

a. Purpose. ETRPS determines if the encountering unit has the engineer personnel required to satisfy the demand.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
LNS	CALL	Number of lanes requiring work before breach.

NMBR	CALL	Number of persons required per lane.

c. Output Variables:

Name	Destination	Contents
ETRPS	CALL	Flag indicating whether unit has the engineer personnel required. (1=YES, 0=NO.)

d. Logical Flow (Figure IV-7-B-41).

(1) Block 1. Calculate the required number of engineer troops (lanes times personnel required per lane).

(2) Block 2. Begin loop (A1) on up to 10 subordinate units.

(3) Block 3. Determine IUID of the first/next subordinate unit (if any).

(4) Block 4. If this subordinate unit is a resolution unit (sum of location coordinates greater than zero), transfer to block L50.

(5) Block 5. Call routine GETWRD to obtain the personnel strength of this subordinate unit from Data File 1.

(6) Block 6. Add personnel strength of this subordinate unit to the total strength of all subordinates of this unit.

(7) Block L50. If loop (A1) is not done, transfer to block 3.

(8) Block 7. Calculate the number of engineer troops available from the total of all subordinate units.

(9) Block 8. Set ETRPS flag to ZERO (engineer troops not available).

(10) Block 9. If the number of engineer troops available (AVAIL) is not greater than or equal to the number required (NEED), RETURN to the calling routine.

(11) Block 10. Set ETRPS flag to 1 (engineer troops are available).

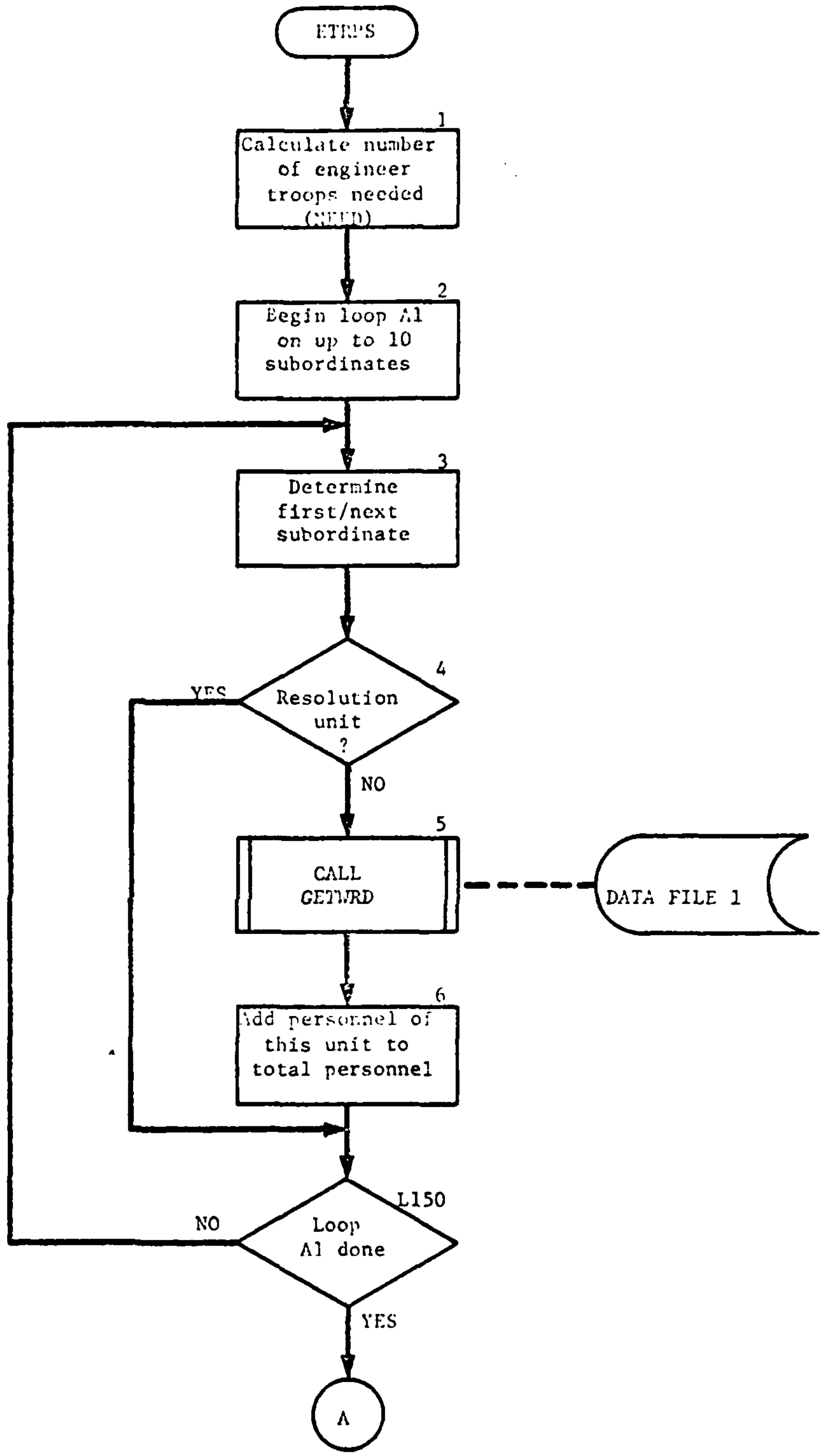
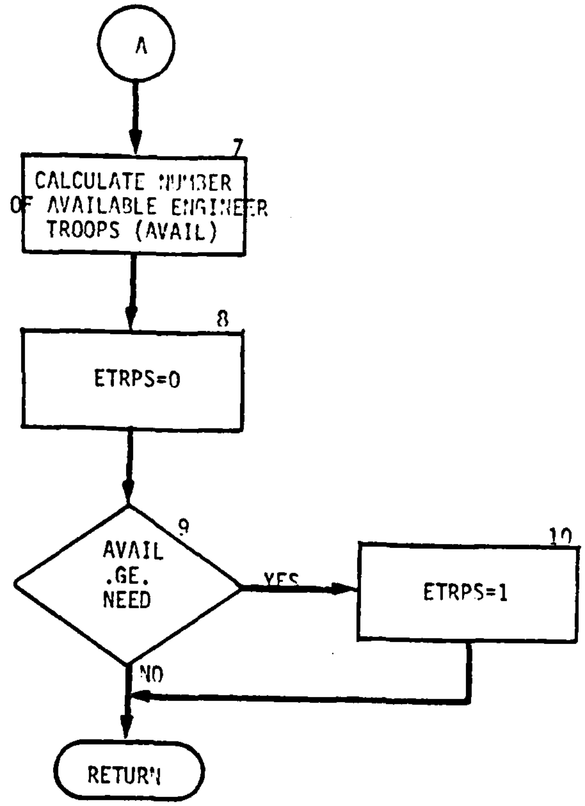


Figure IV-7-B-41. Routine ETRPS.


A
7
CALCULATE NUMBER OF AVAILABLE ENGINEER TROOPS (AVAIL)
8
ETRPS=0
9
AVAIL .GE. NEED
YES
10
ETRPS=1
NO
RETURN

42. ROUTINE PASS.

a. Purpose. PASS determines if there are sufficient lanes to pass through the minefield. If not, PASS calculates the number of additional lanes required.

b. Input Variables:

(1) Standard Common Block Variables.

c. Output Variables:

Name	Destination	Contents
PASS	CALL	Flag indicating whether there are sufficient lanes to pass (1=YES, 0=NO).
INSUFF	CALL	Number of additional lanes required for passage (if any).

d. Logical Flow (Figure IV-7-B-42).

(1) Block 1. Set PASS flag to 1 (sufficient lanes to pass).

(2) Block 2. Are there enough open lanes known to this unit to allow the unit to pass through the minefield? If so, RETURN to calling routine.

(3) Block 3. Set PASS flag to ZERO (insufficient lanes to pass).

(4) Block 4. Calculate the number of additional lanes required for unit to pass (INSUFF). RETURN to calling routine.

43. ROUTINE CONSM.

a. Purpose. CONSM determines whether the unit in UMAIN has enough of the equipment specified to clear the minefield with the number of lanes, and to the depth specified.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
LNS	CALL	Number of lanes required.

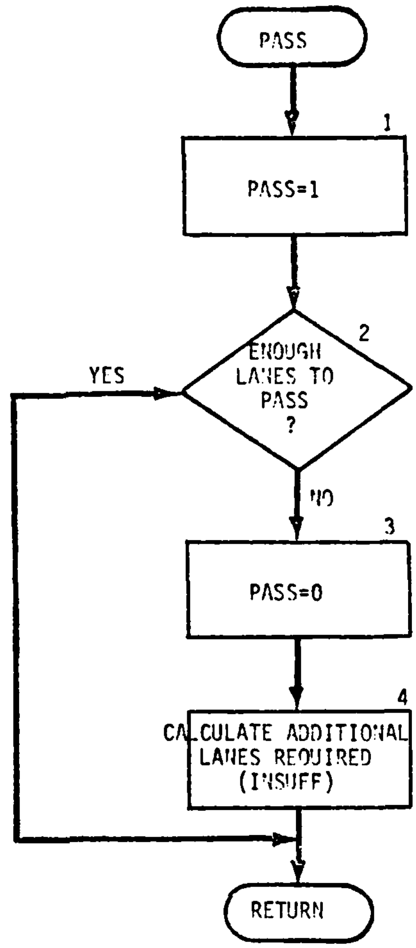


FIGURE IV-7-B-52 ROUTINE PASS

DPTH	CALL	Depth of the minefield.
INC	CALL	Consumption rate increment.
LOCN (2, 3)	CALL	Item code and consumption rate of up to 3 equipment items.

c. Output Variables:

Name	Destination	Contents
CONSM	CALL	Flag indicating whether the unit has the equipment required (1=YES, 0=NO).

d. Logical Flow (Figure IV-7-B-43).

(1) Block 1. Set CONSM flag to 1 (unit has equipment required).

(2) Block 2. Calculate the total distance to be cleared in increments of INC.

(3) Block 3. Begin loop (A1) on up to 3 different types of equipment required.

(4) Block 4. Get the item code of the first/next equipment item.

(5) Block 5. If the item code is ZERO, transfer to block L100.

(6) Block 6. Calculate the amount of this equipment item that would be used to clear the previously calculated distance.

(7) Block L90. If the unit has this required amount of equipment, transfer to block L100.

(8) Block 7. Call routine CONGET to transfer the equipment of this type from trains to the unit's Unit Status File.

(9) Block 8. With this additional equipment from trains, does the unit now have the required amount of equipment? If not, transfer to block L110.

(10) Block L100. If loop (A1) is not done, transfer to block 4, otherwise RETURN to calling routine.

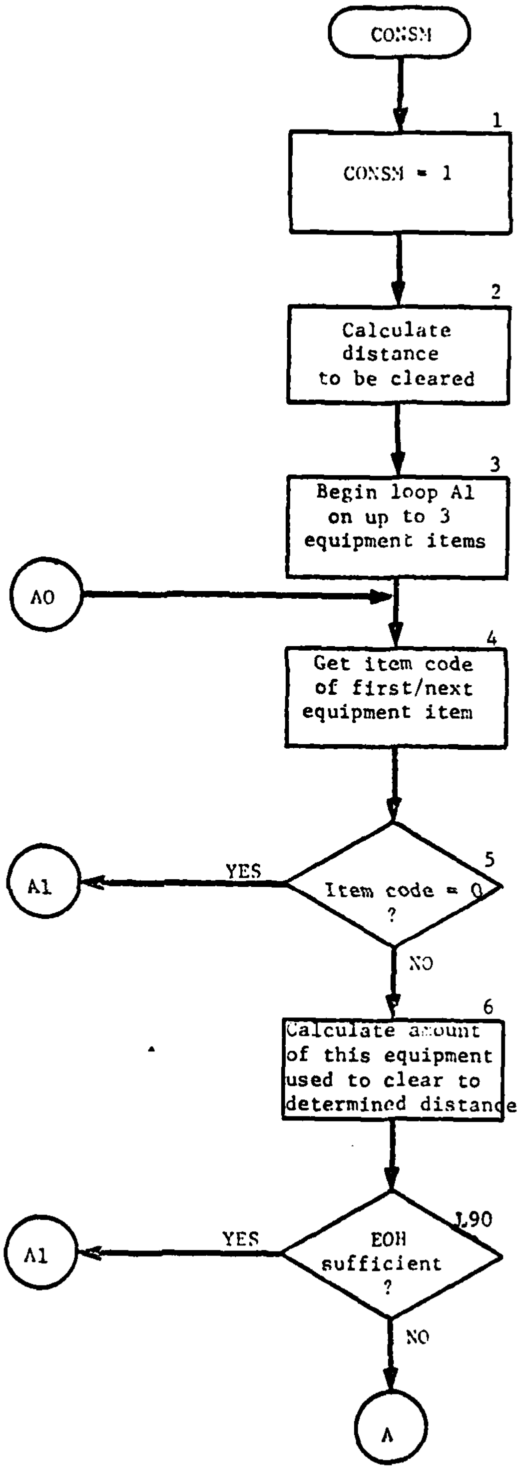
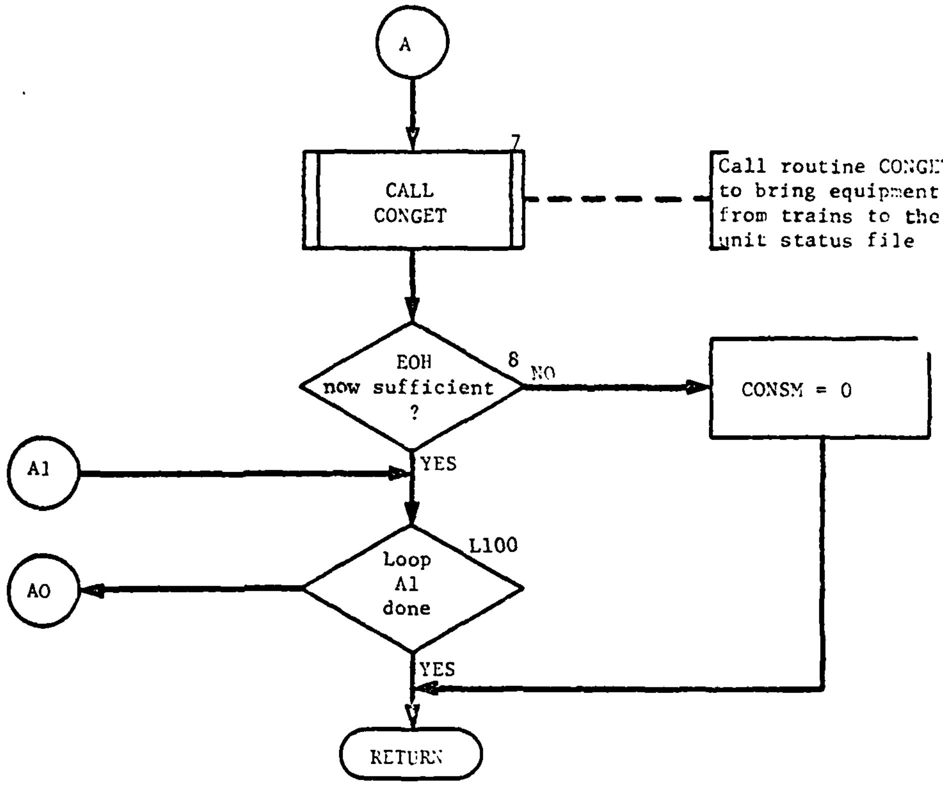


Figure IV-7-B-43. Routine CONSM.


A
7
CALL CONGET
Call routine CONGET to bring equipment from trains to the unit status file
EOH now sufficient ?
8
NO
CONSM = 0
YES
A1
L100
Loop A1 done
A0
YES
RETURN

(11) Block L110. Set CONSM flag to ZERO (unit does not have equipment required) and RETURN to calling routine.

44. ROUTINE MJITM.

a. Purpose. MJITM determines whether a unit has the required amount of specified items of equipment on its Unit Status File.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
LNS	CALL	Number of lanes required for breach.
LOCN (2, 3)	CALL	Item code and amount required per lane of up to 3 types of equipment.
MODCM	CALL	Countermeasure mode.

c. Output Variables:

Name	Destination	Contents
MJITM	CALL	Flag indicating whether unit has the equipment required (1=YES, 0=NO).

d. Logical Flow (Figure IV-7-B-44).

(1) Block 1. Set MJITM flag to 1 (unit has required equipment).

(2) Block 2. If the countermeasure mode is 8, transfer to block 9.

(3) Block 3. Begin loop (A1) on up to 3 equipment types.

(4) Block 4. Get the first/next equipment item from LOCN array.

(5) Block 5. Get the number of items of this equipment type needed per lane.

(6) Block 6. If this unit does not have the required amount of this equipment type on its Unit Status File, transfer to block L125.

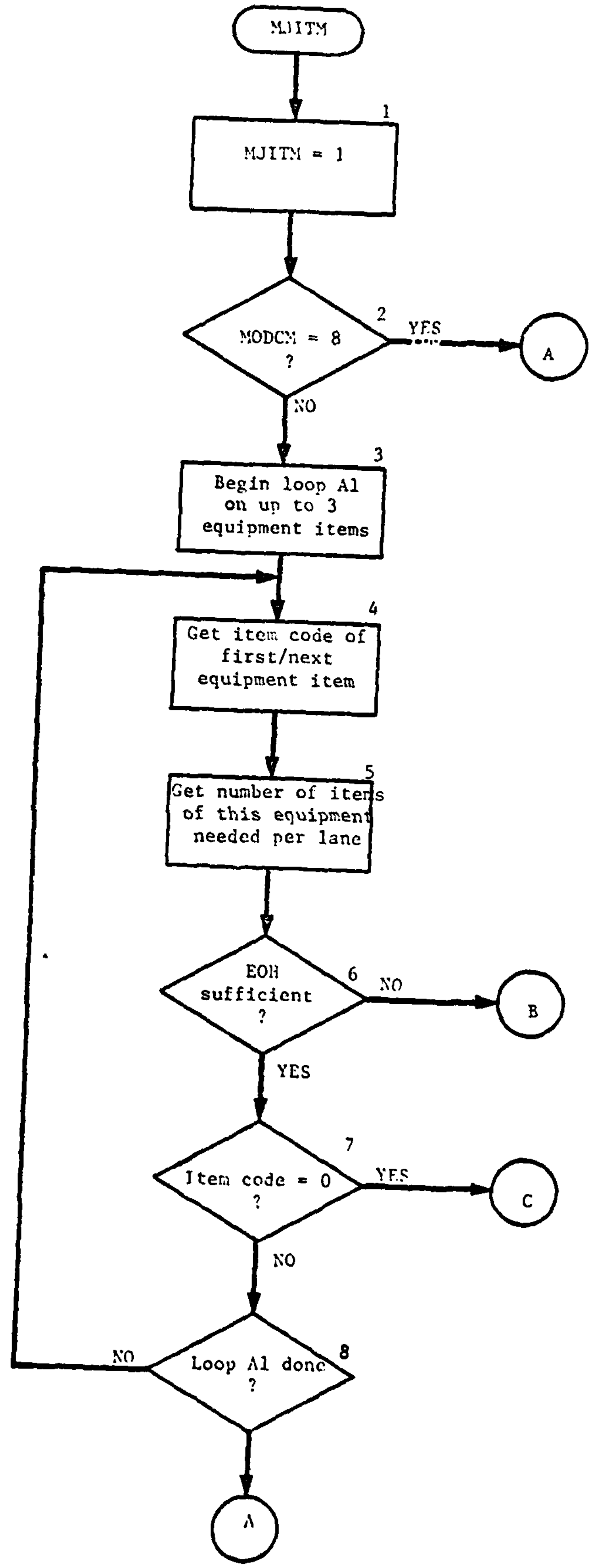
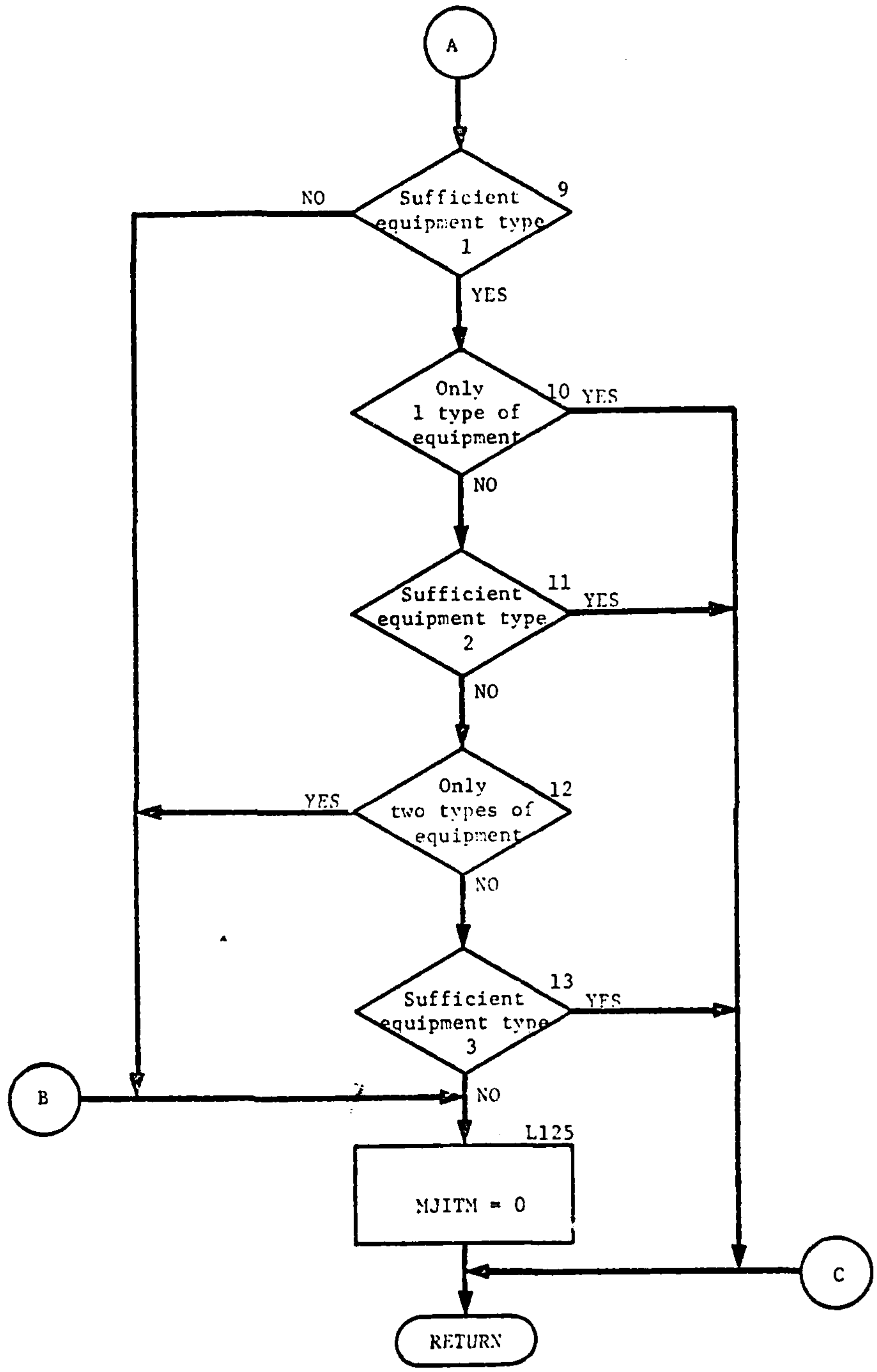


Figure IV-7-B-44. Routine MJITM.


A
Sufficient equipment type 1
9
NO
YES
Only 1 type of equipment
10
YES
NO
Sufficient equipment type 2
11
YES
NO
Only two types of equipment
12
YES
NO
Sufficient equipment type 3
13
YES
NO
B
L125
MJITM = 0
C
RETURN

(7) Block 7. If the item code of this equipment is ZERO, RETURN to the calling routine.

(8) Block 8. If loop (A1) is not done, transfer to block 4.

(9) Block 9. Does this unit have enough of equipment type 1? If not, transfer to block L125.

(10) Block 10. Is this the only type of equipment required? If so, RETURN to calling routine.

(11) Block 11. Does this unit have enough of equipment type 2? If so, RETURN to calling routine.

(12) Block 12. Are these the only types of equipment required? If so, transfer to block L125.

(13) Block 13. Does this unit have enough of equipment type 3? If so, RETURN to calling routine.

(14) Block L125. Set MJITM flag to ZERO (unit does not have required equipment) and RETURN to the calling routine.

45. ROUTINE SET6.

a. Purpose. SET6 sets up the working tables required for the various countermeasure options.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
IPRIOR	CALL	Barrier intelligence flag.

c. Output Variables:

Name	Destination	Contents
IOF (35)	DF2	Barrier-Facility file record.
IDUM (1-256)	DF21	GCM battle record.
ITBL (16, 4)	TWO	GCM Battle Control Table.
MODE	TWO	GCM mode identification.

d. Logical Flow (Figure IV-7-B-45).

(1) Block 1. If the encountering unit has prior knowledge of the minefield (IPRIOR=1), transfer to block 4.

(2) Block 2. Reset the barrier intelligence code to 3.

(3) Block 3. Call routine PUTRCD to return the updated Barrier-Facility file record to Data File 2.

(4) Block 4. Set the time of encounter in the GCM Control Table (ITBL).

(5) Block 5. If the interrupted actions flag (INRUPT) is not ZERO, transfer to block 13.

(6) Block 6. If the form number (IFORM) is 90, transfer to block L300. If IFORM is 40, 50, or 100, transfer to block 9.

(7) Block L100. Call routine LANES to determine how many additional lanes this unit has the capability to breach.

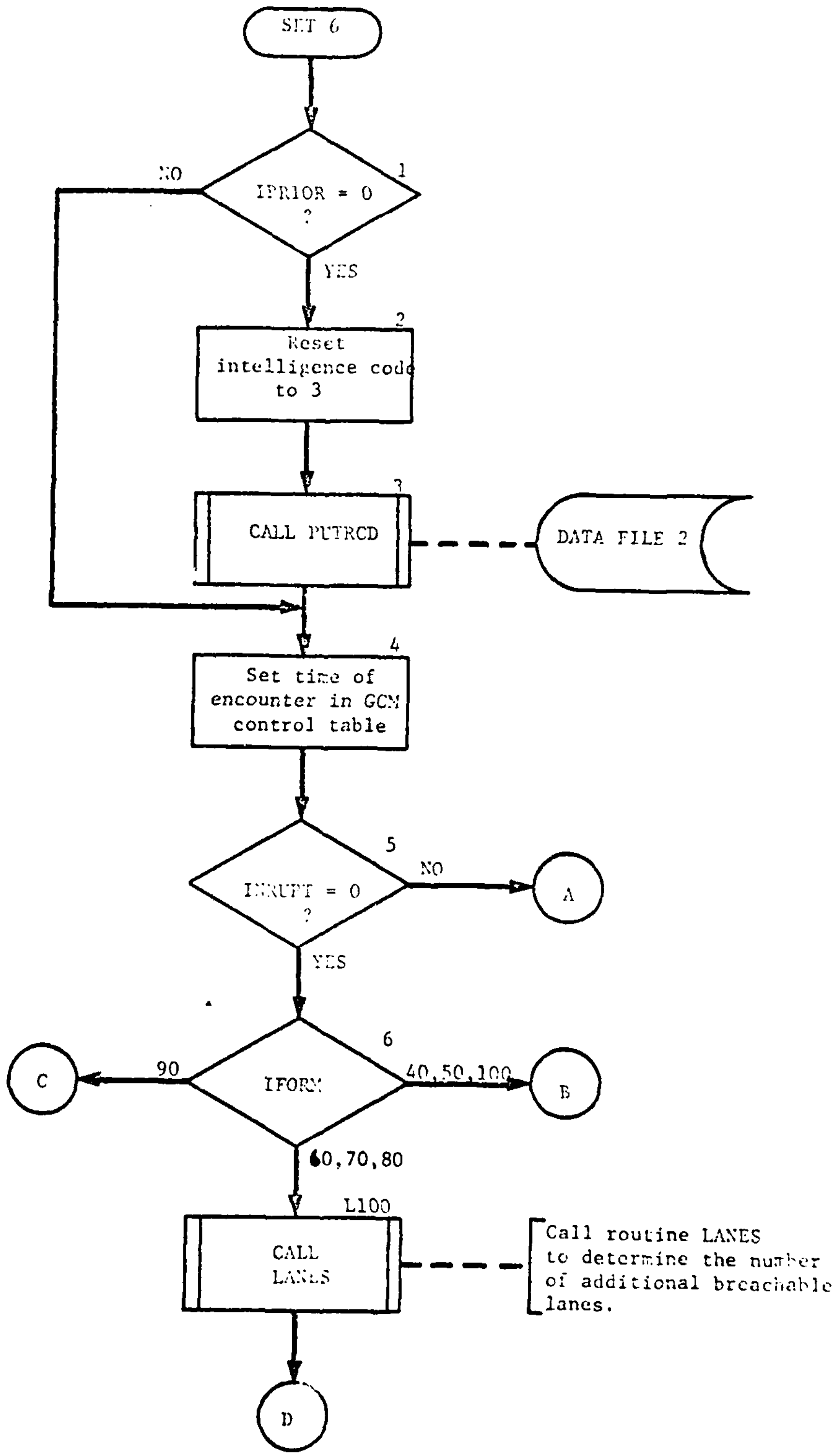


Figure IV-7-B-45. Routine SET6.

AD-A112 652 ARMY COMBINED ARMS COMBAT DEVELOPMENTS ACTIVITY FORT--ETC F/G 15/7
DIVWAG MODEL DOCUMENTATION. VOLUME II. PROGRAMMER/ANALYST MANUA--ETC(U)
JUL 76
UNCLASSIFIED CACDA-TR-8-76-VOL-2-PT-3 NL

5 OF 7

OF 7

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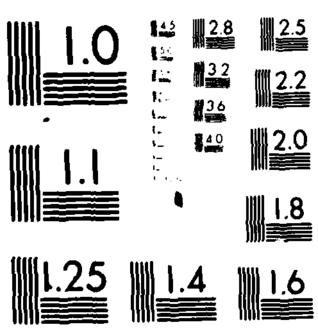
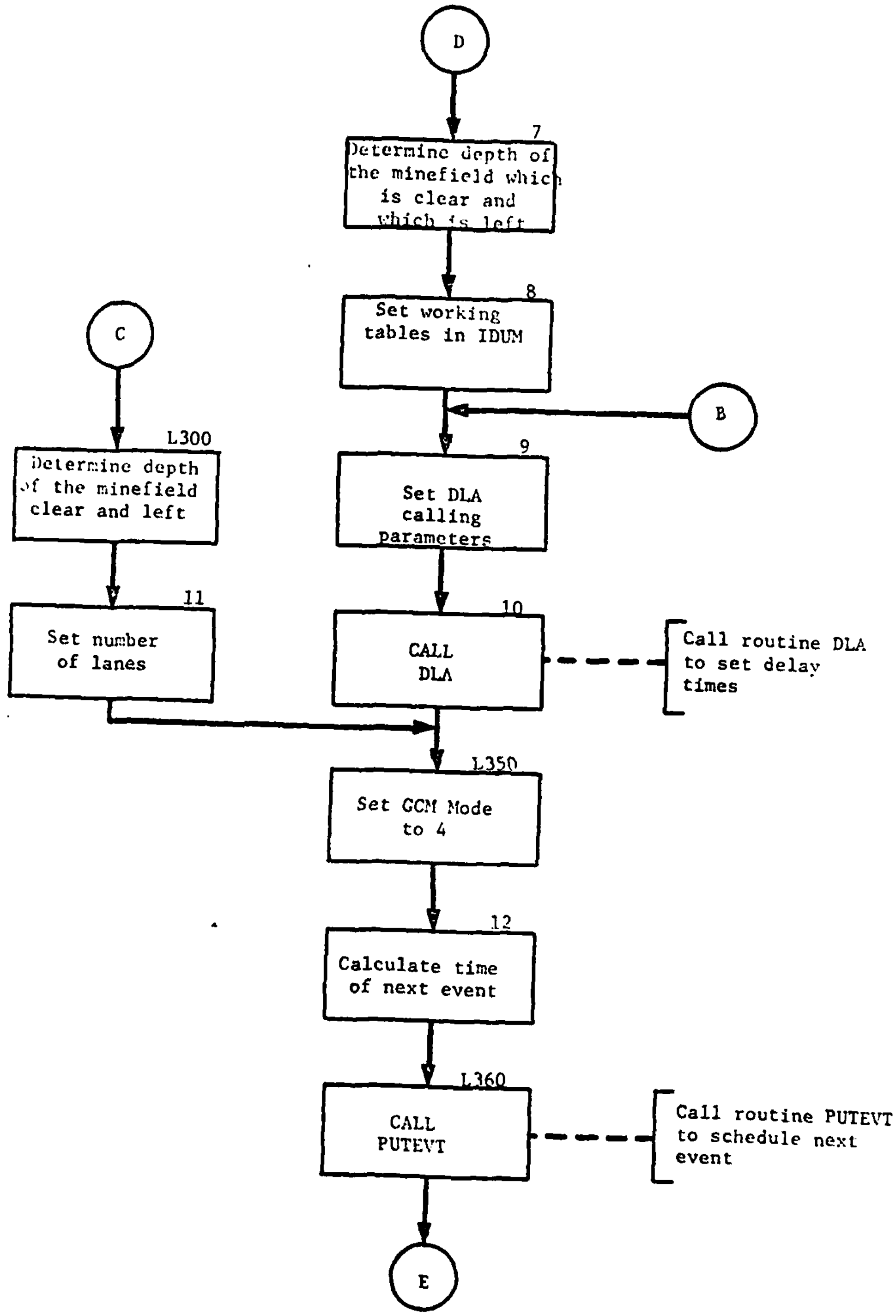
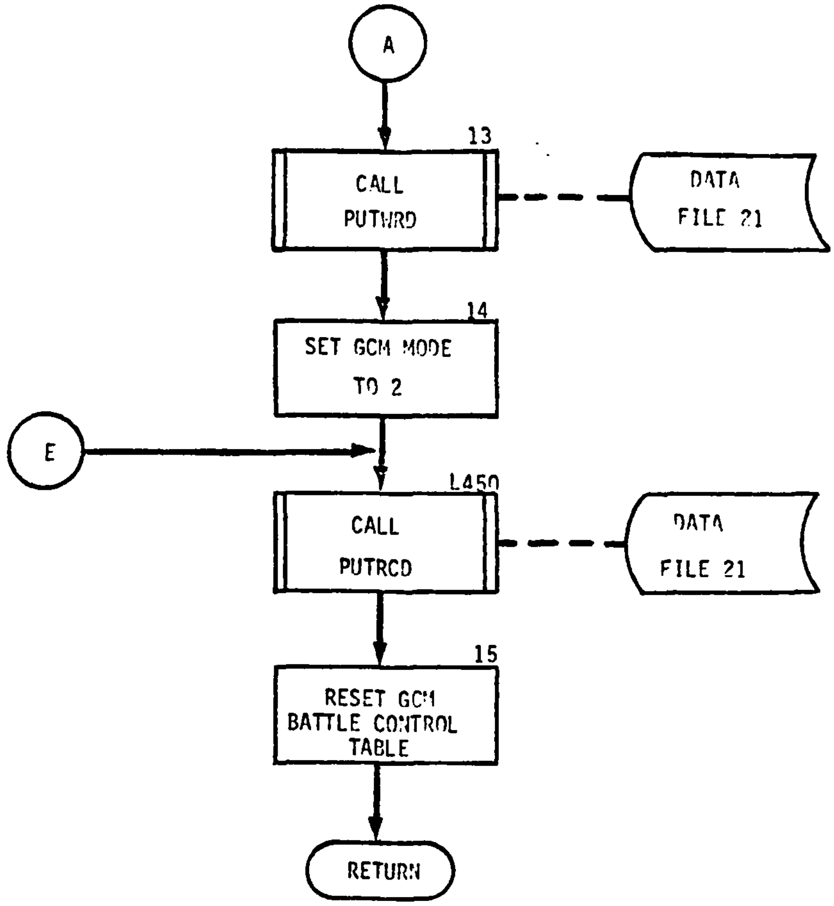


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A


D
7
Determine depth of the minefield which is clear and which is left
8
Set working tables in IDUM
C
B
L300
Determine depth of the minefield clear and left
9
Set DLA calling parameters
11
Set number of lanes
10
CALL DLA
Call routine DLA to set delay times
L350
Set GCM Mode to 4
12
Calculate time of next event
L360
CALL PUTEVT
Call routine PUTEVT to schedule next event
E


A
13
CALL
PUTWRD
DATA
FILE 21
14
SET GCM MODE
TO 2
E
L450
CALL
PUTRCD
DATA
FILE 21
15
RESET GCM
BATTLE CONTROL
TABLE
RETURN

(8) Block 7. Determine how much (depth) of the minefield is cleared, and how much is left to be cleared.

(9) Block 8. Set working tables in IDUM array depending on form number and countermeasure device.

(10) Block 9. Set the decision condition (ICON), countermeasure index (ICM), and the form number (IOLDPM) required for call to routine DLA.

(11) Block 10. Call routine DLA to set the delay times. Transfer to block L350.

(12) Block L300. Determine the depth of the minefield cleared and to be cleared.

(13) Block 11. Set number of lanes to the minimum of lanes open and lanes desired.

(14) Block L350. Set GCM MODE to 4.

(15) Block 12. Calculate the time the next event will take place.

(16) Block L360. Call routine PUTEVT to schedule the next event.

(17) Block 13. Call routine PUTWRD to ZERO out control word in record 153 of File 21.

(18) Block 14. Set GCM MODE to 2.

(19) Block L450. Call routine PUTRCD to set up GCM battle record on Data File 21.

(20) Block 15. Update the GCM Battle Control Table. RETURN to calling routine.

46. ROUTINE LANES.

a. Purpose. LANES determines how many additional lanes the unit in UMAIN can breach with its available resources.

b. Input Variables:

Name	Source	Contents
LD	CALL	Number of lanes desired.
LS	CALL	Number of lanes sufficient.
LO	CALL	Number of lanes known open.

DEP	CALL	Minefield depth.
IDTA (20)	CALL	Countermeasure data table.
AVAIL	CALL	Number of available engineer troops subordinate to the unit in UMAIN.

c. Output Variables:

Name	Destination	Contents
LANES	CALL	Number of additional lanes breachable with the unit's resources.

d. Logical Flow (Figure IV-7-B-46).

(1) Block 1. Calculate the minimum additional lanes required (ISTART).

(2) Block 2. Calculate the most desired number of additional lanes required (ISTOP).

(3) Block 3. Begin loop (A1) on additional lanes using ISTART and ISTOP as starting and ending indices.

(4) Block 4. If the countermeasure mode is 8, transfer to block L25.

(5) Block 5. If this unit does not have sufficient engineer troops available for one more lane, transfer to block 10.

(6) Block 6. Call routine CONSM to determine whether the unit in UMAIN has the required equipment for one more lane.

(7) Block 7. If this unit does not have sufficient equipment for one more lane, transfer to block 10.

(8) Block L25. Call routine MJITM to check for sufficient equipment in the unit's Unit Status File.

(9) Block 8. If this unit does not have sufficient equipment in his Unit Status File for one more lane, transfer to block 10.

(10) Block L100. If this is the end of loop (A1), transfer to block 10.

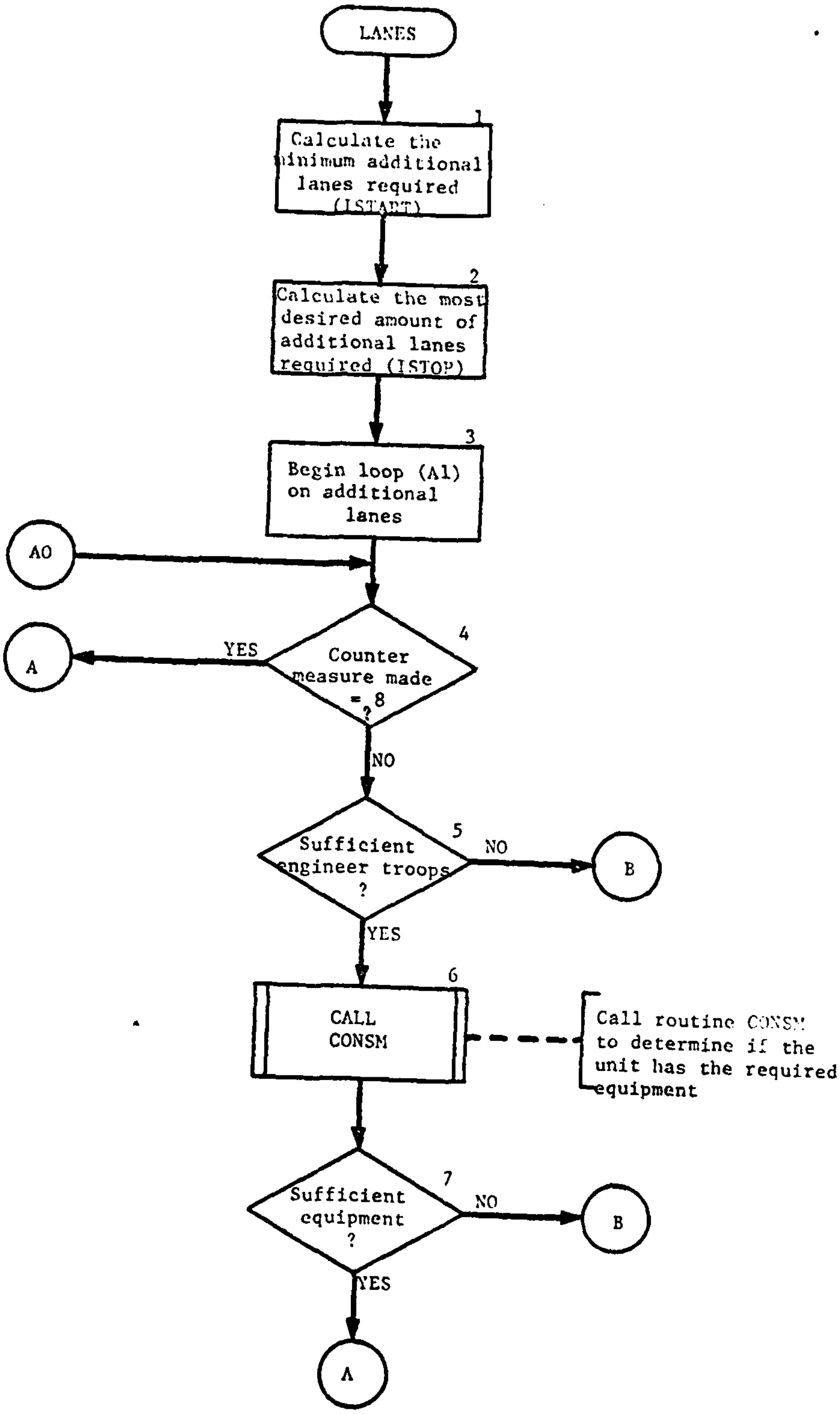
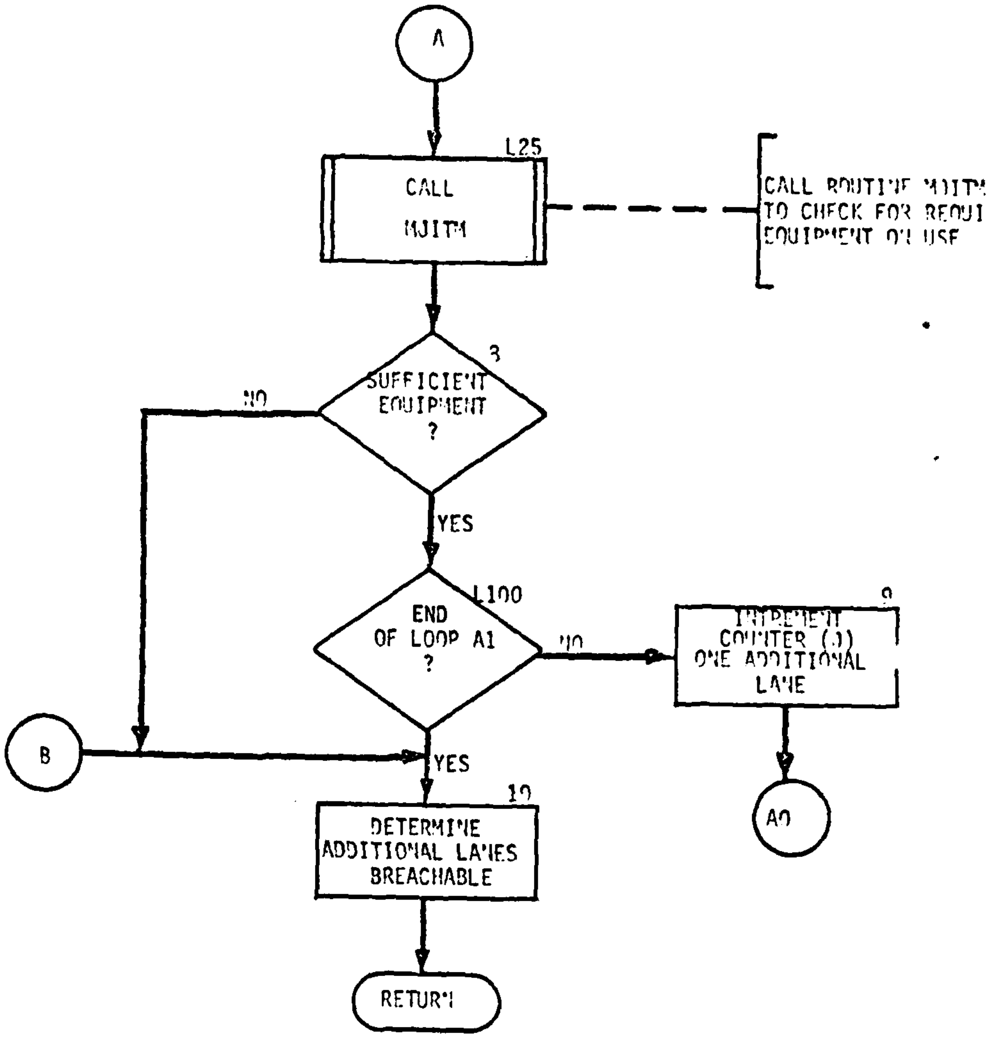


Figure IV-7-B-46. Routine LANES.


A
L25
CALL
MJITM
CALL ROUTINE MJITM
TO CHECK FOR REQUI
EQUIPMENT ON USE
3
SUFFICIENT
EQUIPMENT
?
NO
YES
L100
END
OF LOOP A1
?
NO
9
INCREMENT
COUNTER (J)
ONE ADDITIONAL
LANE
A0
B
YES
10
DETERMINE
ADDITIONAL LANES
BREACHABLE
RETURN

(11) Block 9. Increment the counter (J) for the number of additional lanes breachable. Transfer to block 4.

(12) Block 10. Determine the additional number of lanes breachable using J. RETURN to calling routine.

47. ROUTINE DLA.

a. Purpose. DLA calculates the delay time associated with any particular countermeasure option.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
ICON	CALL	Decision condition.
ICM	CALL	Countermeasure index.
IOLDFM	CALL	Form number.
IPRIOR	CALL	Minefield intelligence flag.
IMTM (3, 20)	DF39	Delay times.

c. Output Variables:

Name	Destination	Contents
DLA	CALL	Delay time.

d. Logical Flow (Figure IV-7-B-47).

(1) Block 1. If the form number (IOLDFM) is not 40, transfer to block L10.

(2) Block 2. Call routine GETWRD to get the simple delay times for a pure delay barrier from Data File 39. Transfer to block L20.

(3) Block L10. If the form number is not 30, or the unit does not have prior knowledge of the barrier, transfer to block L15.

(4) Block 3. Set the total delay time to ZERO and RETURN to the calling routine.

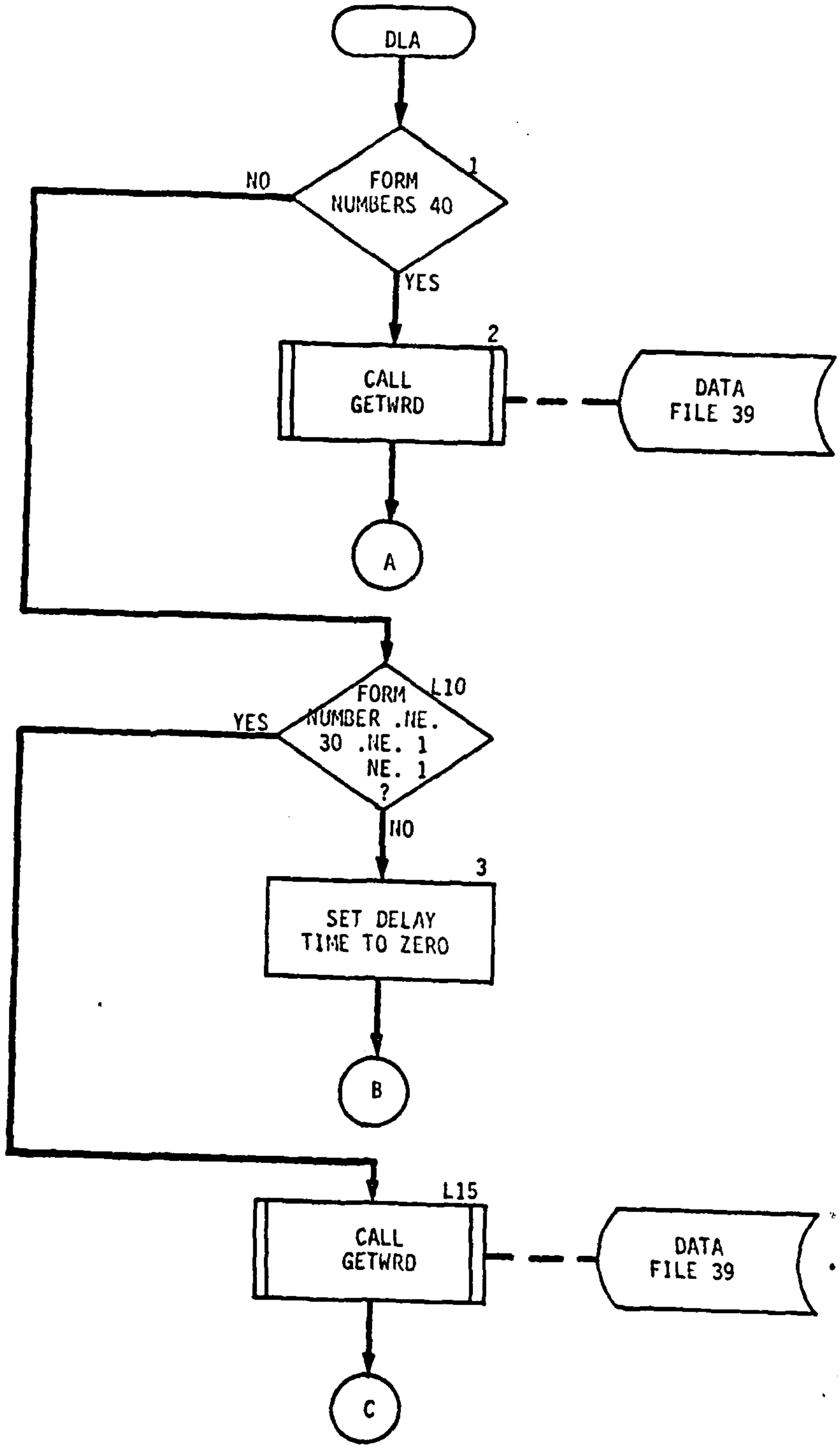
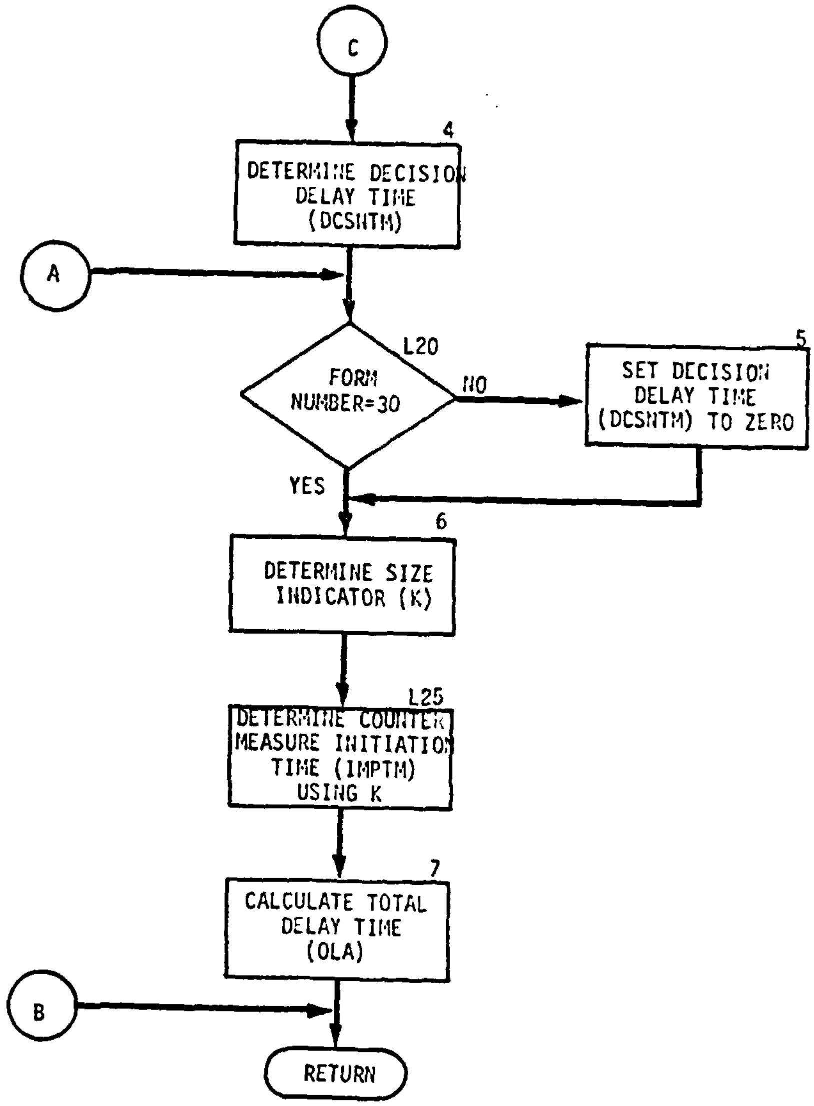


FIGURE IV-7-B-47 ROUTINE DLA


C
4
DETERMINE DECISION
DELAY TIME
(DCSNTM)
A
L20
FORM
NUMBER=30
NO
5
SET DECISION
DELAY TIME
(DCSNTM) TO ZERO
YES
6
DETERMINE SIZE
INDICATOR (K)
L25
DETERMINE COUNTER
MEASURE INITIATION
TIME (IMPTM)
USING K
7
CALCULATE TOTAL
DELAY TIME
(OLA)
B
RETURN

(5) Block L15. Call routine GETWRD to obtain the simple delay time tables from Data File 39.

(6) Block 4. Determine the decision delay time (DCSNTM) based on the decision condition (ICON).

(7) Block L20. If the form number is 30, transfer to block 6.

(8) Block 5. Set the decision delay time (DCSNTM) to ZERO.

(9) Block 6. Determine the size of the encountering unit. Set K to indicate this size.

(10) Block L25. Determine the countermeasure initiation time (IMPTM) using K as an index into time table.

(11) Block 7. Calculate the total delay time (DLA) as the decision delay time (DCSNTM) plus the countermeasure initiation time (IMPTM). RETURN to the calling routine.

48. ROUTINE EXEC7.

a. Purpose. EXEC7 is the driving routine of the in-field portion (segment 7) of the Ground Combat Model and called the various processing routines.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
INRUPT	TWO	Interrupted actions flag, located at IDUM (4100).
IDXATT	TWO	Attacker's index into GCM Battle Control Table.
ILOSS (64)	DF21	Attacking unit's losses.
IBFIL (70)	DF2	Barrier-Facility file records.

c. Output Variables:

Name	Destination	Contents
IDUM (128)	DF21	GCM minefield encounter data.

UMAIN (512) DF1 Unit Status File.

d. Logical Flow (Figure IV-7-B-48).

(1) Block 1. Get index (JREC) into Data File 21 from UMAIN.

(2) Block 2. Call routine GETRCD to get the pertinent GCM battle record from Data File 21.

(3) Block 3. If the interrupt processing flag is not ZERO and IFORM is 81, transfer to block L360.

(4) Block 4. Calculate attacker's index into Data File 21 using IDXATT.

(5) Block 5. Call routine GETRCD to get the GCM losses for the attacker unit (ILOSS).

(6) Block 6. Determine the losses to the breaching vehicles (GCLOS), the original number of breaching vehicles (GCIN), and the probability of breaching vehicle survival (RO).

(7) Block L50. If IFORM is not 81, transfer to block L125.

(8) Block 7. Call routine VSET to set up required data for minefield encounter.

(9) Block 8. Calculate the total number of mines in the minefield (MTOT).

(10) Block 9. Calculate width of the minefield (LFWID).

(11) Block 10. Calculate the expected number of mines in a lane (EM).

(12) Block 11. Set up the original distribution of mines in the minefield.

(13) Block 12. Shift the minefield distribution data from the work area to a save area.

(14) Block 13. Determine the number of lanes in the minefield which are free and which are not free.

(15) Block 14. Reset control words in IDUM array. Transfer to block L150.

(16) Block L125. Shift the minefield distribution data from the save area to the work area.

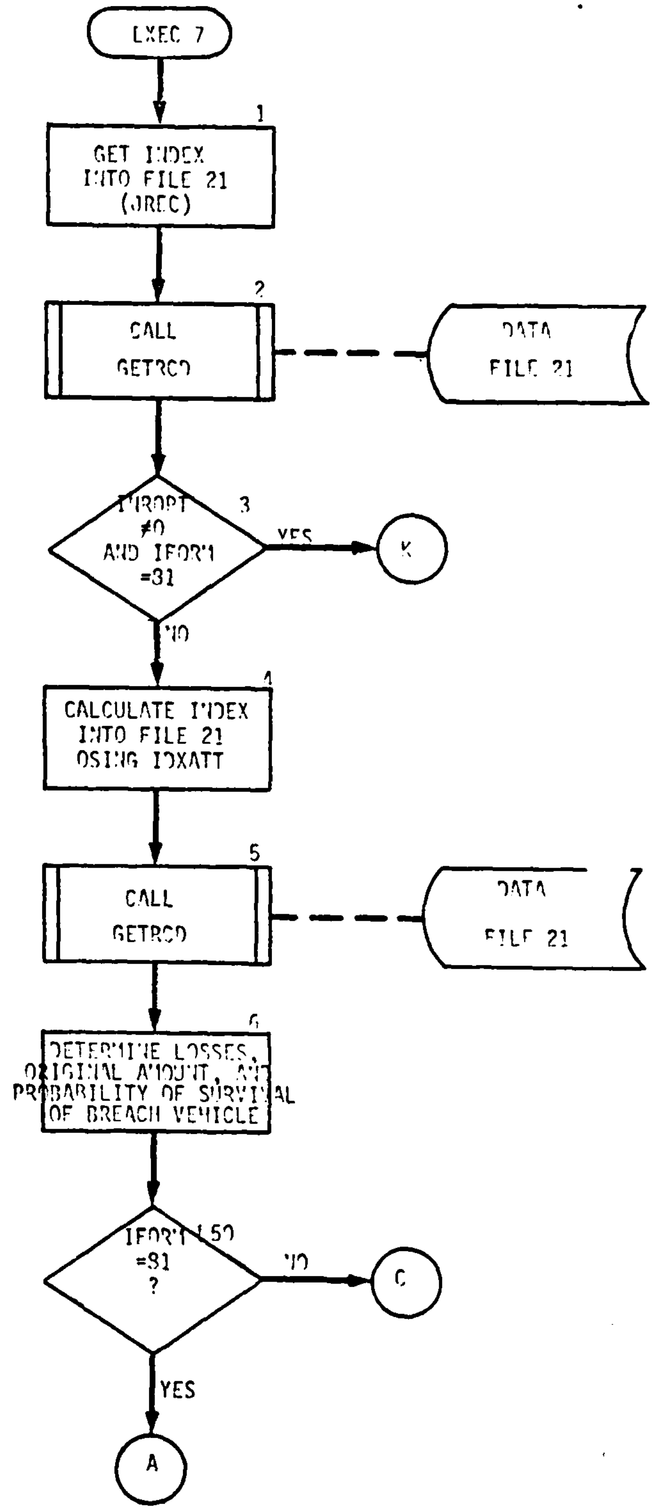
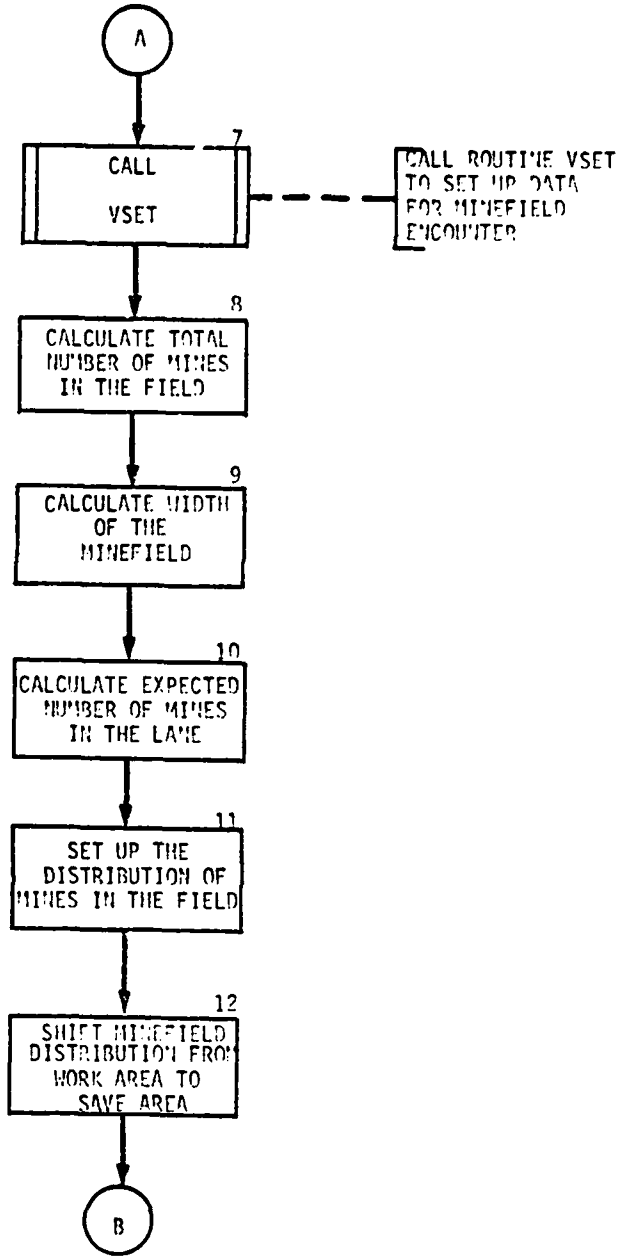
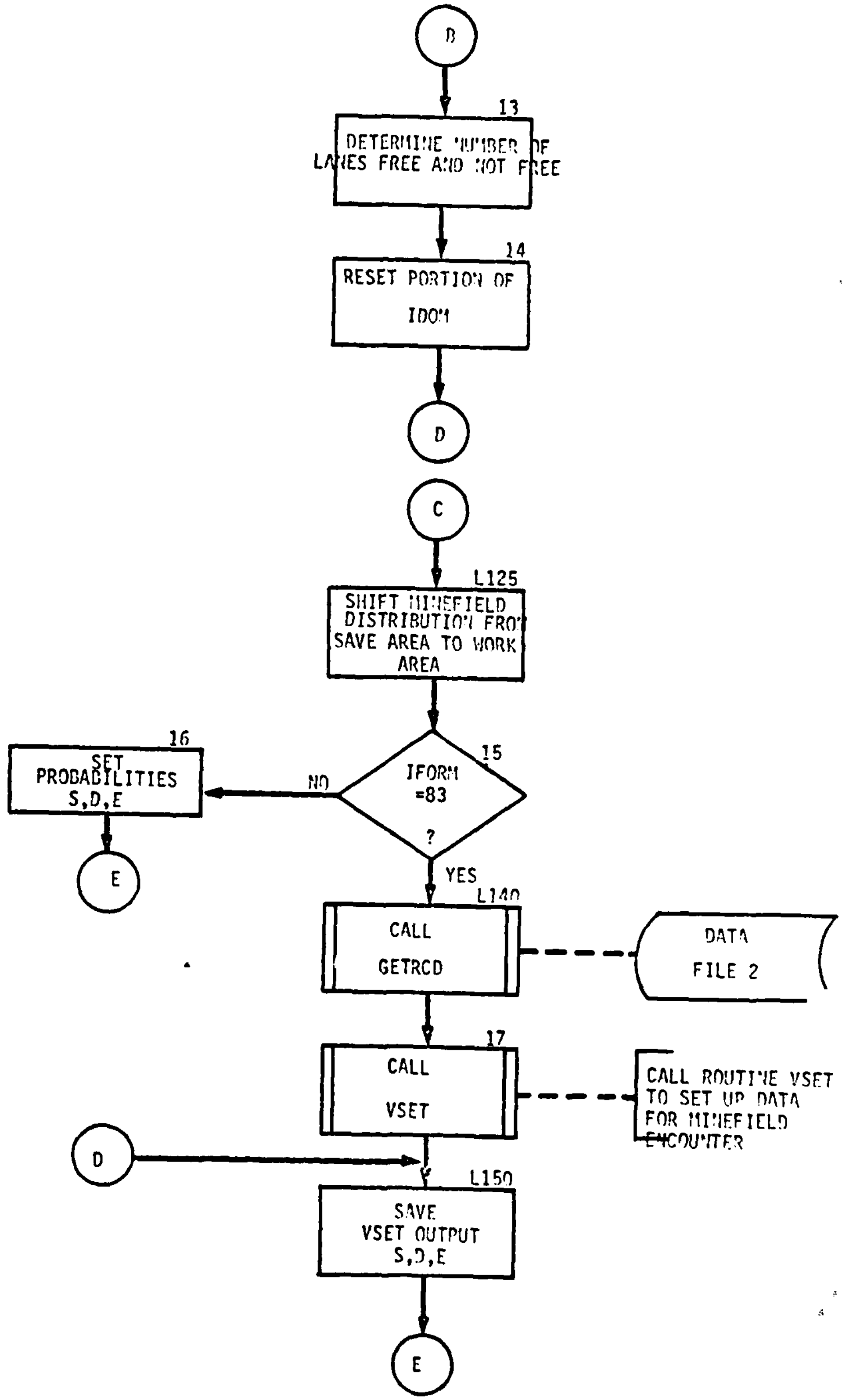
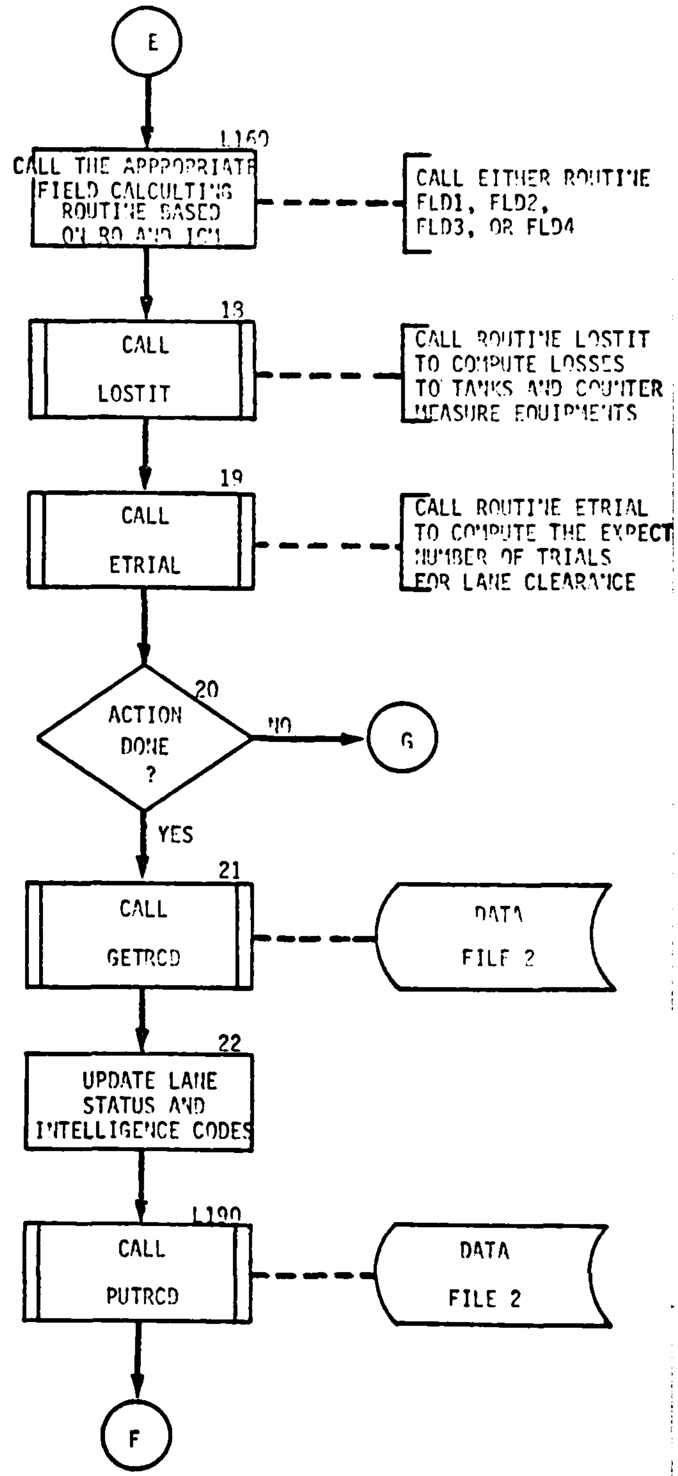
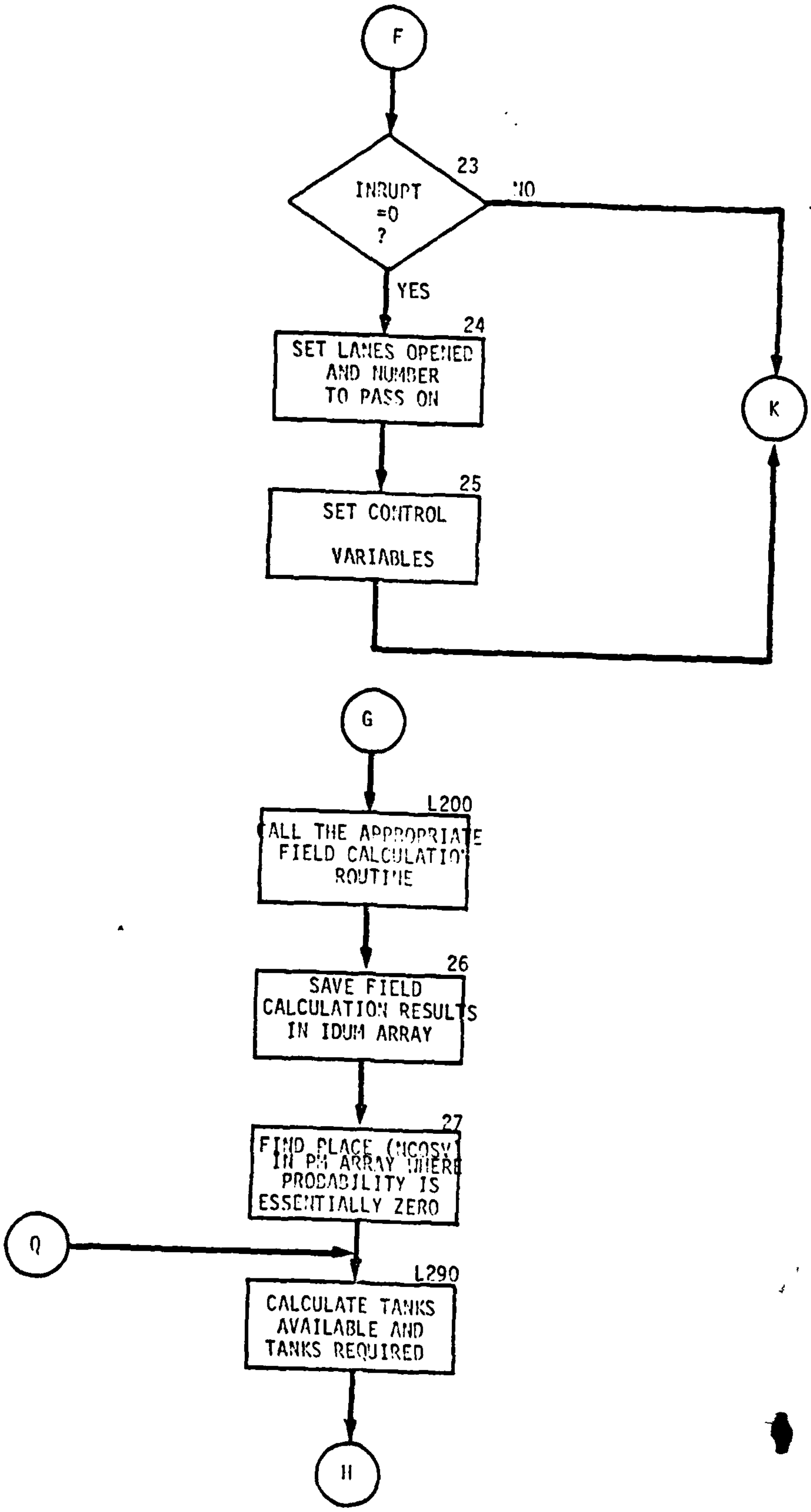


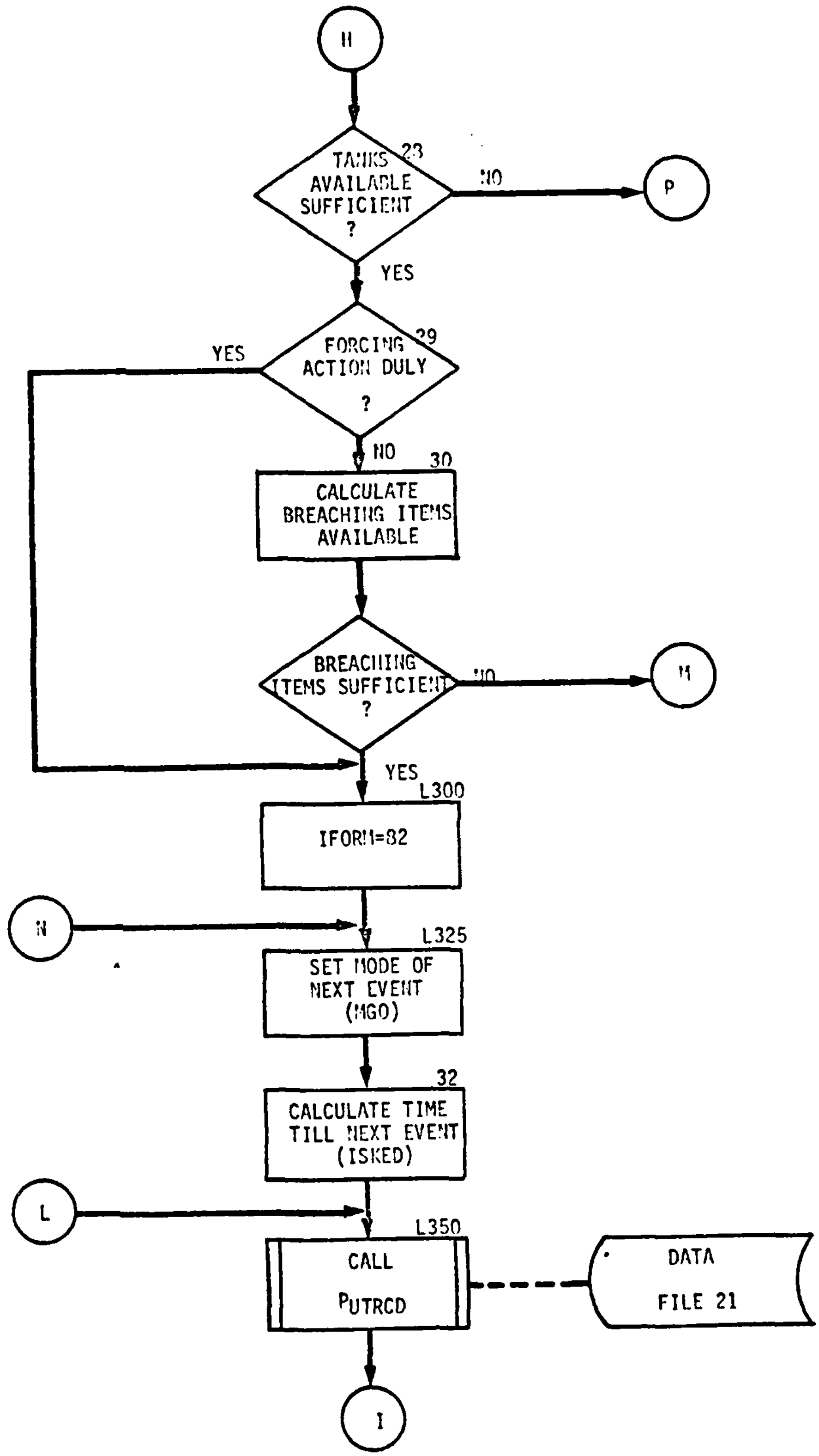
FIGURE IV-7-B-43 ROUTINE EXEC7


A
7
CALL
VSET
CALL ROUTINE VSET
TO SET UP DATA
FOR MINEFIELD
ENCOUNTER
8
CALCULATE TOTAL
NUMBER OF MINES
IN THE FIELD
9
CALCULATE WIDTH
OF THE
MINEFIELD
10
CALCULATE EXPECTED
NUMBER OF MINES
IN THE LANE
11
SET UP THE
DISTRIBUTION OF
MINES IN THE FIELD
12
SHIFT MINEFIELD
DISTRIBUTION FROM
WORK AREA TO
SAVE AREA
B

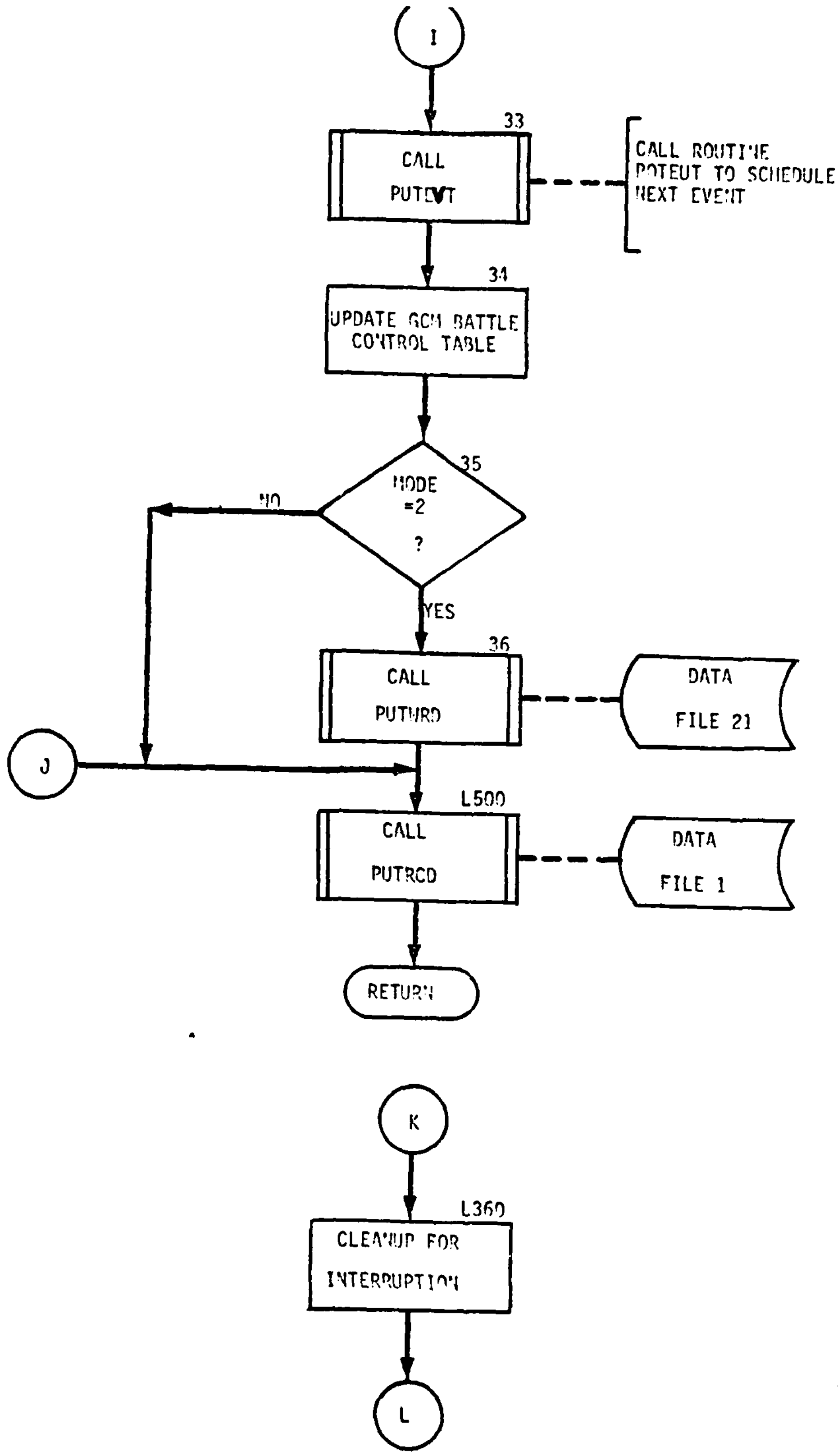

B
13
DETERMINE NUMBER OF LANES FREE AND NOT FREE
14
RESET PORTION OF IDOM
D
C
L125
SHIFT MINEFIELD DISTRIBUTION FROM SAVE AREA TO WORK AREA
15
IFORM =83 ?
NO
16
SET PROBABILITIES S,D,E
E
YES
L140
CALL GETRCD
DATA FILE 2
17
CALL VSET
CALL ROUTINE VSET TO SET UP DATA FOR MINEFIELD ENCOUNTER
D
L150
SAVE VSET OUTPUT S,D,E
E

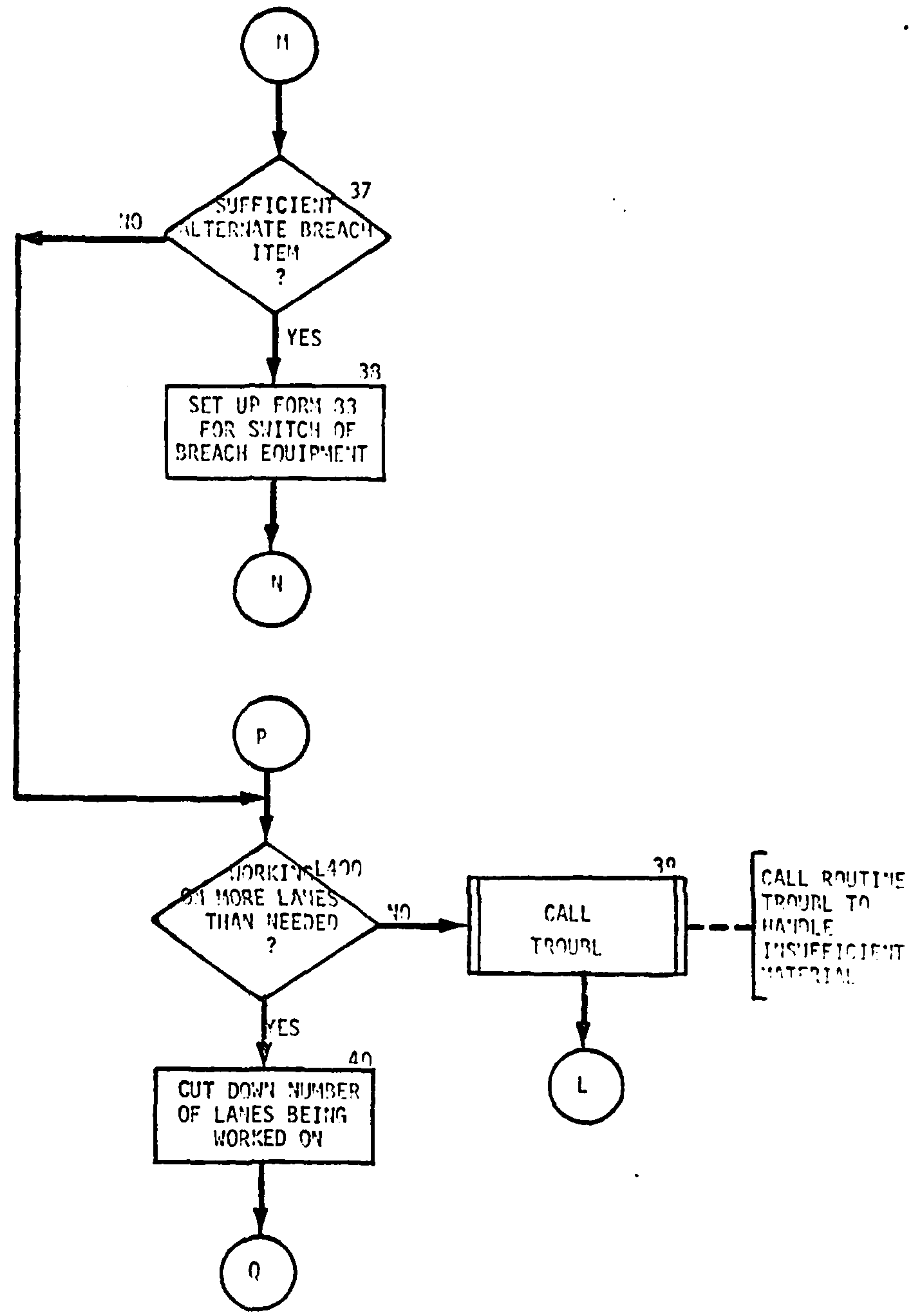

E
L160
CALL THE APPPOPRIATE FIELD CALCULTING ROUTINE BASED ON RO AND ICM
CALL EITHER ROUTINE FLD1, FLD2, FLD3, OR FLD4
18
CALL LOSTIT
CALL ROUTINE LOSTIT TO COMPUTE LOSSES TO TANKS AND COUNTER MEASURE EQUIPMENTS
19
CALL ETRIAL
CALL ROUTINE ETRIAL TO COMPUTE THE EXPECT NUMBER OF TRIALS FOR LANE CLEARANCE
20
ACTION DONE ?
NO
G
YES
21
CALL GETRCD
DATA FILE 2
22
UPDATE LANE STATUS AND INTELLIGENCE CODES
L190
CALL PUTRCD
DATA FILE 2
F


F
INRUPT =0 ?
23
NO
YES
24
SET LANES OPENED AND NUMBER TO PASS ON
K
25
SET CONTROL VARIABLES
G
L200
CALL THE APPROPRIATE FIELD CALCULATION ROUTINE
26
SAVE FIELD CALCULATION RESULTS IN IDUM ARRAY
27
FIND PLACE (NCOSV) IN PM ARRAY WHERE PROBABILITY IS ESSENTIALLY ZERO
Q
L290
CALCULATE TANKS AVAILABLE AND TANKS REQUIRED
H



H
TANKS AVAILABLE SUFFICIENT ?
23
NO
P
YES
FORCING ACTION DULY ?
29
YES
NO
30
CALCULATE BREACHING ITEMS AVAILABLE
BREACHING ITEMS SUFFICIENT ?
NO
M
YES
L300
IFORM=82
N
L325
SET MODE OF NEXT EVENT (MGO)
32
CALCULATE TIME TILL NEXT EVENT (ISKED)
L
L350
CALL PUTRCD
DATA FILE 21
I


I
33
CALL
PUTEVT
CALL ROUTINE
POTEUT TO SCHEDULE
NEXT EVENT
34
UPDATE GCM BATTLE
CONTROL TABLE
35
MODE
=2
?
NO
YES
36
CALL
PUTWRD
DATA
FILE 21
J
L500
CALL
PUTRCD
DATA
FILE 1
RETURN
K
L360
CLEANUP FOR
INTERRUPTION
L


M
SUFFICIENT ALTERNATE BREACH ITEM ?
37
NO
YES
38
SET UP FORM 33 FOR SWITCH OF BREACH EQUIPMENT
N
P
WORKING ON MORE LANES THAN NEEDED ?
L400
NO
39
CALL TROUBL
CALL ROUTINE TROUBL TO HANDLE INSUFFICIENT MATERIAL
L
YES
40
CUT DOWN NUMBER OF LANES BEING WORKED ON
Q

(17) Block 15. If IFORM is 83, transfer to block L140.

(18) Block 16. Set probability of vehicle survival (S), probability that countermeasure will survive, and probability that countermeasure will not survive. Transfer to block L160.

(19) Block L140. Call routine GETRCD to obtain the barrier file from Data File 2.

(20) Block 17. Call routine VSET to set up required data for the minefield encounter.

(21) Block L150. Save VSET out S, D, and E defined above.

(22) Block L160. Call the appropriate field calculation routine (FLD 1, FLD 2, FLD 3, or FLD 4) based on RO and ICM.

(23) Block 18. Call routine LOSTIT to compute the losses to tanks and countermeasure equipment.

(24) Block 19. Call routine ETRIAL to compute the expected number of trials required for lane clearance.

(25) Block 20. Is the current action (breach or force) done? If not, transfer to block L200.

(26) Block 21. Call routine GETRCD to get the barrier file record from Data File 2.

(27) Block 22. Update the lane status and intelligence code in the barrier file record.

(28) Block L190. Call routine PUTRCD to return the updated barrier file record to Data File 2.

(29) Block 23. If the interrupted actions flag (INRUPT) is not ZERO, transfer to block L360.

(30) Block 24. Calculate number of lanes open and number to pass on.

(31) Block 25. Set control variables for event scheduling. Transfer to block L360.

(32) Block L200. Call the appropriate field calculation routine.

(33) Block 26. Save the field calculation results in IDUM.

(34) Block 27. Find the point (NCOSV) in PM array where the probability is essentially ZERO.

(35) Block L290. Calculate the number of tanks available and the number of tanks required.

(36) Block 28. If there are not sufficient tanks available, transfer to block L400.

(37) Block 29. Does the countermeasure mode indicate a forcing operation only? If so, transfer to block L300.

(38) Block 30. Calculate the amount of breaching equipment available.

(39) Block 31. If the amount of breaching equipment is not sufficient, transfer to block 37.

(40) Block L300. Set the form number (IFORM) to 82.

(41) Block L325. Set the mode of the next event (MGO) to 8.

(42) Block 32. Calculate the length of time till the next event (ISKED).

(43) Block L350. Call routine PUTRCD to return GCM minefield encounter data to Data File 21.

(44) Block 33. Call routine PUTEVT to schedule the next event.

(45) Block 34. Update the GCM Battle Control Table.

(46) Block 35. If the mode is not 2, transfer to block L500.

(47) Block 36. Call routine PUTWRD to ZERO out control word on Data File 21.

(48) Block L500. Call routine PUTRCD to return attacker's Unit Status File to Data File 1. RETURN to the calling routine.

(49) Block L360. ZERO out IDUM and clean up for interrupted actions. Transfer to block L350.

(50) Block 37. Are there sufficient alternate breach items of equipment? If no, transfer to block L400.

(51) Block 38. Set up form number 83 for switch of breaching equipment. Transfer to block L325.

(52) Block L400. Is the unit working on more lanes than are needed? If so, transfer to block 40.

(53) Block 39. Call routine TROOBL to handle the situation where there is insufficient material for the breach/ force action. Transfer to block L350.

(54) Block 40. Reduce the number of lanes being worked on. Transfer to block L290.

49. ROUTINE ETRIAL

a. Purpose. ETRIAL calculate the expected number of trials required to open at least the necessary number of lanes.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
LNS	CALL	Number of lanes the unit must open.
LWORK	CALL	Number of work sites.
IPASS	CALL	Number of trials (passes through the model).
RO	TWO	Probability of breaching vehicle survival of direct fires located at IDUM (555).
PS(25)	TWO	Probability of vehicle surviving each of up to 25 trials located at IDUM (608).
NIT	TWO	Iteration counter, located at IDUM (633).

c. Output Variables:

Name	Destination	Contents
PM(25)	TWO	Probability of having at least the desired number of successes on a particular trial (up to 25 trials).
PL(25)	CALL	Probability of having sufficient lanes on a particular trial (up to 25 trials) and not on any previous trial.

d. Logical flow (Figure IV-7-B-49).

(1) Block 1. Set the limits for the calculation loops which follow.

(2) Block 2. Calculate PM array. This array contains the probabilities of having at least the desired

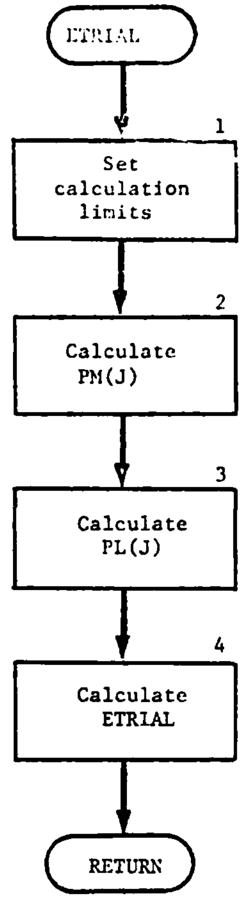


Figure IV-7-B-49. Routine ETRIAL.

number if successes on a particular trial (PM array index).

(3) Block 3. Calculate PL array. This array contains the probabilities of having sufficient lanes on a particular trial (PL array index).

(4) Block 4. Calculate expected number of trials (ETRIAL) using PL array. RETURN to calling routine.

50. ROUTINE LOSTIT

a. Purpose. LOSTIT calculates the number of tanks and countermeasure items which were lost in breach attempt and subtracts them from the unit's Unit Status File. LOSTIT also calculates the number of tanks and countermeasure items which have crossed the minefield.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
LSTART	CALL	Number of addiational lanes required.
IVEH	TWO	Tank item code.
ICM	TWO	Countermeasure item code.

c. Output Variables:

Name	Destination	Contents
EOH(200)	ONE	Units updated Unit Status File.
TCROSS	TWO	Number of tanks which have crossed the minefield.
CCROSS	TWO	Number of countermeasure items which have crossed the minefield.

d. Logical flow (Figure IV-7-B-50).

(1) Block 1. Calculate the number of tanks lost during the breach attempt (TLOSS).

(2) Block 2. Subtract the tanks lost from the unit's Unit Status File.

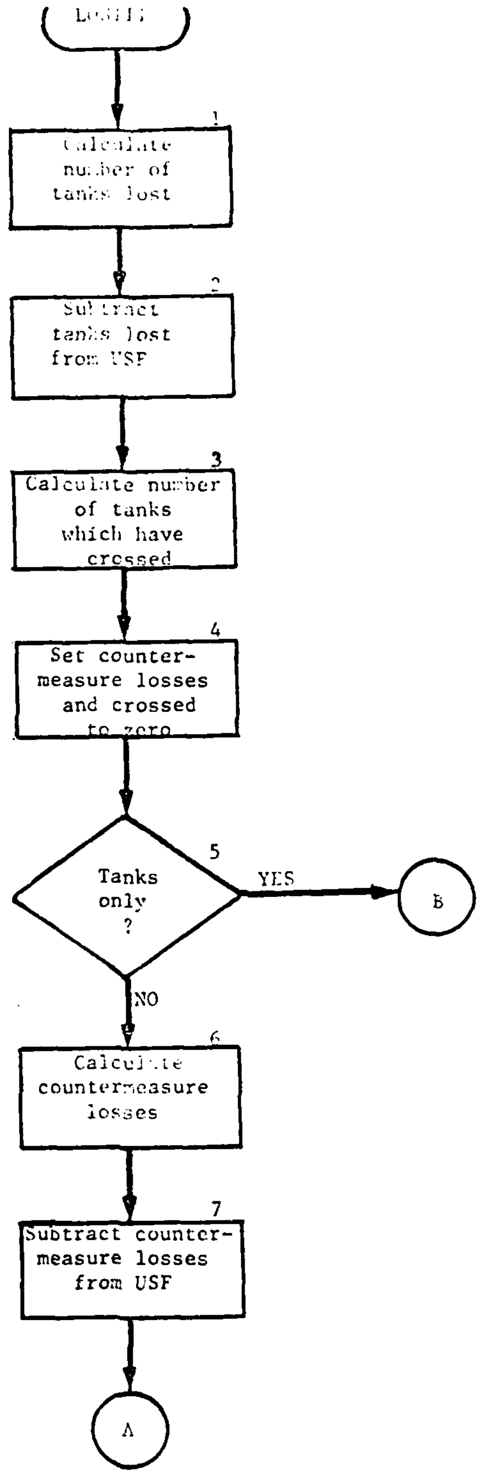
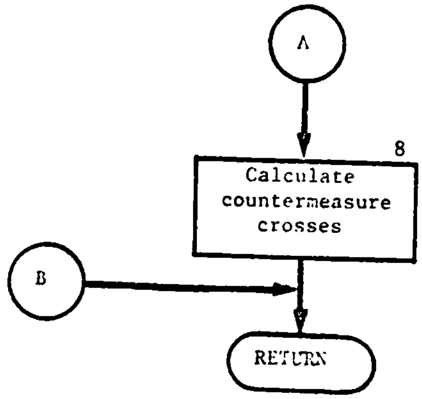


Figure IV-7-B-50. Routine LOSTIT.


A
8
Calculate
countermeasure
crosses
B
RETURN

(3) Block 3. Calculate the number of tanks which have crossed the minefield.

(4) Block 4. Set the countermeasure losses and countermeasure items crossed to ZERO.

(5) Block 5. If this breach involved only tanks (no countermeasure items) RETURN to the calling routine.

(6) Block 6. Calculate the number of countermeasure item losses.

(7) Block 7. Subtract these countermeasure losses from the unit's Unit Status File.

(8) Block 8. Calculate the number of countermeasure items which have crossed the minefield. RETURN to the calling routine.

51. ROUTINE FLD1

a. Purpose. FLD1 in the "in field" calculation routine which handles the case when there are not direct fires and no countermeasure item.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
CM(J), J=1,50	TWO	Probability of exactly J mines in a path, located at IDUM (502).
CMO	TWO	Probability of ZERO mines, located at IDUM (501).
NCO	TWO	Maximum value of J to use, located at IDUM (556).
IT	CALL	Iteration counter.

c. Output Variables:

Name	Destination	Contents
PM(J), J=1,50	TWO	Resultant probability of exactly J mines left after breach attempt, located at IDUM (558).

PMO	TWO	Resultant probability of exactly ZERO mines left, located at IDUM (557).
PS(J), J=1,50	TWO	Probability of survival on trial J, located at IDUM (608).
NIT	TWO	Iterations completed, located at IDUM (633).

d. Logical flow (Figure IV-7-B-51).

(1) Block 1. If the desired iteration counter (IT) is not greater than 25, transfer to block 3.

(2) Block 2. Set iteration counter to 25.

(3) Block 3. Initialize variables.

(4) Block 4. Begin loop (A1) on the number of iterations (IT).

(5) Block 5. Increment the number of iterations (IT) which have been completed.

(6) Block 6. Calculate the probability (PS) that the breaching vehicle will survive through the field. For this calculation use C(J) (probability of one breaching vehicle surviving encounter with one mine).

(7) Block 7. Calculate the probability (PMO) that there will be no mines left after the breaching vehicle encounters the minefield. For this calculation also use C and S.

(8) Block 8. Calculate the probability (PM(K)) that there will be exactly K mines left after the breaching. vehicle encounters the minefield. This calculation requires C, S, and NC (maximum number of mines present).

(9) Block 9. If the number of iterations desired is 1, RETURN to calling routine.

(10) Block 10. If the probability of exactly ZERO mines left (PMO) is essentially 1, RETURN to calling routine.

(11) Block 11. Reset the required control variable for the next iteration.

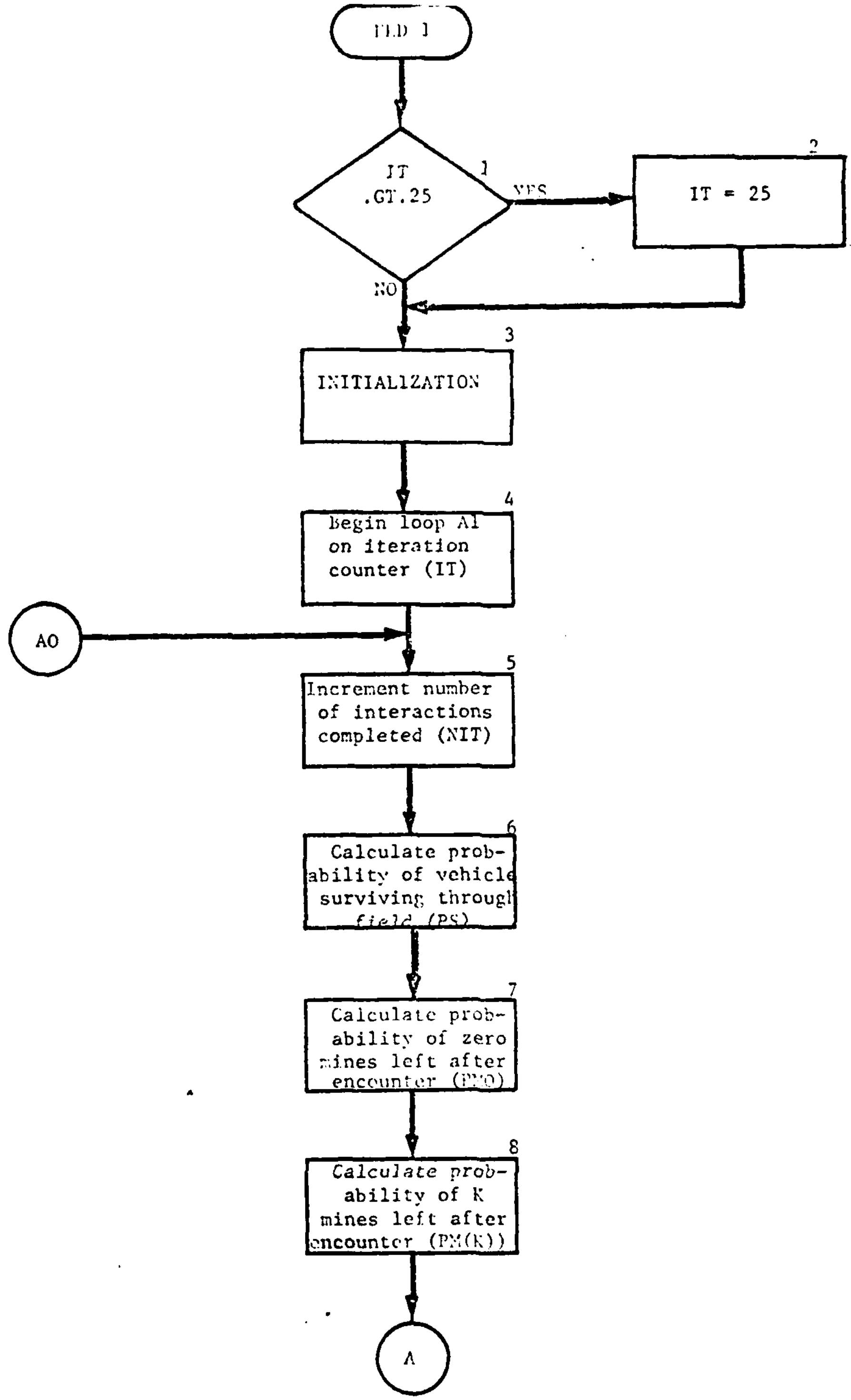
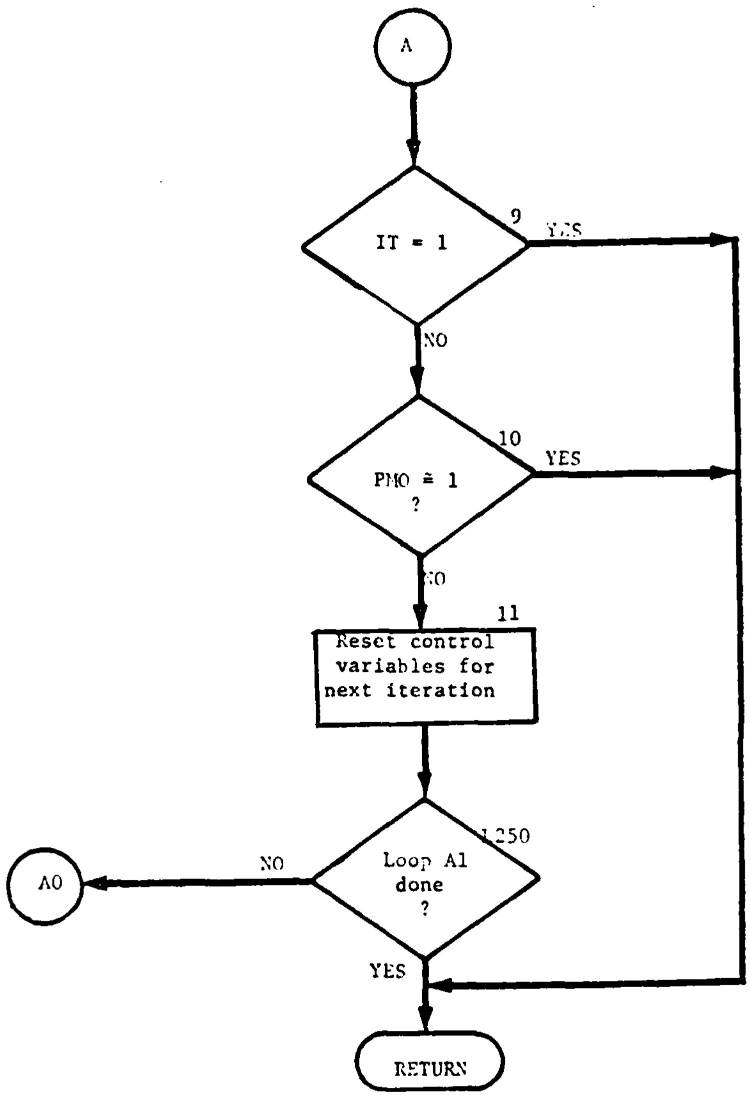


Figure IV-7-B-51. Routine FLD 1.


A
IT = 1
9
YES
NO
PMO = 1
?
10
YES
NO
11
Reset control
variables for
next iteration
1250
Loop A1
done
?
NO
A0
YES
RETURN

(12) Block L250. If the loop (A1) is not done, transfer to block 5. If loop is done, RETURN to calling routine.

52. ROUTINE FLD2

a. Purpose. FLD2 is the "in-field" calculation routine which handles the case where there is direct fire, but there is no countermeasure item.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
CM(J),J=1,50	TWO	Probability of exactly J mines in a path, located at IDUM (502).
CMO	TWO	Probability of ZERO mines, located at IDUM (501).
S	TWO	Probability of one breaching vehicle surviving encounter with one mine, located at IDUM (552).
NCO	TWO	Maximum value of J to use, located at IDUM (556).
IT	CALL	Iteration counter.
RO	TWO	Probability of vehicle surviving direct fires over the field, located at IDUM (555).

c. Output Variables:

Name	Destination	Contents
PM(J),J=1,50	TWO	Resultant probability of exactly J mines left after breach attempt, located at IDUM (558).
PMO	TWO	Probability of exactly ZERO mines left, located at IDUM (557).
PS(J),J=1,25	TWO	Probability of vehicle surviving on trial J, located at IDUM (608).
NIT	TWO	Iterations completed, located at IDUM (633).

d. Logical flow (Figure IV-7-B-52)

(1) Block 1. If the desired iteration counter (IT) is not greater than 25, transfer to block 3.

(2) Block 2. Set the iteration counter to 25.

(3) Block 3. Initialize variables.

(4) Block 4. Calculate the probability (R(J)) of survival up to mine J.

(5) Block 5. Begin loop (A1) on the number of iterations (IT).

(6) Block 6. Increment the number of iterations which have been completed (NIT).

(7) Block 7. Calculate the probability (PS) that the breaching vehicle will survive through the field. For this calculation use C(J) (probability of J mines initially and S).

(8) Block 8. Calculate the probability (PMO) that there will be ZERO mines left after the encounter. For this calculation use C, R, and S.

(9) Block 9. Calculate the probability (PM(K)) that there will be exactly K mines left after the breaching vehicle encounters the minefield. This calculation requires C, R, S, and NC (maximum number of mines).

(10) Block 10. If only one iteration is required, RETURN to calling routine.

(11) Block 11. If the probability of exactly ZERO mines left (PMO) is essentially 1, (greater than or equal to .99999), RETURN to calling routine.

(12) Block 12. Reset the required control variables for the next iteration.

(13) Block L250. If loop (A1) is not done, transfer to block 6. If loop (A1) is done, RETURN to the calling routine.

53. ROUTINE FLD3

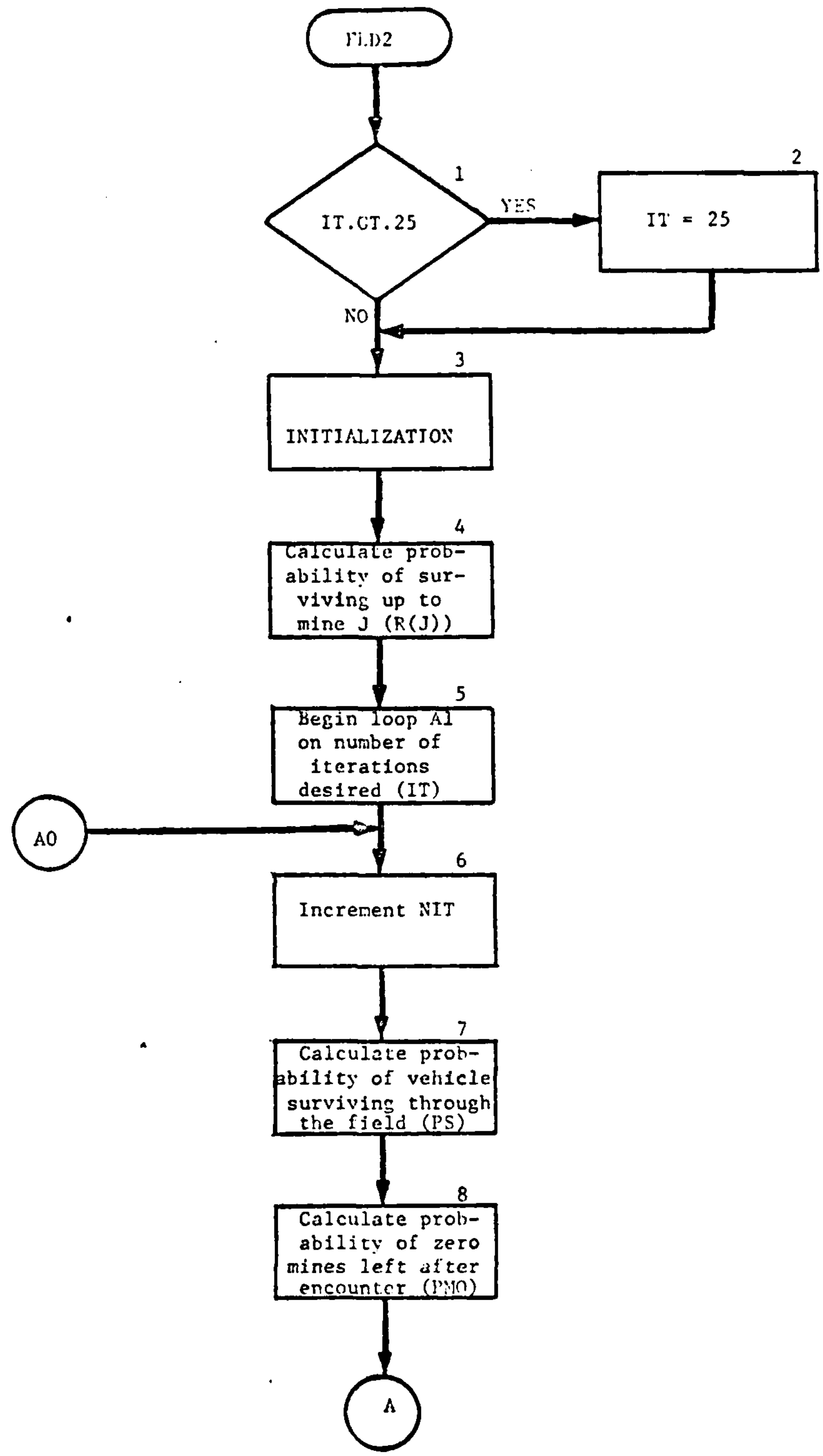
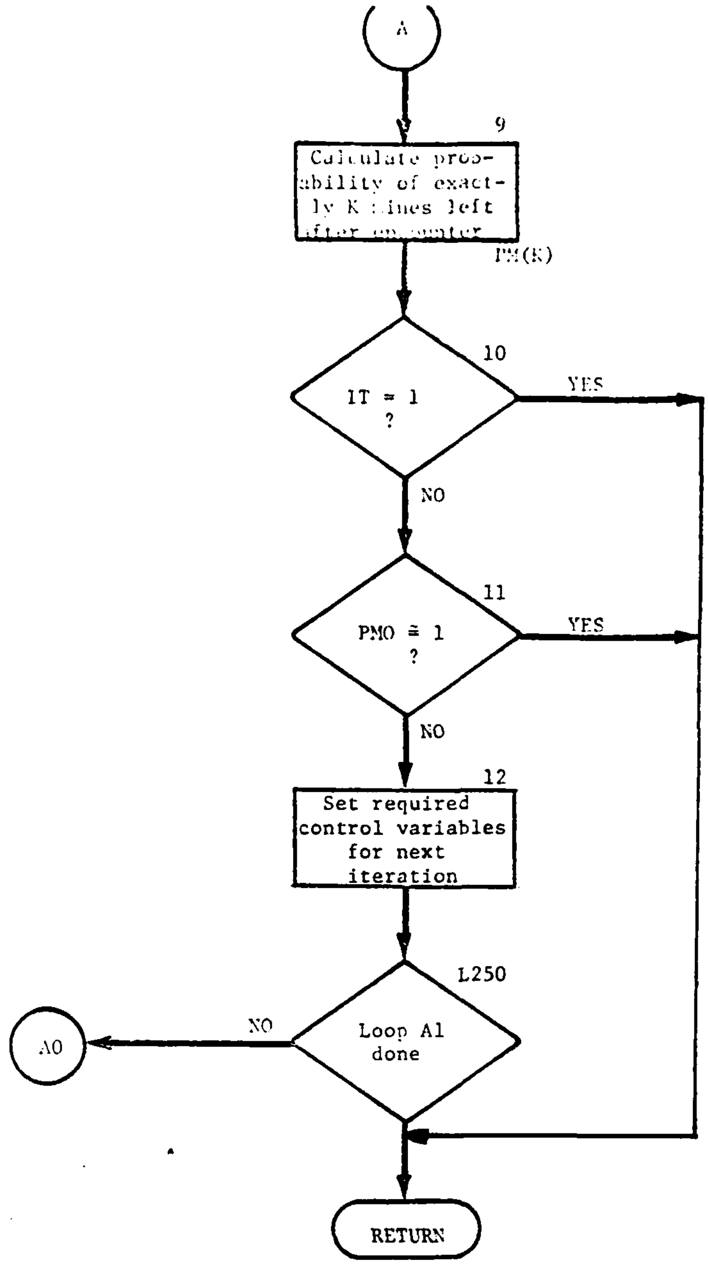


Figure IV-7-B-52. Routine FLD2.


A
9
Calculate probability of exactly K mines left after encounter
PM(K)
10
IT = 1
?
YES
NO
11
PMO ≅ 1
?
YES
NO
12
Set required control variables for next iteration
L250
Loop A1 done
NO
A0
RETURN

a. Purpose. FLD3 is the "in field" calculation routine which handles the case where there is no direct fire, but there is a countermeasure item.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
CM(J),J=1,50	TWO	Probability of exactly J mines in a path, located at IDUM (502).
CMO	TWO	Probability of exactly ZERO mines, located at IDUM (501).
S	TWO	Probability of one breaching vehicle surviving encounter with one mine, located at IDUM (552).
NCO	TWO	Maximum value of J to use, located at IDUM (556).
IT	CALL	Iteration counter.
D	TWO	Probability of countermeasure negating the mine with no damage to the countermeasure, located at IDUM (553).
E	TWO	Probability of countermeasure negating the mine with loss of the countermeasure located at IDUM (554).

c. Output Variables:

Name	Destination	Contents
PM(J),J=1,50	TWO	Resultant probability of exactly J mines left after breach attempt, located at IDUM (558).
PMO	TWO	Probability of exactly ZERO mines left, located at IDUM (557).
PS(J),J=1,25	TWO	Probability of vehicle surviving on trial J, located at IDUM (608).
PST(J),J=1,25	TWO	Probability of vehicle and countermeasure surviving on trial J, located at IDUM (634).

NIT	TWO	Iterations completed, located at IDUM (633).

d. Logical Flow (Figure IV-7-B-53).

(1) Block 1. If the desired iteration counter (IT) is not greater than 25, transfer to block 3.

(2) Block 2. Set iteration counter (IT) to 25.

(3) Block 3. Calculate the probability (F) that the countermeasure, given that there is a countermeasure, will negate the mine.

(4) Block 4. Calculate the probability (U(N)) that the breaching vehicle will survive exactly N encounters.

(5) Block 5. Calculate the probability (T(N)) that the breaching vehicle will be lost on the Nth encounter.

(6) Block 6. Initialize variables.

(7) Block 7. Begin loop (A1) on the number of iterations (IT).

(8) Block 8. Increment the number of iterations which have been completed (NIT).

(9) Block 9. Calculate the probability (PST(I)) that the breaching vehicle and the countermeasure item will survive. This calculation requires C, U, and NC (maximum number of mines).

(10) Block 10. Calculate the probability (PS(I)) that the breaching vehicle will survive. This calculation requires C, U, and NC.

(11) Block 11. Calculate the probability (PMO) that there will be exactly ZERO mines left after the breach attempt. This calculation requires C and U.

(12) Block 12. Calculate the probability (PM(K)) that there will be exactly K mines left after the breach attempt. This calculation requires C, T, and NC.

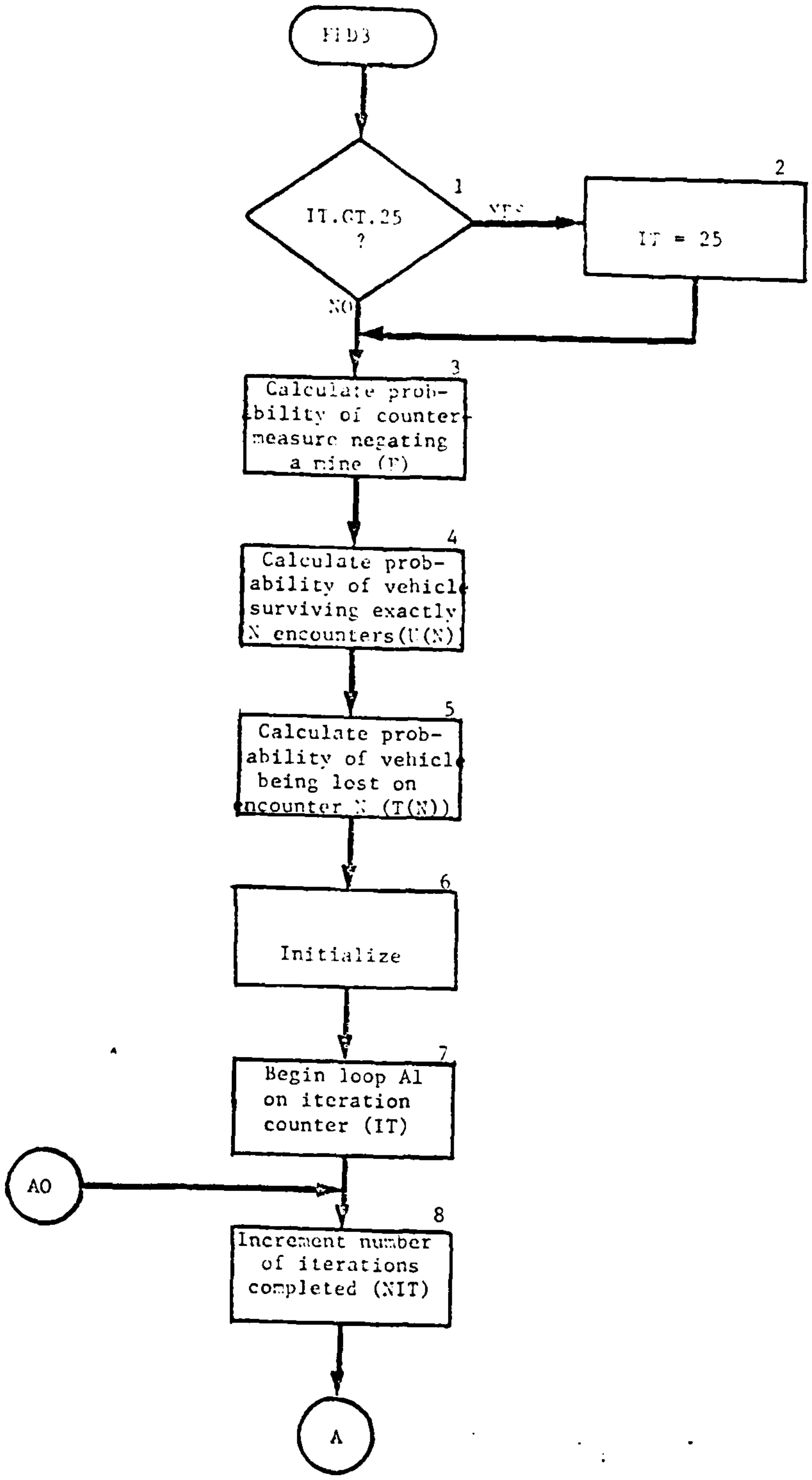
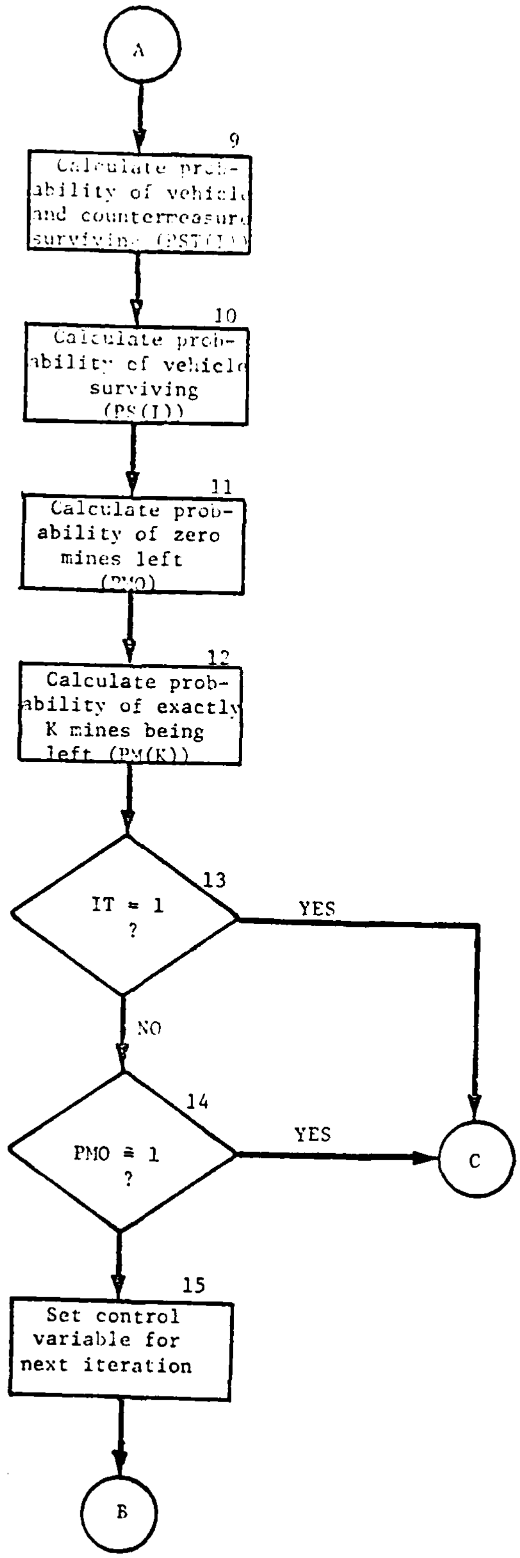
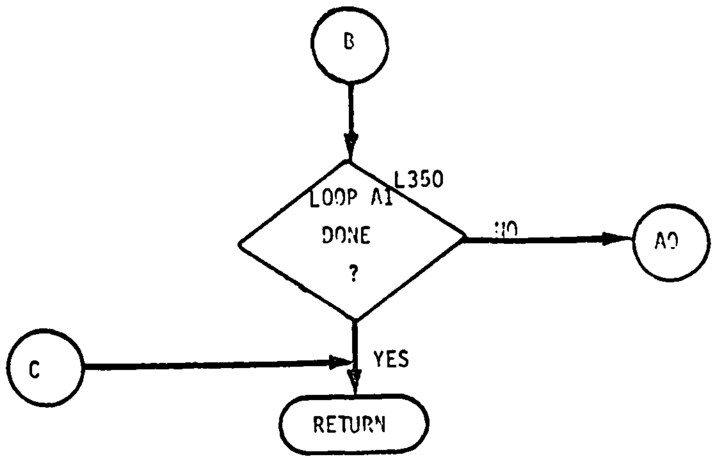


Figure IV-7-B-53. Routine FLD3.


A
9
Calculate probability of vehicle and countermeasure surviving (PST(I))
10
Calculate probability of vehicle surviving (PS(I))
11
Calculate probability of zero mines left (PMO)
12
Calculate probability of exactly K mines being left (PM(K))
13
IT = 1 ?
YES
NO
14
PMO ≅ 1 ?
YES
C
15
Set control variable for next iteration
B


B
L350
LOOP A1
DONE
?
NO
A0
C
YES
RETURN

(13)	Block 13.	If the number of iterations required is 1, RETURN to the calling routine.
(14)	Block 14.	If the probability (PMO) of ZERO mines left is essentially 1 (greater than or equal to .99999), RETURN to the calling routine.
(15)	Block 15.	Reset the required control variables for the next iteration.
(16)	Block L350.	If loop (A1) is not done, transfer to block 8. If loop (A1) is done, RETURN to the calling routine.

54. ROUTINE FLD4

a. Purpose. FLD4 is the "in field" calculation routine which handles the case where there is direct fire and a countermeasure item.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
CM(J),J=1,50	TWO	Probability of exactly J mines in a path, located at IDUM (502).
CMO	TWO	Probability of ZERO mines, located at IDUM (501).
S	TWO	Probability of one breaching vehicle surviving encounter with one mine, located at IDUM (552).
RO	TWO	Probability of vehicle 2 surviving direct fires over the field, located at IDUM (555).
NCO	TWO	Maximum value of J to use, located at IDUM (556).
IT	CALL	Iteration counter.
D	TWO	Probability of countermeasure negating the mine with no damage to the countermeasure, located at IDUM (553).

E	TWO	Probability of countermeasure negating the mine with loss of the countermeasure located at IDUM (554).

c. Output Variables:

Name	Destination	Contents
PM(J),J=1,50	TWO	Resultant probability of exactly J mines left after breach attempt, located at IDUM (558).
PMO	TWO	Probability of exactly ZERO mines left, located at IDUM (557).
PS(J),J=1,25	TWO	Probability of vehicle surviving on trial J, located at IDUM (608).
PST(J),J=1,25	TWO	Probability of vehicle and countermeasure surviving on trial J, located at IDUM (634).
NIT	TWO	Iterations completed, located at IDUM (633).

d. Logical Flow (Figure IV-7-B-54).

(1) Block 1. If the desired iteration counter (IT) is not greater than 25, transfer to block 3.

(2) Block 2. Set iteration counter (IT) to 25.

(3) Block 3. Initialize variables.

(4) Block 4. Calculate the probability (R(J)) that the breaching vehicle survives up to mine J. RO is required for this calculation.

(5) Block 5. Calculate the probability (F) that the countermeasure, given that there is a countermeasure, will negate the mine.

(6) Block 6. Calculate the probability (U(N)) that the breaching vehicle will survive N encounters. This calculate requires S, F, D, and NC (maximum number of mines).

(7) Block 7. Calculate the probability (T(N)) that the breaching vehicle will be lost on the Nth encounter. This calculation requires S,F,E, and NC.

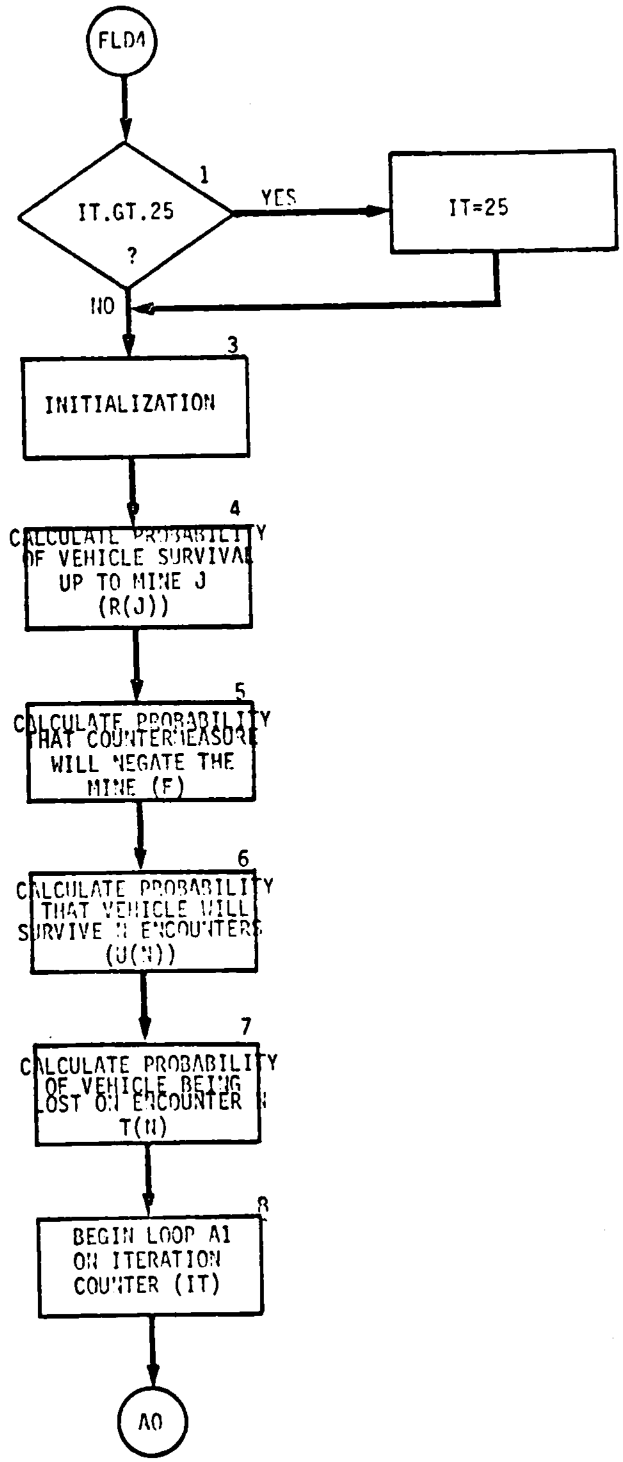
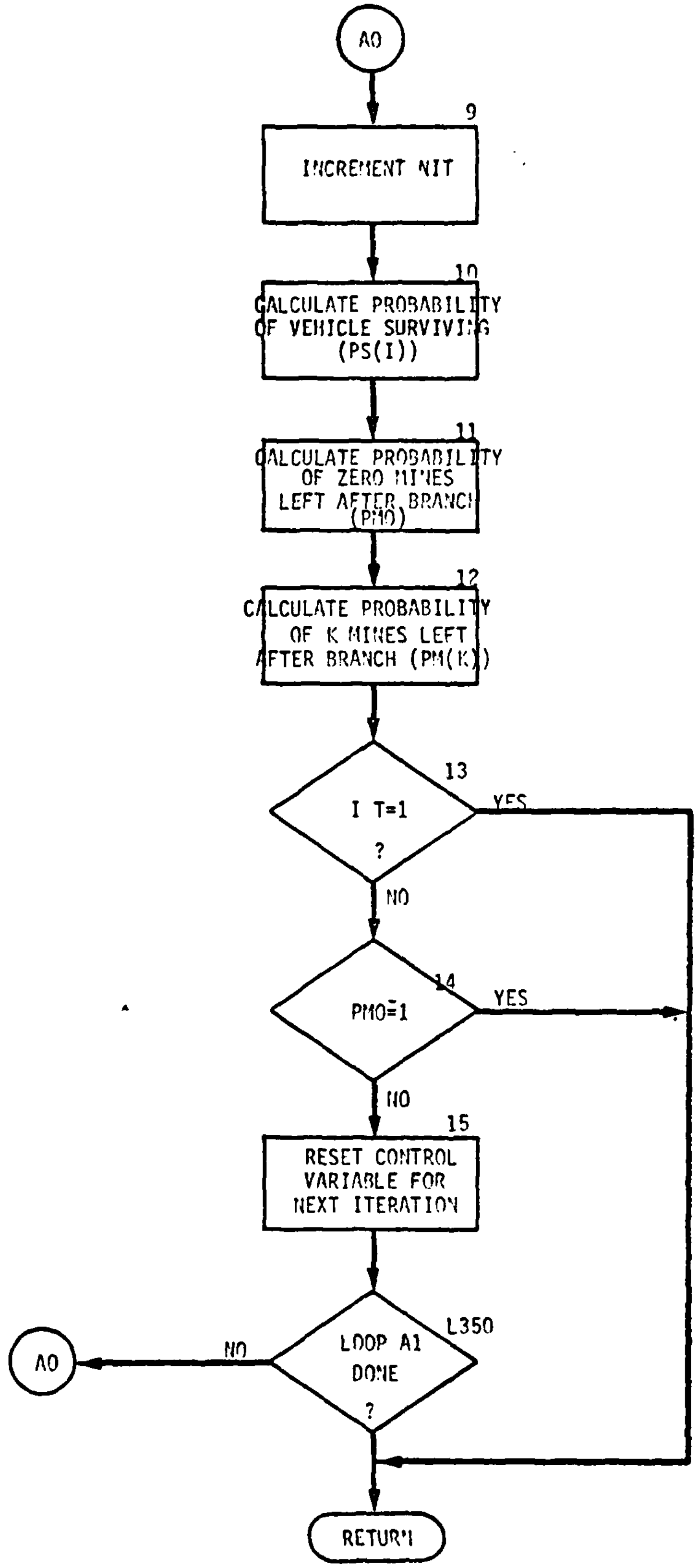


FIGURE IV-7-B-54 ROUTINE FLD4


A0
9
INCREMENT NIT
10
CALCULATE PROBABILITY OF VEHICLE SURVIVING (PS(I))
11
CALCULATE PROBABILITY OF ZERO MINES LEFT AFTER BRANCH (PM0)
12
CALCULATE PROBABILITY OF K MINES LEFT AFTER BRANCH (PM(K))
13
I T=1 ?
YES
NO
14
PM0=1
YES
NO
15
RESET CONTROL VARIABLE FOR NEXT ITERATION
L350
LOOP A1 DONE ?
NO
A0
RETURN

(8)	Block 8.	Begin loop (A1) on the iteration counter (IT).
(9)	Block 9.	Increment the number of iterations completed (NIT).
(10)	Block 10.	Calculate the probability (PS(I)) that the breaching vehicle will survive. This calculation requires C, U, and NC.
(11)	Block 11.	Calculate the probability (PMO) that there will be exactly ZERO mines left after the breach attempt. This calculation requires C, U, and R.
(12)	Block 12.	Calculate the probability (PM(K)) that there will be exactly K mines left after the breach attempt. This calculation requires C, T, and NC.
(13)	Block 13.	If the number of iterations required is 1, RETURN to the calling routine.
(14)	Block 14.	If the probability (PMO) of ZERO mines left is essentially 1 (greater than or equal to .99999), RETURN to the calling routine.
(15)	Block 15.	Reset the required control variables for the next iteration.
(16)	Block L350.	If loop (A1) is not done, transfer to block 9. If loop (A1) is done, RETURN to the calling routine.

55. ROUTINE VSET

a. Purpose. VSET sets up required data for the minefield breach attempt.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
MNDTA(20,10)	DF33	Countermine data located at IDUM (1001).
SZE(20,3)	DF33	Track and belly widths for encountering and breaching vehicles, located at IDUM (1201).

VVUL(20,30)	DF33	Probability of kill given detonation at the belly and given detonation at the track for encountering and breaching vehicles, located at IDUM (1261).
CMVUL(20,15)	DF33	Countermeasure vulnerability data, located at IDUM (1861).
IOF(70)	CALL	Minefield data.
IVEH	CALL	Item code of the breaching vehicle.
ICM	CALL	Item code of the countermeasure item.
IBFCD	CALL	Countermeasure control flag.
MODSNS	DF16	Day/night indicator.

c. Output Variables:

Name	Destination	Contents
LWIDTH	CALL	Breaching vehicle total width.
D	TWO	Probability that countermeasure will survive mine encounter, located at IDUM (553).
E	TWO	Probability that the countermeasure will not survive the mine encounter, located at IDUM (554).
IBFCD	CALL	Countermeasure control flag.
S	TWO	Probability that the breaching vehicle will survive, located at IDUM (552).

d. Logical Flow (Figure IV-7-B-55).

(1) Block 1. Determine the Red/Blue indices required for File 33 access.

(2) Block 2. Call routine GETRCD to obtain the countermine data (MNDTA) from Data File 33.

(3) Block 3. Call routine GETRCD to obtain the size of breaching vehicles (SZE) from Data File 33.

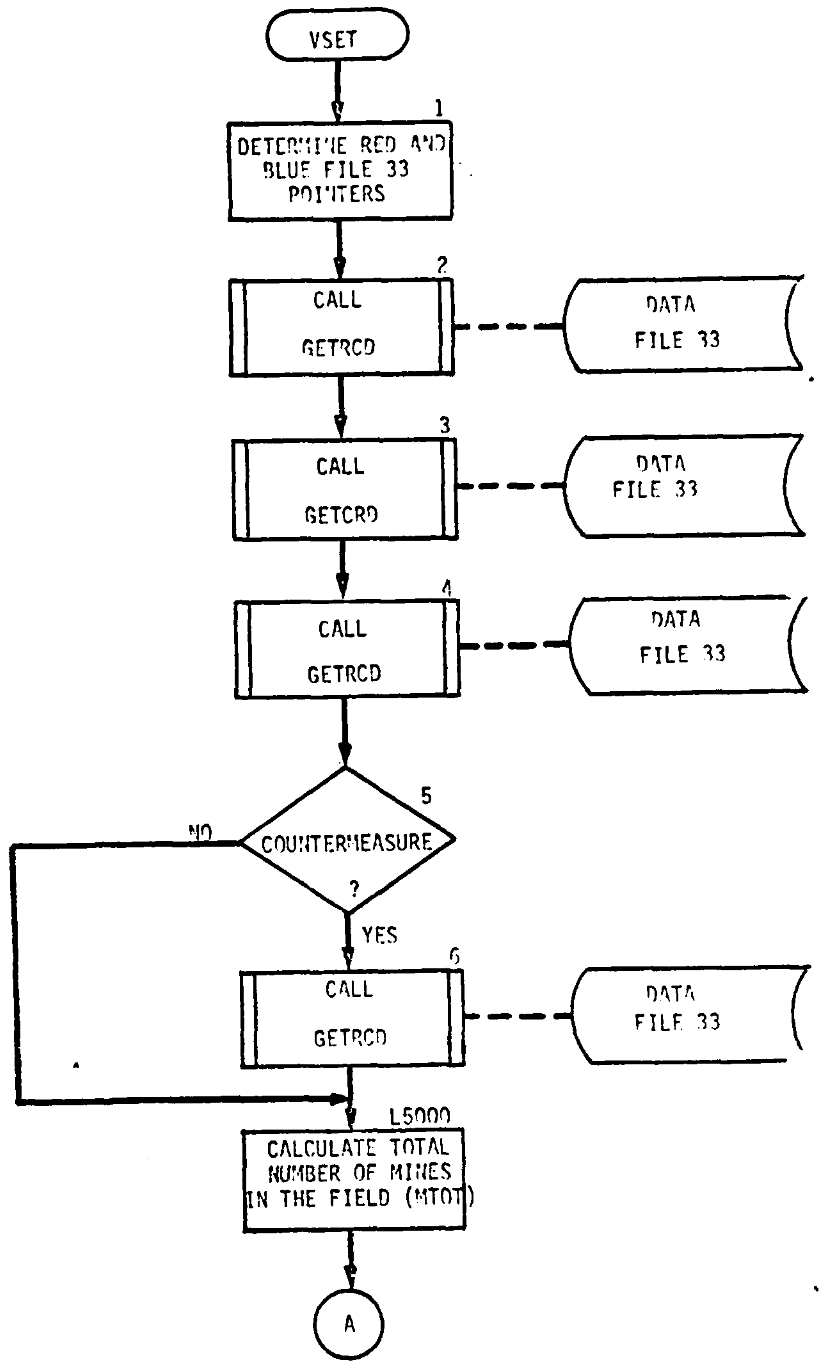
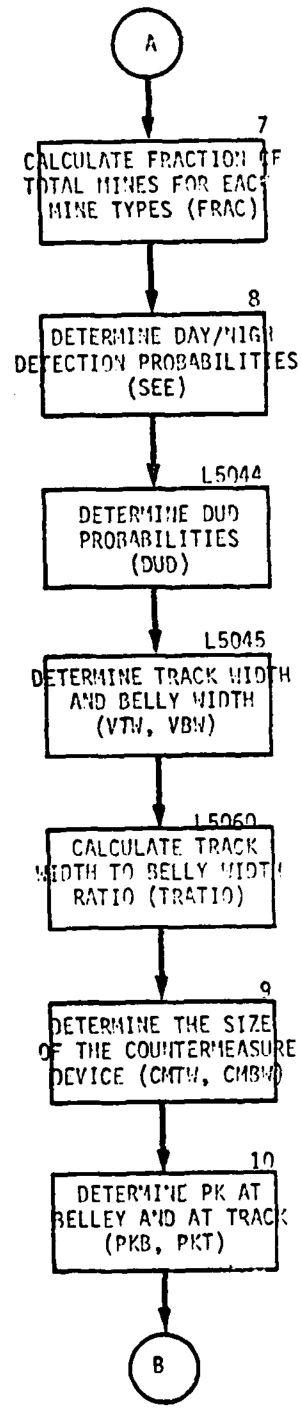
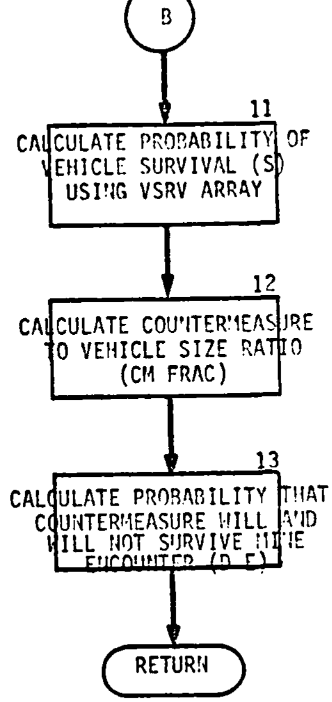


FIGURE IV-7-B-55 ROUTINE VSET


A
7
CALCULATE FRACTION OF TOTAL MINES FOR EACH MINE TYPES (FRAC)
8
DETERMINE DAY/NIGHT DETECTION PROBABILITIES (SEE)
L5044
DETERMINE DUD PROBABILITIES (DUD)
L5045
DETERMINE TRACK WIDTH AND BELLY WIDTH (VTW, VBW)
L5060
CALCULATE TRACK WIDTH TO BELLY WIDTH RATIO (TRATIO)
9
DETERMINE THE SIZE OF THE COUNTERMEASURE DEVICE (CMTW, CMBW)
10
DETERMINE PK AT BELLEY AND AT TRACK (PKB, PKT)
B


B
11
CALCULATE PROBABILITY OF VEHICLE SURVIVAL (S) USING VSRV ARRAY
12
CALCULATE COUNTERMEASURE TO VEHICLE SIZE RATIO (CM FRAC)
13
CALCULATE PROBABILITY THAT COUNTERMEASURE WILL AND WILL NOT SURVIVE MINE
RETURN

(4) Block 4. Call routine GETRCD to obtain breaching vehicle vulnerability data (VVUL) from Data File 33.

(5) Block 5. If there is no countermeasure item, transfer to block L5000.

(6) Block 6. Call routine GETRCD to obtain the countermeasure vulnerability data (CMVUL) from Data File 33.

(7) Block L5000. Calculate the total number of mines in the minefield (MTOT).

(8) Block 7. Calculate for each mine type the fraction of the total number of mines (MTOT) that are that type of mine (FRAC).

(9) Block 8. Determine the day/night detection probabilities (SEE).

(10) Block L5044. Determine the probability that a mine is a dud (DUD).

(11) Block L5045. Determine the track width and belly width of the breaching vehicle (VTW, VBW).

(12) Block L5060. Calculate the track width to belly width ratio (TRATIO).

(13) Block 9. Determine the size of the countermeasure device (CMTW, CMBW).

(14) Block 10. Determine the probability of kill given detonation at the track (PKT) and given detonation at the belly (PKB).

(15) Block 11. Calculate the probability of the breaching vehicle surviving (S). Intermediate values (VSRV) are required for this calculation.

(16) Block 12. Calculate the countermeasure to breaching vehicle size ratio (CMFRAC).

(17) Block 13. Calculate the probability that countermeasure will sirvive the mine encounter (D) and that the countermeasure will not survive the mine encounter (E). Intermediate values (PDCM, PECM, and ADJST) are required for this calculation. RETURN to the calling routine.

56. ROUTINE TROUBL

a. Purpose. TROUBL handles the case where the breach/force action must be halted because of material shortages. If another option exists, TROUBL will set up that option; otherwise it sets up a withdraw from the field.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
IDBP	TWO	Option number and number of options tried (PACKED), located at IDUM (5).
ITBL(5,10)	DF39	Countermine decision table.
CMDTA(20,30)	DF39	Countermine data.
IFREE	TWO	Number of free paths, located at IDUM (13).
LS	TWO	Number of lanes sufficient, located at IDUM (11).
LO	TWO	Number of lanes open, located at IDUM (12).

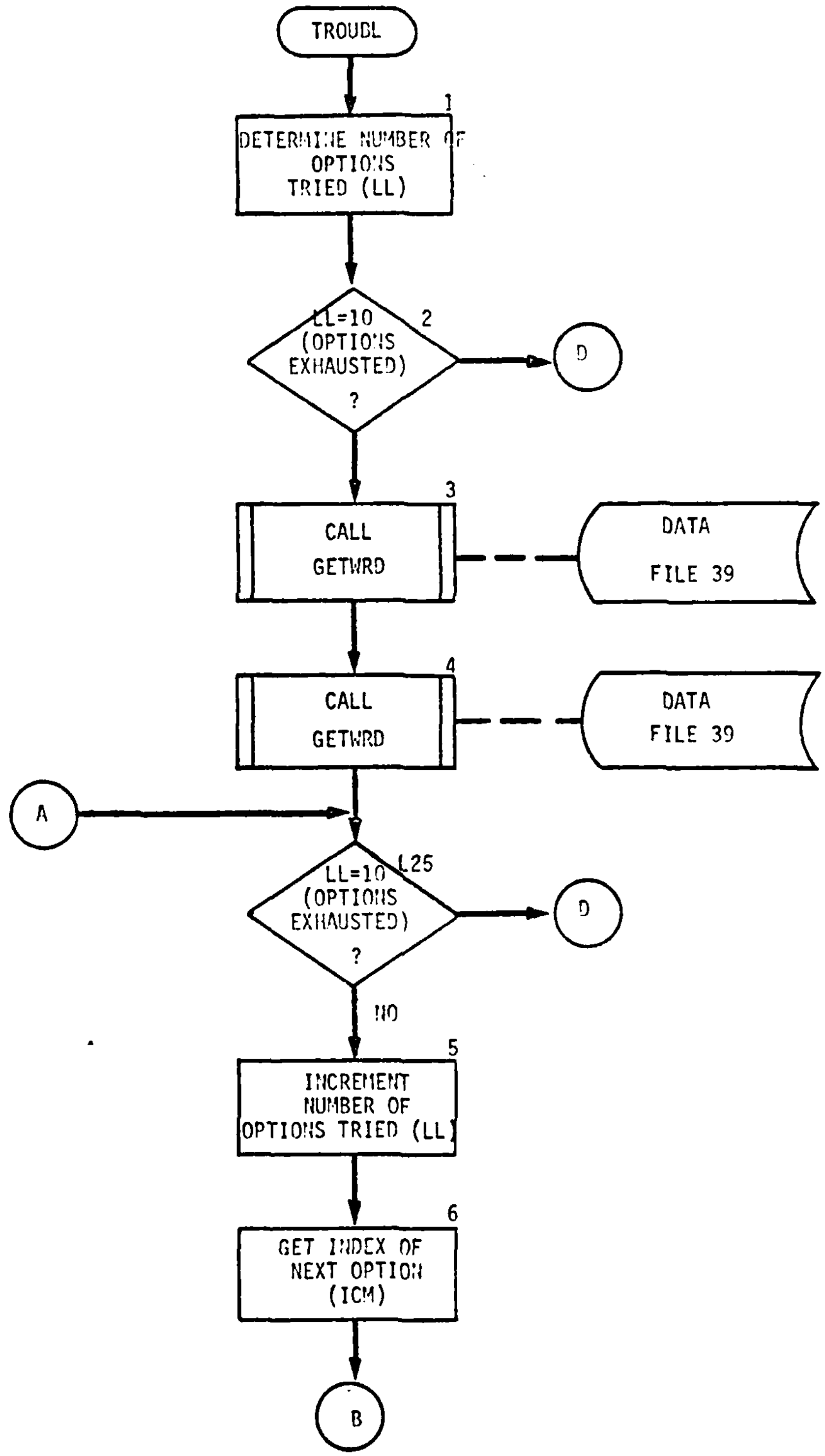
c. Other Variables:

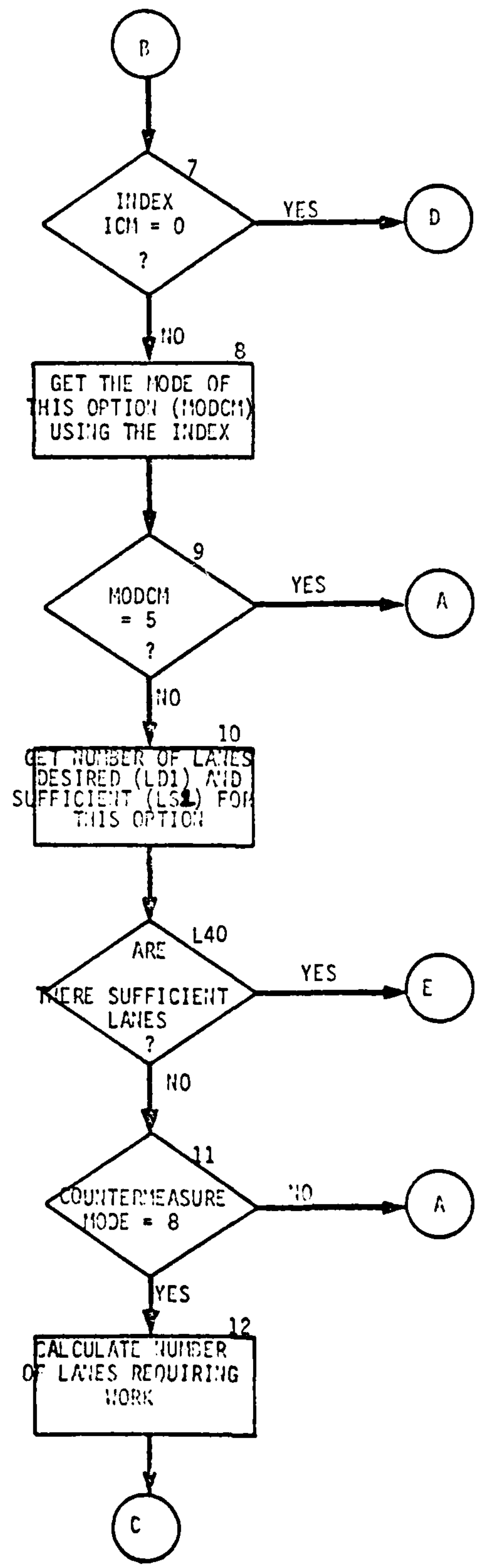
Name	Destination	Contents
M	CALL	Mode of the next event.
TSKED	CALL	Time till the next event.
IDBP	TWO	Option number of number of options tried (PACKED), located at IDUM (5).
RDUM(30)	TWO	Data required for next event.

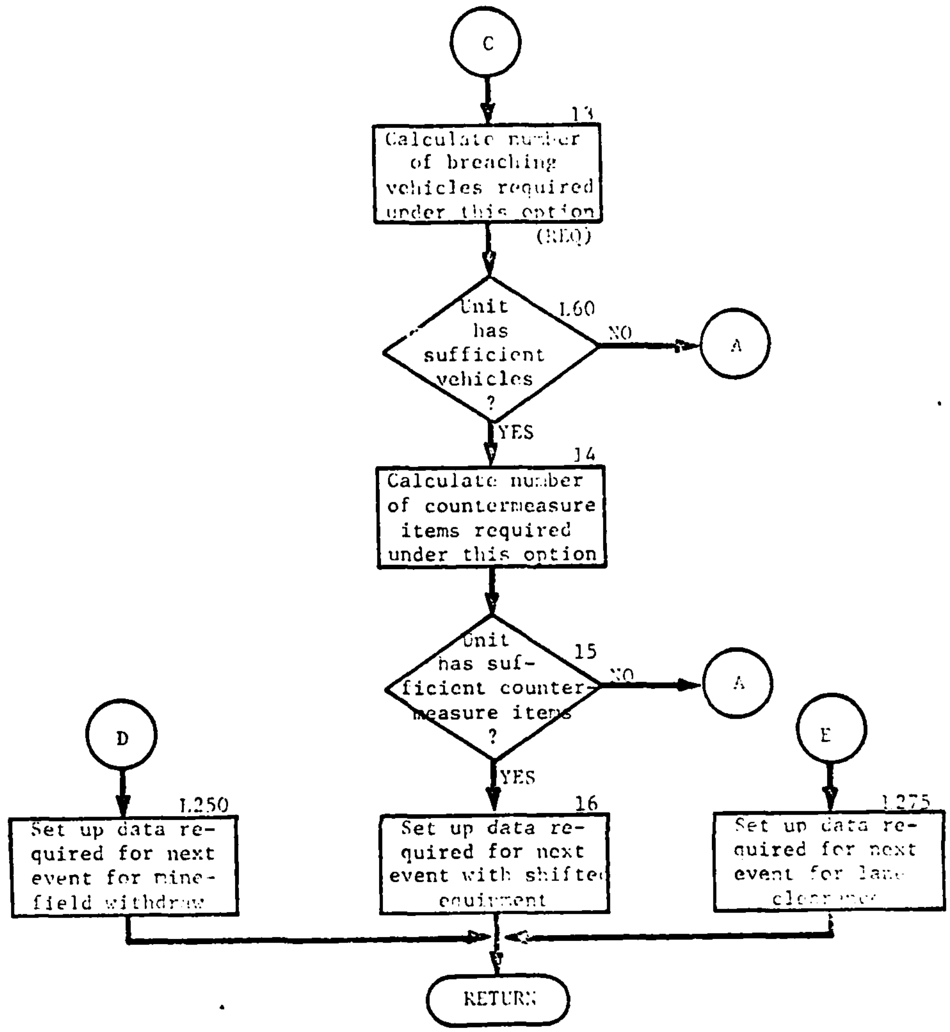
d. Logical Flow (Figure IV-7-B-56).

(1) Block 1. Determine the number of options tried.

(2) Block 2. Have all the options been tried (LL=10)? If so, transfer to block L250.


TROUBL
1
DETERMINE NUMBER OF
OPTIONS
TRIED (LL)
LL=10
(OPTIONS
EXHAUSTED)
?
2
D
3
CALL
GETWRD
DATA
FILE 39
4
CALL
GETWRD
DATA
FILE 39
A
LL=10
(OPTIONS
EXHAUSTED)
?
L25
D
NO
5
INCREMENT
NUMBER OF
OPTIONS TRIED (LL)
6
GET INDEX OF
NEXT OPTION
(ICM)
B


B
7
INDEX ICM = 0 ?
YES
D
NO
8
GET THE MODE OF THIS OPTION (MODCM) USING THE INDEX
9
MODCM = 5 ?
YES
A
NO
10
GET NUMBER OF LANES DESIRED (LD1) AND SUFFICIENT (LS1) FOR THIS OPTION
L40
ARE THERE SUFFICIENT LANES ?
YES
E
NO
11
COUNTERMEASURE MODE = 8
NO
A
YES
12
CALCULATE NUMBER OF LANES REQUIRING WORK
C


C
13
Calculate number of breaching vehicles required under this option
(REQ)
Unit has sufficient vehicles ?
1.60
NO
A
YES
14
Calculate number of countermeasure items required under this option
Unit has sufficient countermeasure items ?
15
NO
A
YES
D
1.250
Set up data required for next event for minefield withdraw
16
Set up data required for next event with shifted equipment
E
1.275
Set up data required for next event for lane clearance
RETURN

(3) Block 3. Call routine GETWRD to obtain the countermeasure decision table from Data File 39.

(4) Block 4. Call routine GETWRD to obtain required countermeasure data from Data File 39.

(5) Block L25. If all the options have been tried (LL=10), transfer to block L250.

(6) Block 5. Increment the number of options tried (LL).

(7) Block 6. Get the table index (ICM) of the next option.

(8) Block 7. If this index (ICM) is ZERO, transfer to block L250.

(9) Block 8. Using this index (ICM), get the countermeasure mode (MODCM) of this option.

(10) Block 9. If the countermeasure mode of this option is 5, transfer to block L25.

(11) Block 10. Get the number of lanes desired (LD1) and the number of land sufficient (LS1) for this option.

(12) Block L40. Are there now sufficient lanes for passage? If so, transfer to block L275.

(13) Block 11. If the countermeasure mode is not 8, transfer to block L25.

(14) Block 12. Calculate the number of lanes that require work for passage.

(15) Block 13. Calculate the number of breaching vehicles required under this option (REQ).

(16) Block L60. Does this unit have sufficient breaching vehicles? If not, transfer to block L25.

(17) Block 14. Calculate the number of countermeasure items is required under this option.

(18) Block 15. Does this unit have sufficient countermeasure items? If not, transfer to block L25.

(19) Block 16. Set up the data required for the next event with the shifted breach equipment. RETURN to the calling routine.

(20) Block L250. Set up the data required for the next event for minefield withdraw. RETURN to the calling routine.

(21) Block L275. Set up the data required for the next event for lane clearance. RETURN to the calling routine.

57. ROUTINE EXEC8.

a. Purpose. EXEC8 controls the flow through various mine counteraction routines. EXEC8 gets the appropriate data, calling the processing routine, and sets up the next GCM event.

b. Input Variables.

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
IDUM(512)	DF21	GCM barrier encounter data.
INRUPT	TWO	Interrupted actions flag, located at IDUM (4100).

c. Output Variables.

Name	Destination	Contents
ITBL(16,4)	TWO	GCM Battle Control Table, located at IDUM (4035).
IDUM(512)	DF21	GCM barrier encounter data.

d. Logical Flow (Figure IV-7-B-57).

(1) Block 1. Call routine GETRCD to get the GCM barrier encounter data from Data File 21 and place it in IDUM.

(2) Block 2. If not delayed by a pure delay barrier, transfer to block 4.

(3) Block 3. Call routine STALL to determine whether time delay at the pure delay barrier has expired. Transfer to block L75.

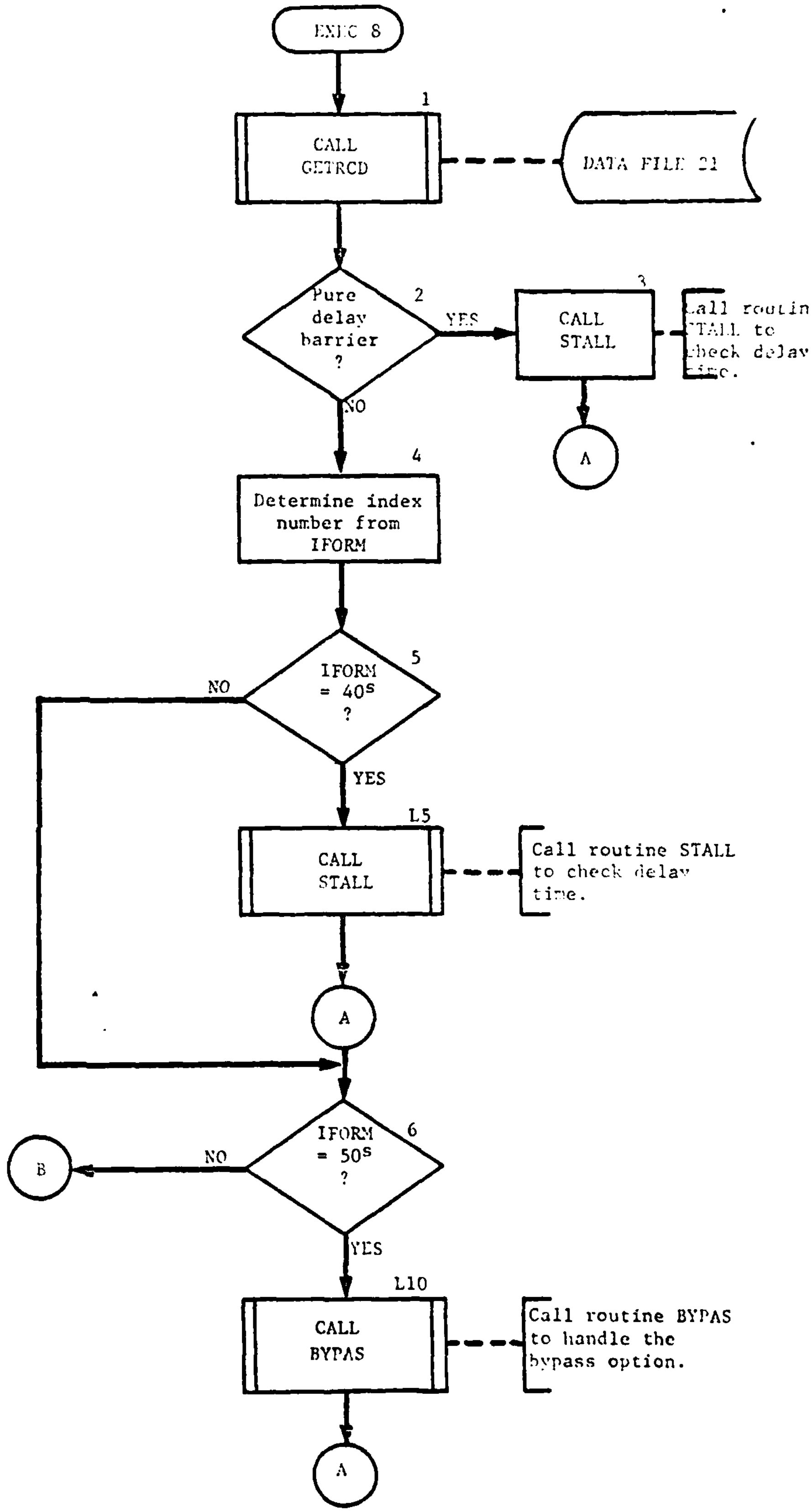
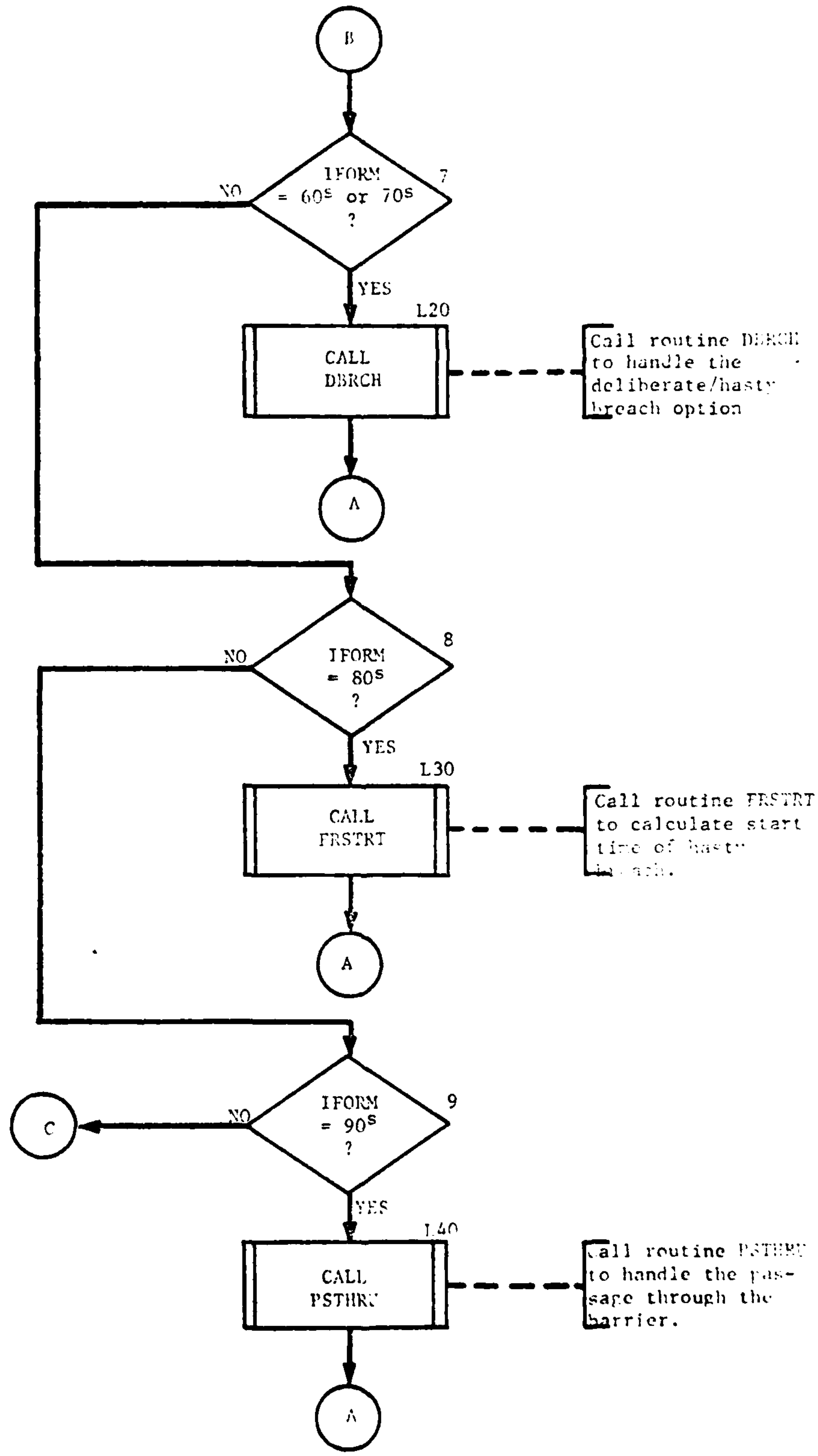
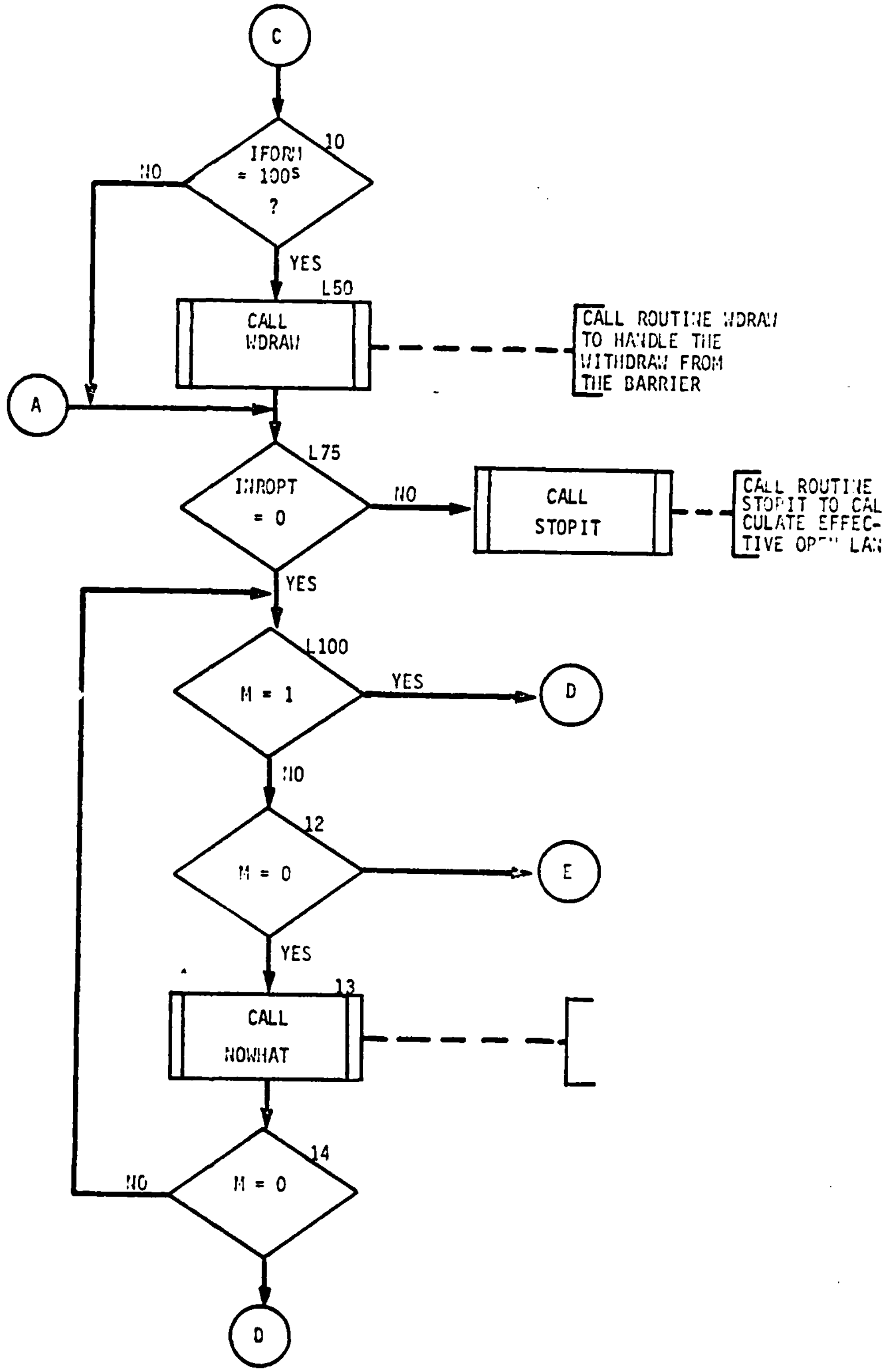
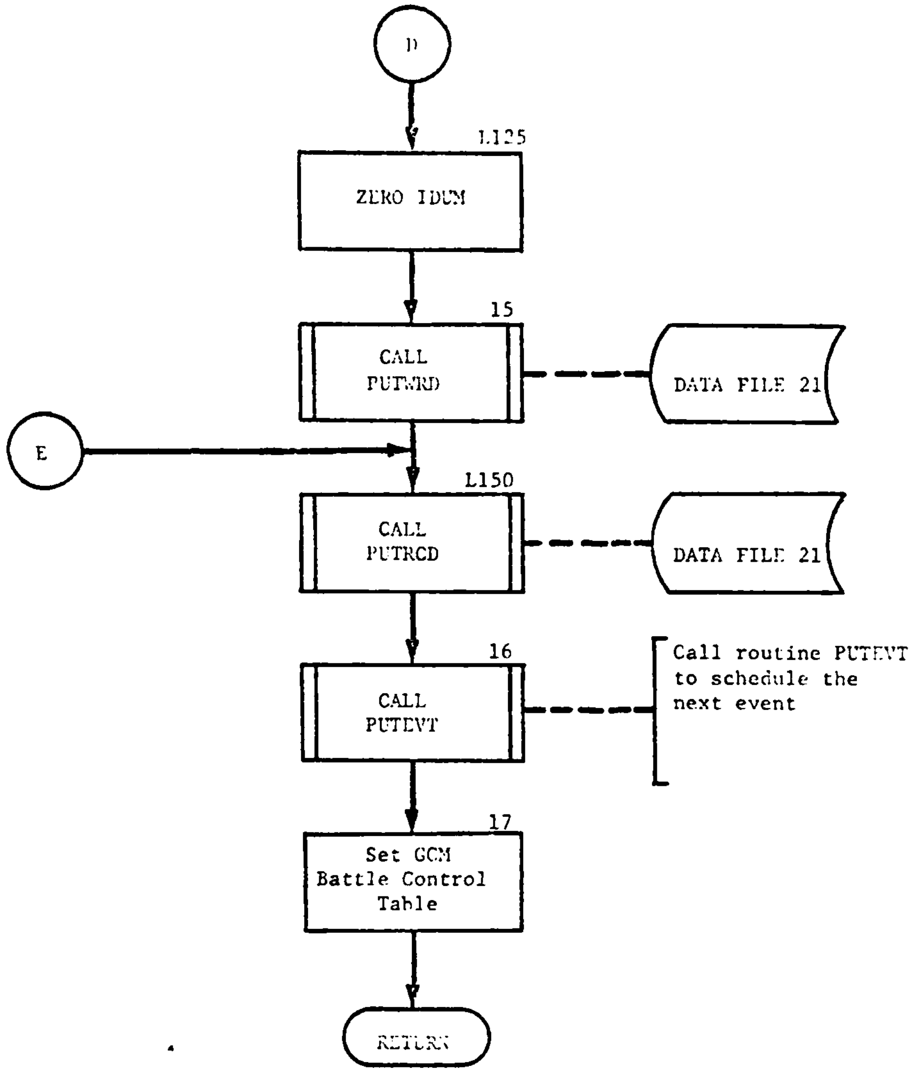


Figure IV-7-B-57. Routine EXEC8.


B
IFORM = 60s or 70s ?
7
NO
YES
L20
CALL DBRCH
to handle the
deliberate/hasty
breach option
A
IFORM = 80s ?
8
NO
YES
L30
CALL FRSTRT
Call routine FRSTRT
to calculate start
A
IFORM = 90s ?
9
NO
C
YES
L40
CALL PSTHRU
to handle the pas-
sage through the
barrier.
A



C
IFORM = 100s ?
10
NO
YES
L50
CALL WDRAW
CALL ROUTINE WDRAW TO HANDLE THE WITHDRAW FROM THE BARRIER
A
L75
INROPT = 0
NO
CALL STOPIT
CALL ROUTINE STOPIT TO CALCULATE EFFECTIVE OP
YES
L100
M = 1
YES
D
NO
12
M = 0
E
YES
13
CALL NOWHAT
14
NO
M = 0
D


D
L125
ZERO IDUM
15
CALL
PUTWRD
DATA FILE 21
E
L150
CALL
PUTRCD
DATA FILE 21
16
CALL
PUTEVT
Call routine PUTEVT
to schedule the
next event
17
Set GCM
Battle Control
Table
RETURN

(4) Block 4. Determine the index number (I) from IFORM.

(5) Block 5. If IFORM is not in the 40's, transfer to block 6.

(6) Block L5. Call routine STALL to check for delay time expiration. Transfer to block L75.

(7) Block 6. If IFORM is not in the 50's, transfer to block 7.

(8) Block L10. Call routine BYPAS to handle the bypass around the barrier. Transfer to block L75.

(9) Block 7. If IFORM is not in the 60's or 70's, transfer to block 8.

(10) Block L20, Call routine DBRCH to handle the deliberate/hasty breach option. Transfer to block L75.

(11) Block 8. If IFORM is not in the 80's, transfer to block 9.

(12) Block L30. Call routine FRSTRT to calculate when the hasty breach will commense. Transfer to block L75.

(13) Block 9. If IFORM is not in the 90's, transfer to block 10.

(14) Block L40. Call routine PSTHRU to handle the passage through the barrier. Transfer to block L75.

(15) Block 10. If IFORM is not in the 100's, transfer to block L75.

(16) Block L50. Call routine WDRAW to handle the withdraw from the barrier.

(17) Block L75. If the interrupted actions flag is not set, transfer to block L100.

(18) Block 11. Call routine STOPIT to calculate the number of effective open lanes. Transfer to block L125.

(19) Block L100. If mode (M) is 1, transfer to block L125.

(20) Block 12. If mode is ZERO, transfer to block L150.

(21) Block 13. Call routine NOWHAT to select and set up the reaction to an aborted deliberate breach attempt.

(22) Block 14. If mode is ZERO, transfer to block L100.

(23) Block L125. ZERO out IDUM array.

(24) Block 15. Call routine PUTWRD to zero the control word in Data File 21.

(25) Block L150. Call routine PUTRCD to return the GCM barrier encounter data to Data File 21.

(26) Block 16. Call routine PUTGUT to schedule the GCM event for the appropriate time.

(27) Block 17. Set up the GCM Battle Control Table (ITBL). RETURN to the calling routine.

58. ROUTINE STALL.

a. Purpose. STALL determines whether the delay time for a pure delay barrier has expired. If time has expired, STALL sets up the continued advance.

b. Input Variables.

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
ITM	TWO	Time left at pure delay barrier, located at IDUM (4).
IVIN	TWO	Unit movement rate after pure delay, located at IDUM (8).

c. Output Variables:

Name	Destination	Contents
M	CALL	Mode.
ISKED	CALL	Time till next GCM event.
ITM	TWO	Time left at pure delay barrier.
UMAIN (512)	DF1	Updated Unit Status File.

d. Logical Flow (Figure IV-7-B-58).

(1) Block 1. If there is no more delay required at the pure delay barrier (ITM≤0), transfer to block L10.

(2) Block 2. Calculate the delay time now required at the pure delay barrier.

(3) Block 3. Set the mode to 4 and RETURN to the calling routine.

(4) Block L10. Calculate the unit's new location and movement rate.

(5) Block 4. Call routine PUTRCD to return the unit's updated Unit Status File to Data File 1.

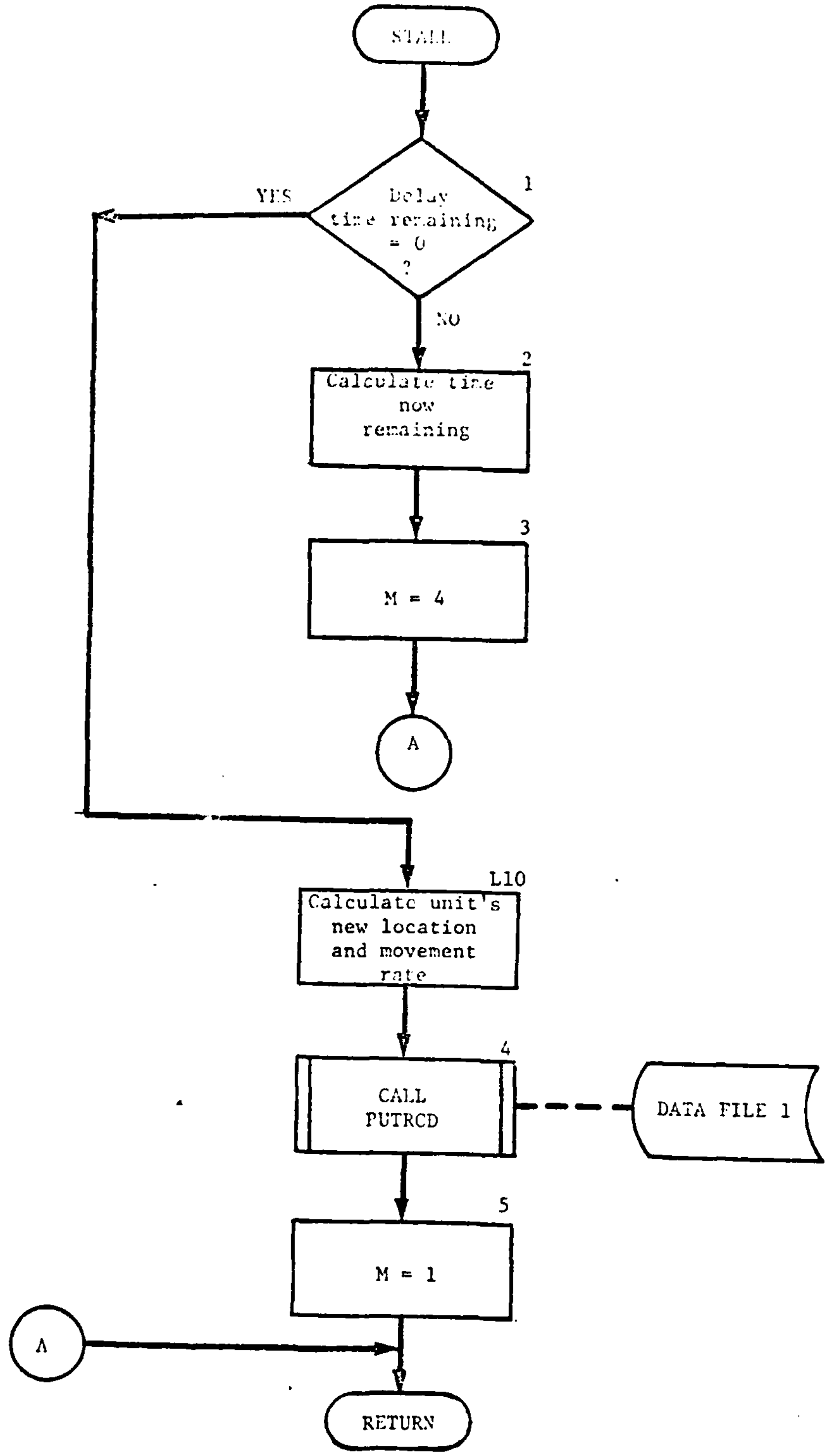


Figure IV-7-B-58. Routine STALL.

(6) Block 5. Set the mode to 1 and RETURN to the calling routine.

59. ROUTINE STOPIT.

a. Purpose. STOPIT calculates the number of effective open lanes and updates the Barrier/Facility File.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
M	CALL	Mode.
IREC	TWO	Record number of File 2 record, located at IDUM (2).
DLEFT	TWO	Depth of the field left to clear, located at IDUM (6).
DOPEN	TWO	Depth of the field open, located at IDUM (7).
LWORK	TWO	Number of lanes under work, located at IDUM (9).
PMISS	TWO	Percent of lanes missed, located at IDUM (30).

c. Output Variables:

Name	Destination	Contents
LE	DF2	Number of effective open lanes.
M	CALL	Mode.

d. Logical Flow (Figure IV-7-B-59).

(1) Block 1. If the mode is not 6, 7, or 0, transfer to block L100.

(2) Block 2. Calculate the number of effective number of lanes open.

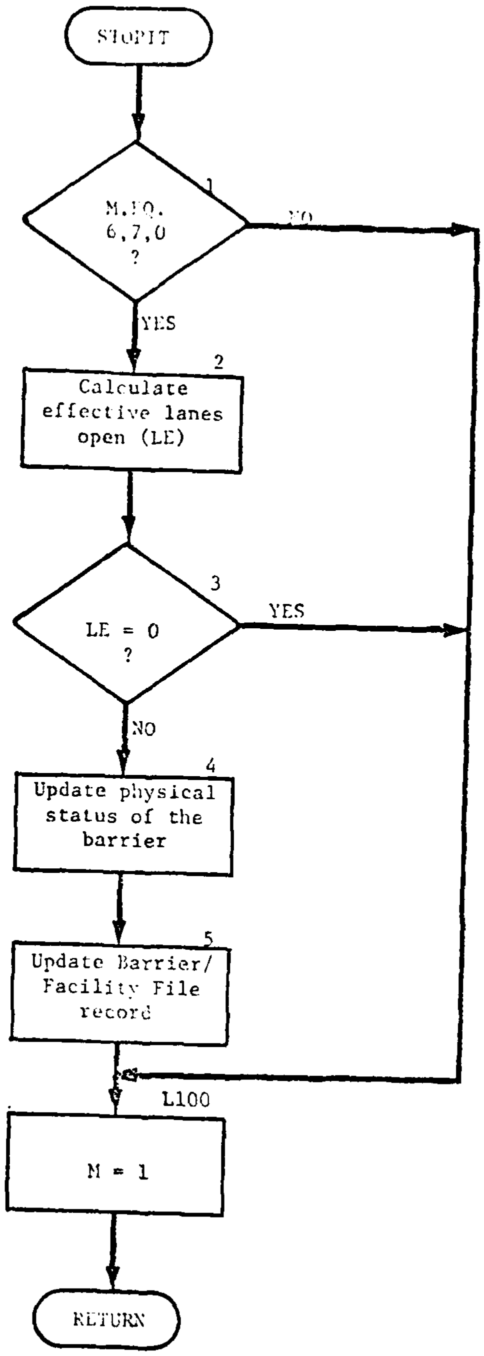


Figure IV-7-B-59. Routine STOPIT.

(3) Block 3. If there are no effective open lanes, transfer to block L100.

(4) Block 4. Update the physical status of the barrier.

(5) Block 5. Update the Barrier/Facility File.

(6) Block L100. Set the mode to 1, and RETURN to the calling routine.

60. ROUTINE FRSTRT.

a. Purpose. FRSTRT sets control variables for, and calculates the time of the next event (hasty breach).

b. Input Variables.

(1) Standard Common Block Variables.

(2) Other Variables. None

c. Output Variables:

Name	Destination	Contents
M	CALL	Mode.
TSKED	CALL	Time till next event (hasty breach).
IFORM	TWO	GCM barrier encounter control variable, located at IDUM (3).

d. Logical Flow (Figure IV-7-B-60).

(1) Block 1. Set IFORM to 81 and mode (M) to 8.

(2) Block 2. Calculate the time (TSKED) till the next event hasty breach).

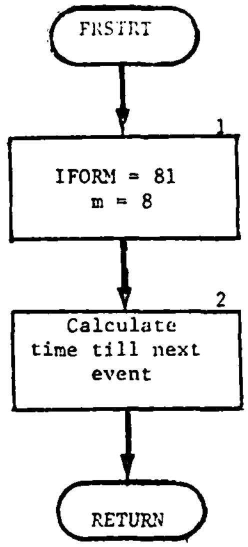


Figure IV-7-B-60. Routine FRSTRT.

61. ROUTINE PSTHRU.

a. Purpose. PSTHRU handles a unit's passage through the minefield.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
ATTYPE	DF16	Transport type indicators, located at IDUM (2008).
FIL28 (189)	DF28	Distribution of personnel and equipment for this unit, located at IDUM (2016).
ITMAT (8)	TWO	Item codes of the attacker's eight weapon systems, located at IDUM (4024).
FRACOV	TWO	Fraction of the unit's frontage which encounters the minefield, located at IDUM (14).
IVEHOV	TWO	Item code of vehicle that can be over the minefield, located at IDUM (15).
VOVER	TWO	Number of vehicles over, located at IDUM (28).
LANES	TWO	Number of lanes available for passage, located at IDUM (9).
VATTV (8)	TWO	Velocities of the attacker's eight weapon systems, located at IDUM (4016).
DEPF	TWO	Depth of the minefield, located at IDUM (6).
VIN	TWO	Velocity crossing the minefield, located at IDUM (8).
IFORM	TWO	GCM barrier encounter control word, located at IDUM (3).

c. Output Variables:

Name	Destination	Contents
M	CALL	Mode.
TSKED	CALL	Time till the next event (passage through the minefield).
IFORM	TWO	GCM barrier encounter control word, located at IDUM (3).
IRUNV	TWO	GCM velocity in the field, located at IDUM (32).
TLEFT	TWO	Time left for bypass, located at IDUM (31).
VC (8)	TWO	Number of each vehicle type to cross the field, located at IDUM (2205).
VU (8)	TWO	Number of each vehicle type not covered by the field, located at IDUM (2205).
VFB	TWO	Number of each vehicle type in the front band, located at IDUM (2000).
UMAIN (512)	DF1	Unit's Unit Status File.

d. Logical Flow (Figure IV-7-B-61).

(1) Block 1. If IFORM is not 90, transfer to block L150.

(2) Block 2. If the interrupted actions flag is not set (=0), transfer to block L10.

(3) Block 3. Set the mode to 1, RETURN to the calling routine.

(4) Block L10. Call routine GET to obtain the transport type indicators from Data File 16.

(5) Block 4. Call routine GETRCD to obtain the unit's distribution of personnel and equipment from Data File 28.

(6) Block 5. Calculate the sum (SVFB) of the vehicles in the front band of this unit.

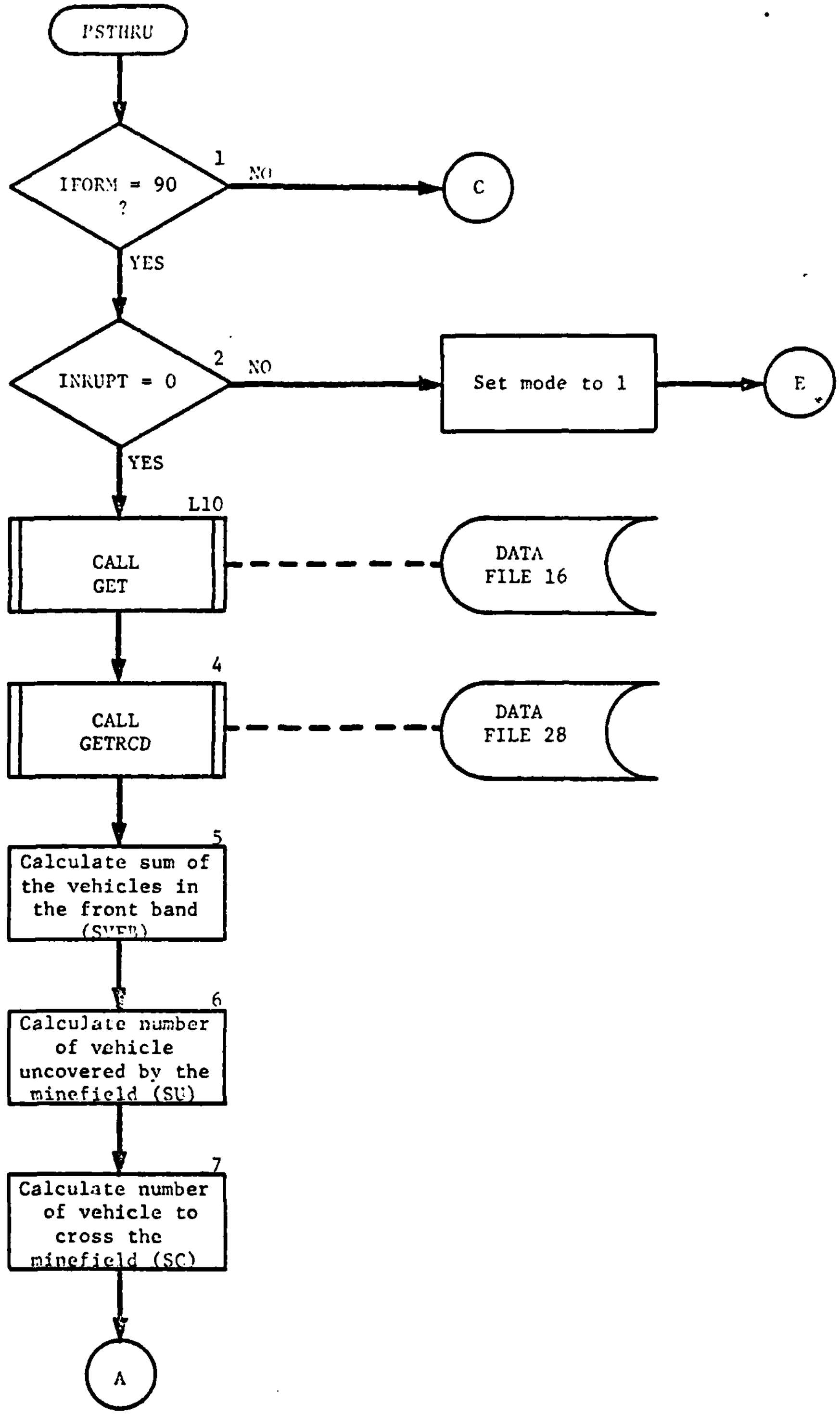
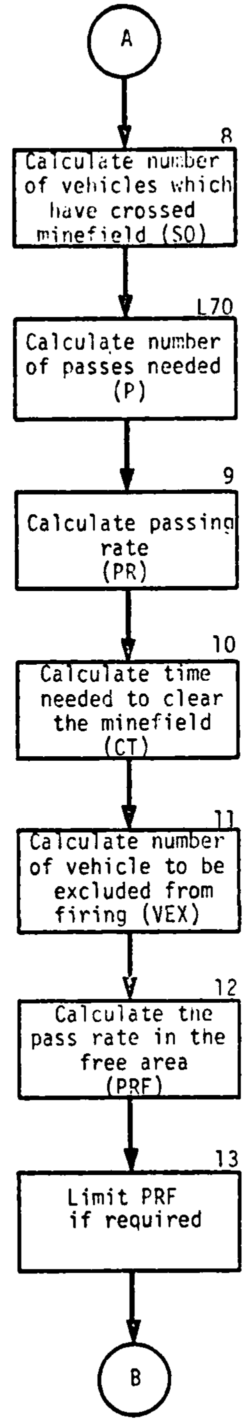
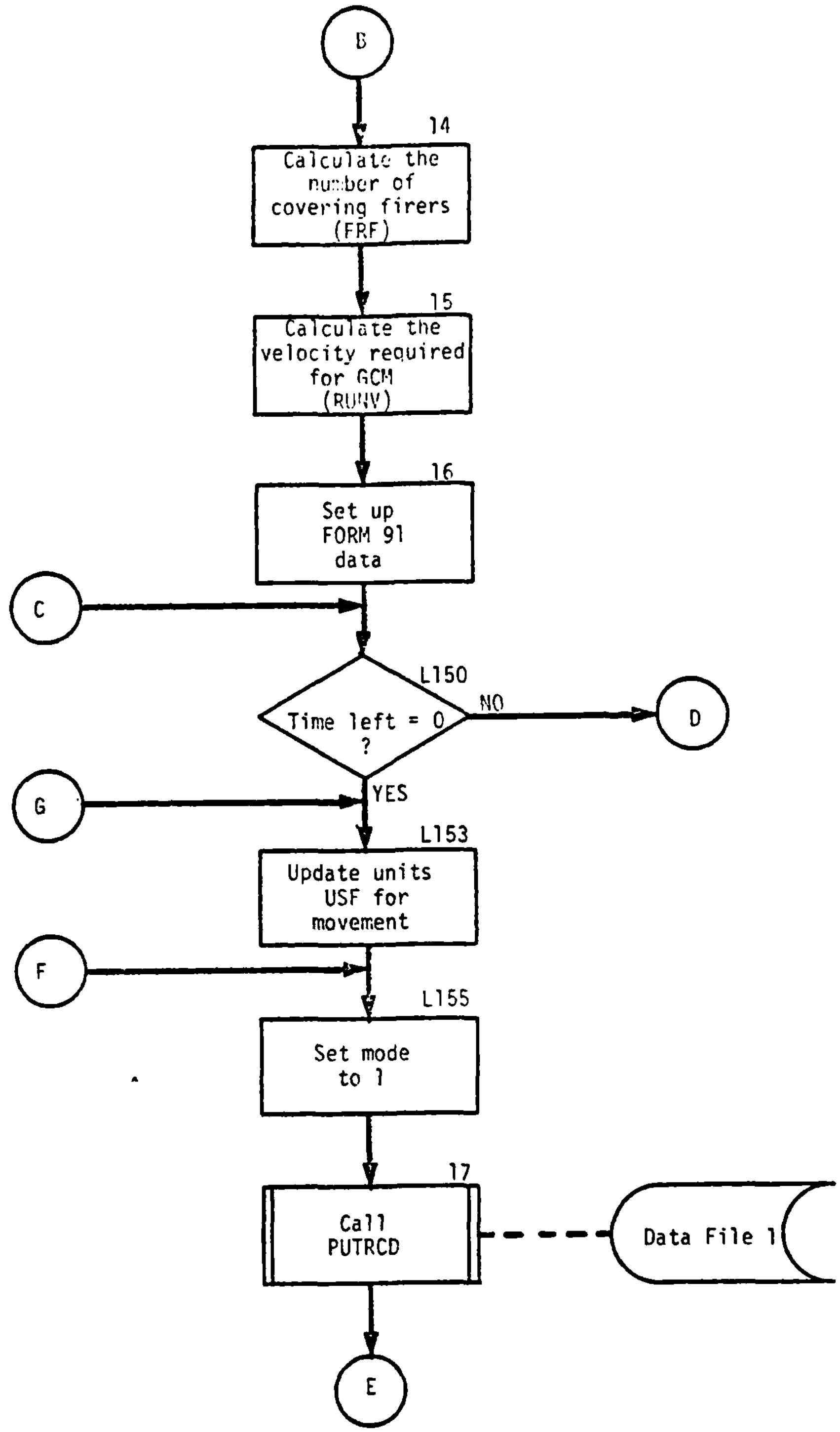
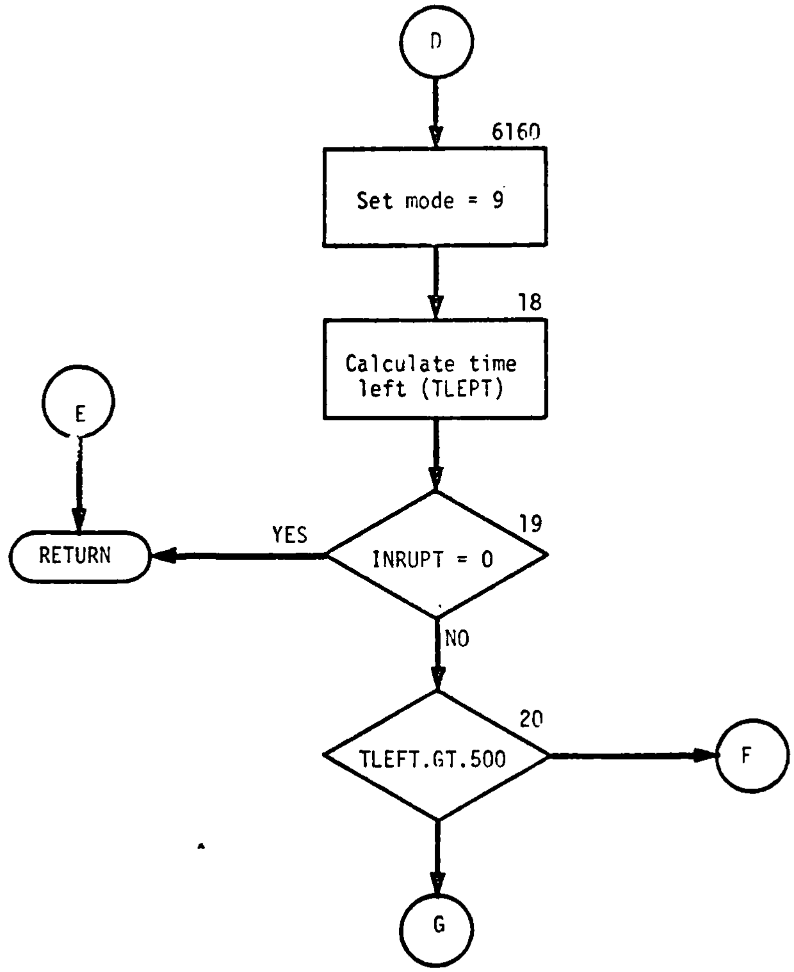


Figure IV-7-B-61. Routine FSTHRU.


A
8
Calculate number of vehicles which have crossed minefield (SO)
L70
Calculate number of passes needed (P)
9
Calculate passing rate (PR)
10
Calculate time needed to clear the minefield (CT)
11
Calculate number of vehicle to be excluded from firing (VEX)
12
Calculate the pass rate in the free area (PRF)
13
Limit PRF if required
B


B
14
Calculate the number of covering firers (FRF)
15
Calculate the velocity required for GCM (RUNV)
16
Set up FORM 91 data
C
L150
Time left = 0 ?
NO
D
YES
G
L153
Update units USF for movement
F
L155
Set mode to 1
17
Call PUTRCD
Data File 1
E


D
6160
Set mode = 9
18
Calculate time left (TLEPT)
E
19
INRUPT = 0
YES
RETURN
NO
20
TLEFT.GT.500
F
G

(7) Block 6. Calculate the number of vehicles not covered by the minefield (SU).

(8) Block 7. Calculate the number of vehicles to cross the minefield (SC).

(9) Block 8. Calculate the number of vehicles which have crossed the minefield (SO).

(10) Block L70. Calculate the number of passes (P) required to cross the field with this many vehicles.

(11) Block 9. Calculate the rate (PR) at which the vehicle will pass through the field.

(12) Block 10. Calculate the time required (CT) to clear the depth of the minefield plus a factor of 50 meters.

(13) Block 11. Calculate the number of vehicles to be excluded from firing in GCM (VEX).

(14) Block 12. Calculate the pass rate (PRF) in the free area (speed which the front band can clear the field).

(15) Block 13. Limit PRF to any limiting vehicle (if any).

(16) Block 14. Calculate the number of covering firers (FRF).

(17) Block 15. Calculate the unit velocity required for GCM (RUNV) as the weighted average velocity of free firers and uncovered vehicles.

(18) Block 16. Set up FORM 91 data for GCM.

(19) Block L150. Is there any time left? If not, transfer to block L160.

(20) Block L153. Update the unit's Unit Status File for movement.

(21) Block L155. Set the mode to 1.

(22) Block 17. Call routine PUTRCD to return the unit's Unit Status File to Data File 1. RETURN to the calling routine.

(23) Block L160. Set the mode to 9.

(24) Block 18. Calculate the time left (TLEFT).

(25) Block 19. If the interrupted actions flag is not set (=0), RETURN to the calling routine.

(26) Block 20. If there is more than 5 minutes left, transfer to block L155. Otherwise, transfer to block L153.

62. ROUTINE BYPAS.

a. Purpose. BYPAS handles the calculations required for unit bypass around a barrier.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
COMP	TWO	Maximum unit width compaction, located at IDUM (15).
RTEST	TWO	Maximum unit width for bypass, located at IDUM (16).
VIN	TWO	Velocity crossing the minefield, located at IDUM (8).
WIN	TWO	Width in the minefield, located at IDUM (9).
BPX	TWO	X-coordinate of the bypass point, located at IDUM (6).
BPY	TWO	Y-coordinate of the bypass point, located at IDUM (7).
IFORM	TWO	GCM barrier encounter control word, located at IDUM (3).
TLEFT	TWO	Time left, located at IDUM (22).

c. Output Variables:

Name	Destination	Contents
IFORM	TWO	GCM barrier encounter control word, located at IDUM (3).

XMP, YMP	TWO	Mid point of next move segment, located at IDUM (10) and IDUM (11).
XLP, YLP	TWO	End point of the next move segment, located at IDUM (12) and IDUM (13).
XACTN, YACTN	TWO	Desired point, located at IDUM (17) and IDUM (18).
WATBPP	TWO	Width at the bypass point, located at IDUM (19).
VUSE	TWO	New unit velocity, located at IDUM (20).
TMOVE	TWO	Time of the move, located at IDUM (21).
TLEFT	TWO	Time left, located at IDUM (22).
UMAIN (512)	DF1	Unit Status File.
M	CALL	Mode.
TSKED	CALL	Time till next event.

d. Logical Flow (Figure IV-7-B-62).

(1) Block 1. If IFORM is not 50, transfer to block L50.

(2) Block 2. Initialize the width, depth, and orientation angle.

(3) Block 3. Calculate the unit's leading edge corner points (X1, Y1, X2, Y2).

(4) Block 4. Calculate the distance from each of these corners to the bypass point (BPX, BPY).

(5) Block 5. Determine which corner is the farthest from the bypass point (D1).

(6) Block 6. Determine the distance the other corner must move (D2).

(7) Block 7. Calculate the width of the unit at the bypass point (WATBPP).

(8) Block 8. Calculate the angle (THETA) between the barrier end point and the unit's objective.

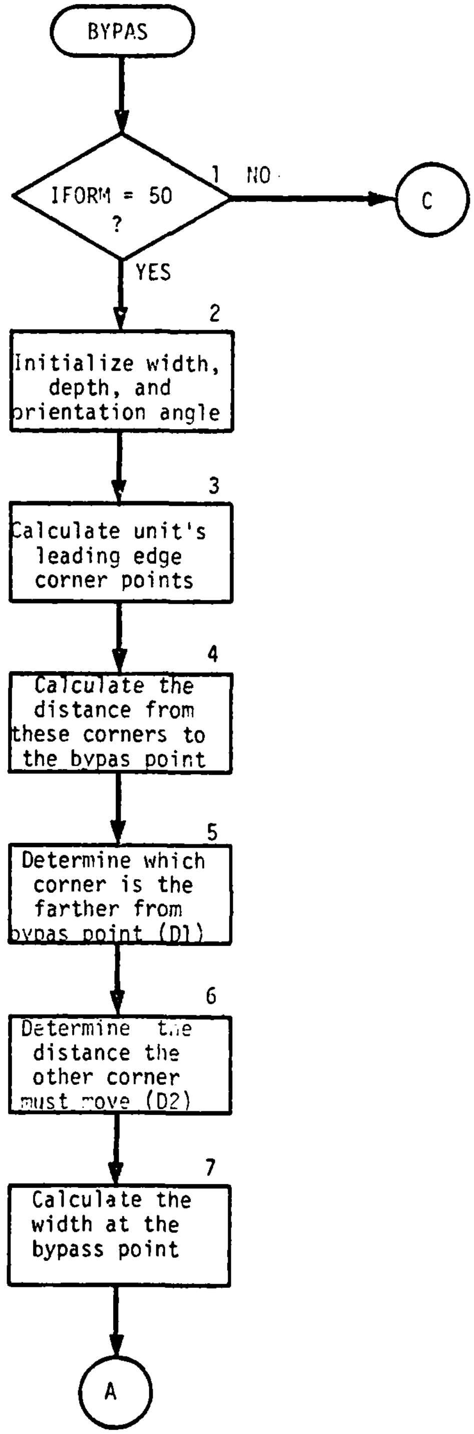
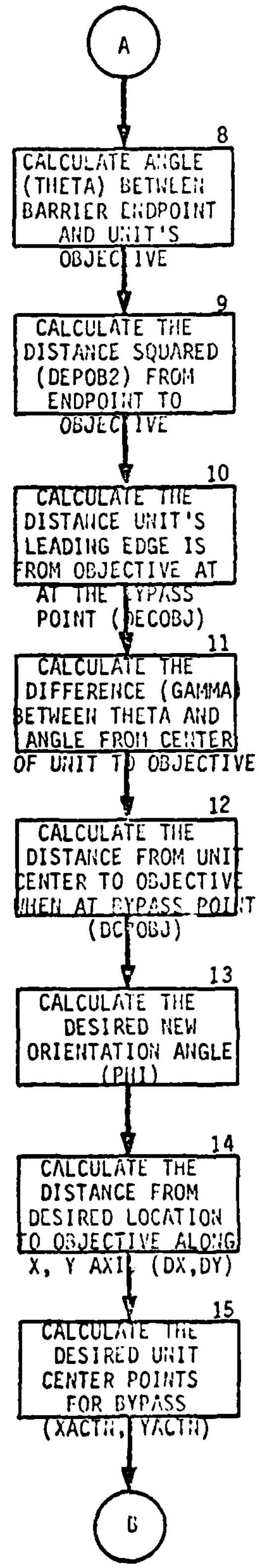
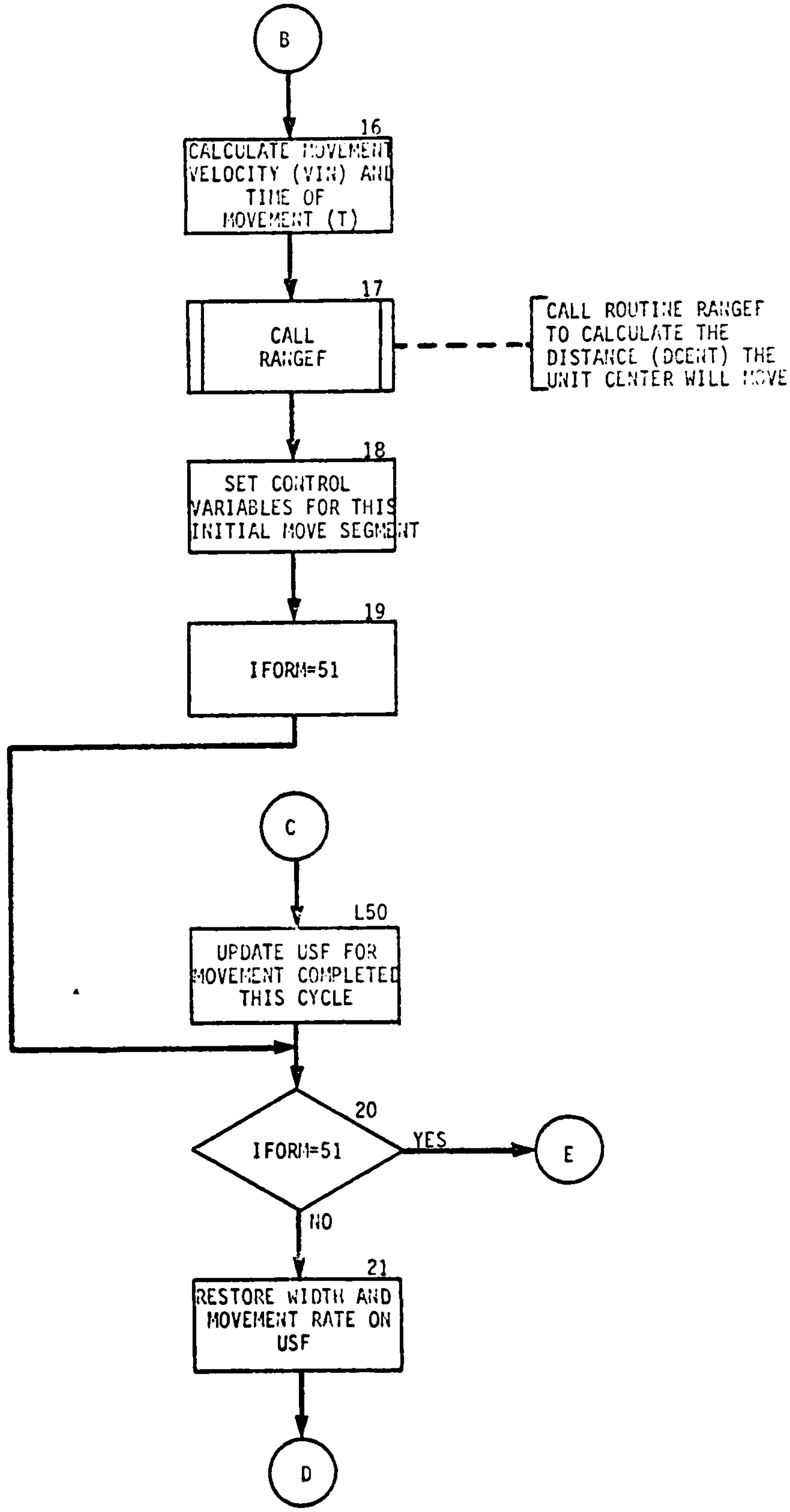
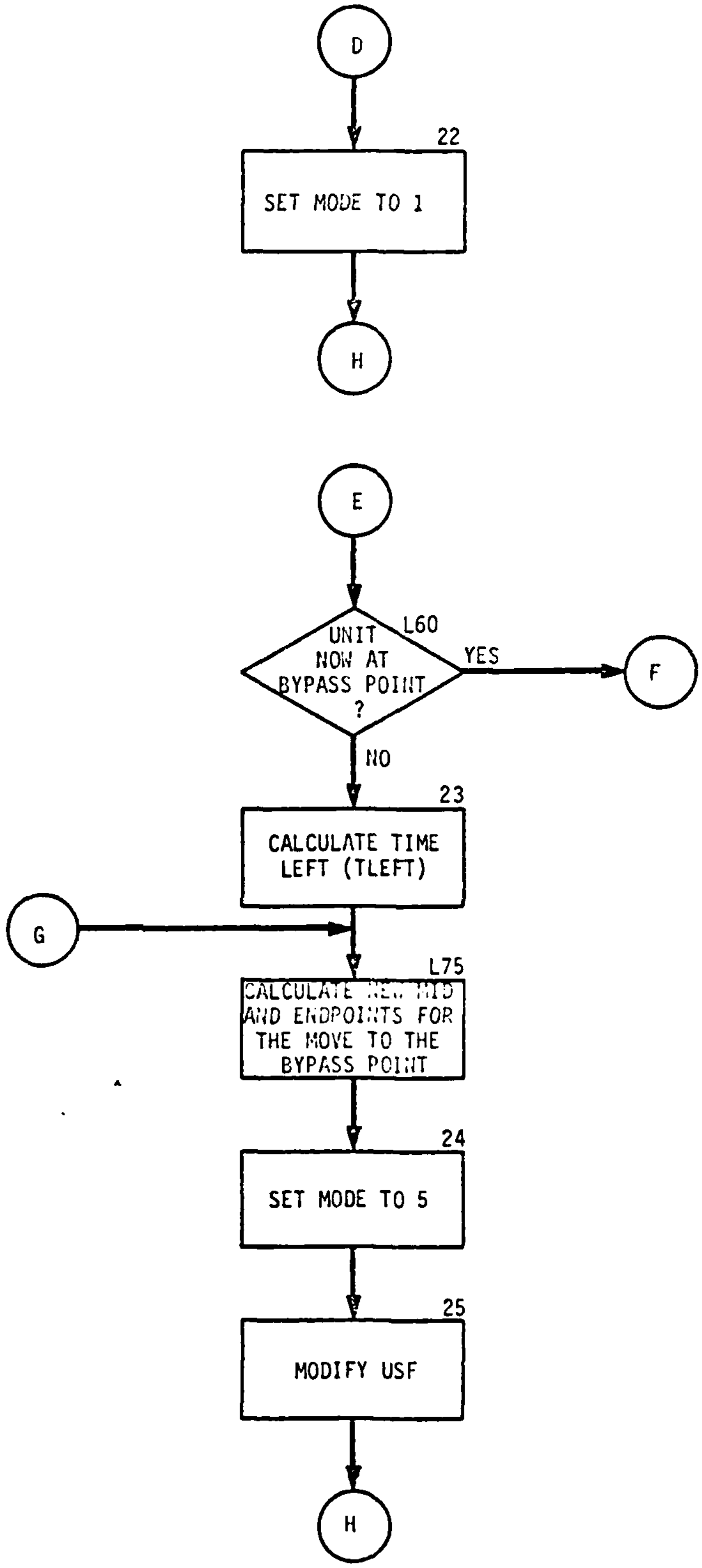
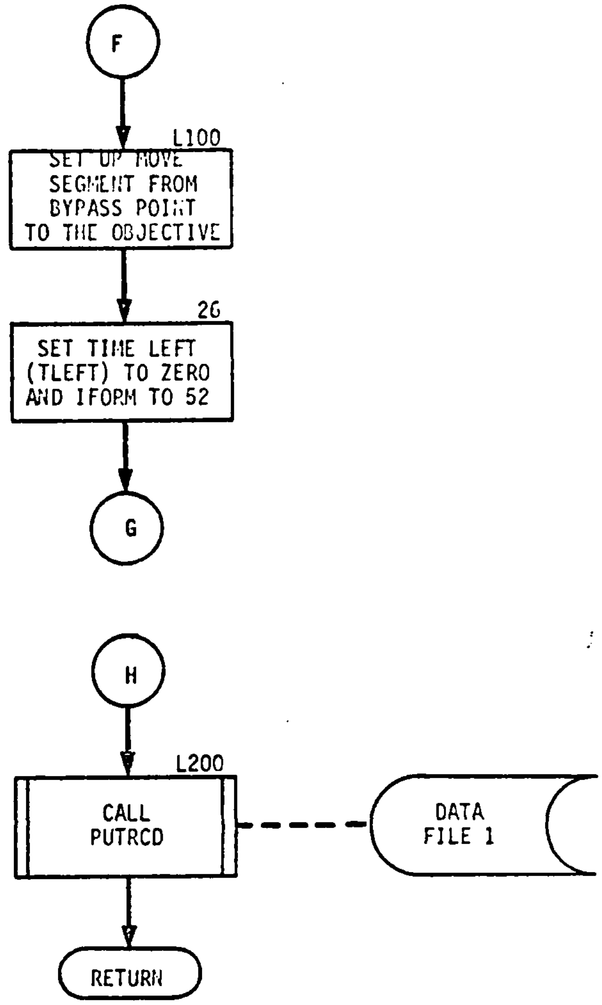


Figure IV-7-B-62. Routine BYPAS


A
8
CALCULATE ANGLE (THETA) BETWEEN BARRIER ENDPOINT AND UNIT'S OBJECTIVE
9
CALCULATE THE DISTANCE SQUARED (DEPOB2) FROM ENDPOINT TO OBJECTIVE
10
CALCULATE THE DISTANCE UNIT'S LEADING EDGE IS FROM OBJECTIVE AT AT THE BYPASS POINT (DECOBJ)
11
CALCULATE THE DIFFERENCE (GAMMA) BETWEEN THETA AND ANGLE FROM CENTER OF UNIT TO OBJECTIVE
12
CALCULATE THE DISTANCE FROM UNIT CENTER TO OBJECTIVE WHEN AT BYPASS POINT (DCPOBJ)
13
CALCULATE THE DESIRED NEW ORIENTATION ANGLE (PHI)
14
CALCULATE THE DISTANCE FROM DESIRED LOCATION TO OBJECTIVE ALONG X, Y AXIS (DX,DY)
15
CALCULATE THE DESIRED UNIT CENTER POINTS FOR BYPASS (XACTN, YACTN)
B


B
16
CALCULATE MOVEMENT VELOCITY (VIN) AND TIME OF MOVEMENT (T)
17
CALL RANGEF
CALL ROUTINE RANGEF TO CALCULATE THE DISTANCE (DCENT) THE UNIT CENTER WILL MOVE
18
SET CONTROL VARIABLES FOR THIS INITIAL MOVE SEGMENT
19
IFORM=51
C
L50
UPDATE USF FOR MOVEMENT COMPLETED THIS CYCLE
20
IFORM=51
YES
E
NO
21
RESTORE WIDTH AND MOVEMENT RATE ON USF
D


D
22
SET MODE TO 1
H
E
L60
UNIT NOW AT BYPASS POINT ?
YES
F
NO
23
CALCULATE TIME LEFT (TLEFT)
G
L75
AND ENDPOINTS FOR THE MOVE TO THE BYPASS POINT
24
SET MODE TO 5
25
MODIFY USF
H


F
L100
SET UP MOVE SEGMENT FROM BYPASS POINT TO THE OBJECTIVE
26
SET TIME LEFT (TLEFT) TO ZERO AND IFORM TO 52
G
H
L200
CALL PUTRCD
DATA FILE 1
RETURN

(9) Block 9. Calculate the distance squared (DEPOB2) from the barrier end point to the unit's objective.

(10) Block 10. Calculate the distance from the unit's leading edge to its objective when the unit is at the bypass point (DECOBJ).

(11) Block 11. Calculate the difference between THETA and the angle from the center of the unit to the objective (GAMMA).

(12) Block 12. Calculate the distance from the unit center to the objective when the unit is at the bypass point (DCPOBJ)

(13) Block 13. Calculate the desired new orientation angle (PHI).

(14) Block 14. Calculate the distance from the desired location to the objective along the X, Y axis (DX, DY).

(15) Block 15. Calculate the desired unit center point for bypass (XACTN, YACTN).

(16) Block 16. Calculate the movement velocity (VIN) and the time of movement (T).

(17) Block 17. Call routine RANGEF to calculate the distance the unit center will move (DCENT).

(18) Block 18. Set the control variables for this move segment.

(19) Block 19. Set IFORM to 51 and transfer to block 20.

(20) Block L50. Update the unit's Unit Status File for the movement segment just completed.

(21) Block 20. If IFORM is 51, transfer to block L60.

(22) Block 21. Restore the width and movement rate on the unit's Unit Status File.

(23) Block 22. Set the mode to 1 and transfer to block L200.

(24) Block L60. If the unit is now at the bypass point, transfer to block L100.

(25) Block 23. Calculate the time left (TLEFT).

(26) Block L75. Calculate the new mid and end points for the move to the bypass point.

(27) Block 24. Set the mode to 5.

(28) Block 25. Modify the unit's Unit Status File. Transfer to block L200.

(29) Block L100. Set up the move segment from the bypass point to the unit's objective.

(30) Block 26. Set the time left (TLEFT) to ZERO and IFORM to 52. Transfer to Block L75.

(31) Block L200. Call routine PUTRCD to return the unit's Unit Status File to Data File 1. RETURN to the calling routine.

63. ROUTINE WDRAW

a. Purpose. WDRAW sets up or continues the unit's withdraw from the minefield.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
IFORM	TWO	GCM barrier encounter control word, located at IDUM (3).
VIN	TWO	Unit's velocity, located at IDUM (8).
IDXATT	TWO	Unit's index into the GCM Battle Control Table, located at IDUM (4033).
IDATA(64)	DF21	GCM Battle Control Table.

c. Other Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
M	CALL	Mode.
TSKED	CALL	Time until next event.
IFORM	TWO	GCM barrier encounter control word, located at IDUM (3).
(XLP,YLP)	TWO	End point of next move segment from current location to the objective, located at IDUM (12) and IDUM (13).
(XMP, YMP)	TWO	Mid point of the next move segment from current location to the objective, located at IDUM (10) and IDUM (11).

d. Logical Flow (Figure IV-7-B-63).

(1) Block 1. If IFORM is not 100, transfer to block L25.

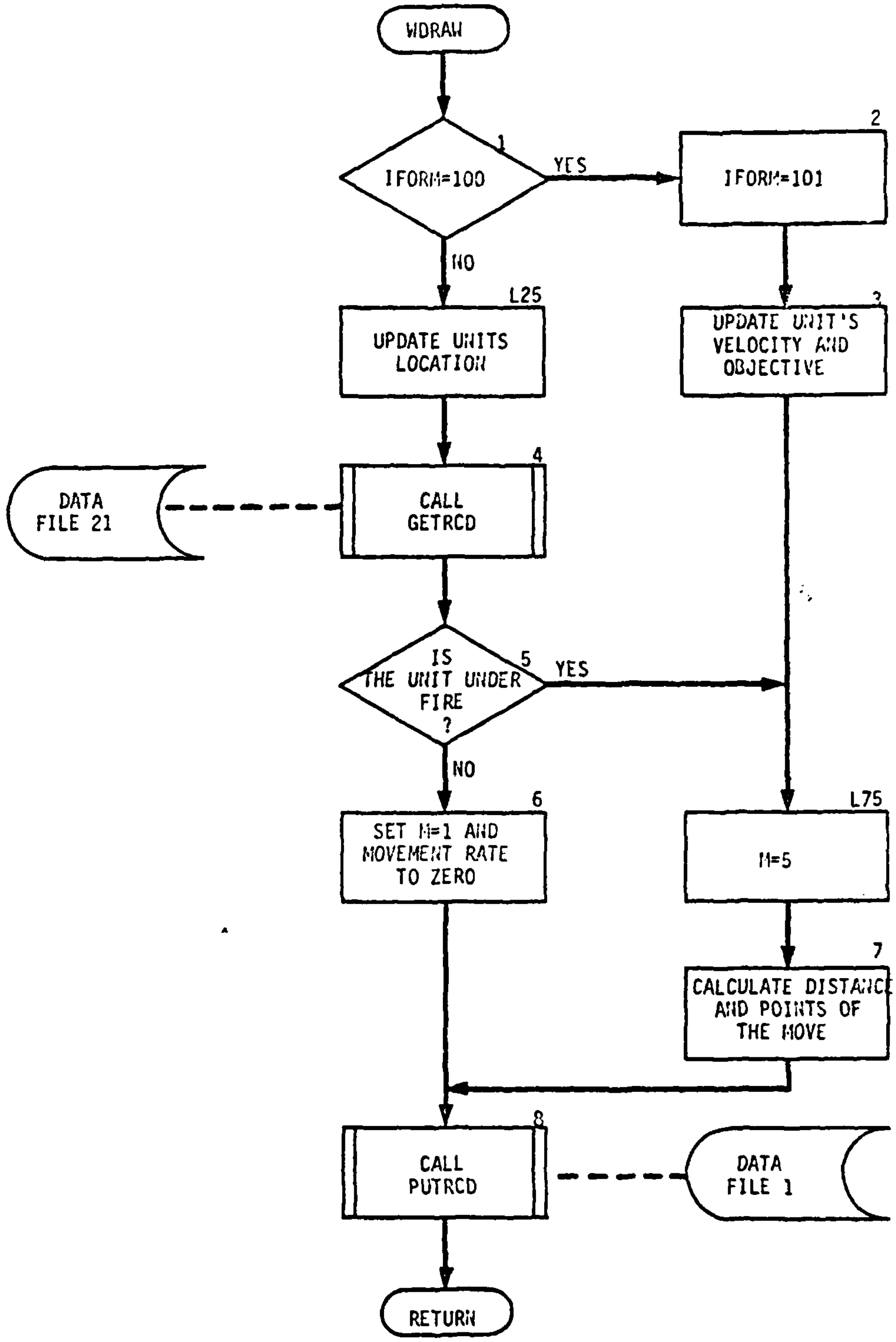


FIGURE IV-7-B-63 ROUTINE WDRAW

(2) Block 2. If IFORM to 101.

(3) Block 3. Update the unit's velocity and objective. Transfer to block L75.

(4) Block L25. Update the unit's location.

(5) Block 4. Call routine GETRCD to obtain the GCM Battle Control Table from Data File 21.

(6) Block 5. If the unit is under fire (a non-ZERO entry in GCM Battle Control Table for this unit), transfer to block L75.

(7) Block 6. Set the mode to 1 and the movement rate to ZERO for further processing. Transfer to block 8.

(8) Block L75. Set mode to 5.

(9) Block 7. Calculate the distance, end points, and mid points of the next move segment.

(10) Block 8. Call routine PUTRCD to return the unit's Unit Status File to Data File 1. RETURN to the calling routine.

64. ROUTINE DBRCH

a. Purpose. DBRCH sets up or continues a unit's deliberate breach of a minefield.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
IFORM	TWO	GCM barrier encounter conrol word, located at IDUM (3).
NINC	TWO	Number of increments now, located at IDUM (29).
LWORK	TWO	Number of lanes to work, located at IDUM (9).
FRACOV	TWO	Fraction of the unit front in the minefield, located at IDUM (14).

REAL 1, REAL 2	TWO	Number excluded of major items, located at IDUM (16) and IDUM (18).
DLEFT	TWO	Depth of the minefield yet to clear, located at IDUM (6).
DOPEN	TWO	Depth of the minefield cleared, located at IDUM (7).
INC	TWO	Standard increment size, located at IDUM (27).
RMISS	TWO	Miss rate, located at IDUM (28).
PMISS	TWO	Percent missed, located at IDUM (30).
TINC	TWO	Time of a standard increment, located at IDUM (25).
LOPEN	TWO	Lanes open, located at IDUM (12).
IREC	TWO	Barrier - Facility file record number located at IDUM (2).

c. Output Variables:

Name	Destination	Contents
M	CALL	Mode.
TSKED	CALL	Time until next event.
DLEFT	TWO	Depth of the minefield left to clear, located at IDUM (6).
DOPEN	TWO	Depth of the minefield cleared, located at IDUM (7).
FREEP	TWO	Number of free paths, located at IDUM (13).
IFORM	TWO	GCM barrier encounter control word, located at IDUM (3).
LOPEN	TWO	Lanes open, located at IDUM (12).
LWORK	TWO	Lanes to work, located at IDUM (9).
NINC	TWO	Number of increments now, located at IDUM (29).

PMISS	TWO	Percent missed, located at IDUM (30).
REAL 1, REAL 2	TWO	Number excluded of major items, located at IDUM (16) and IDUM (18).

d. Logical Flow (Figure IV-7-B-64).

(1) Block 1. Using IFORM, calculate the control words IBASE and IMOD.

(2) Block 2. If IMOD is ZERO, transfer to block L175.

(3) Block 3. Subtract the used expendable items calculated from the unit's Unit Status File.

(4) Block 4. If IMOD is 1, transfer to block L50.

(5) Block 5. Calculate number of free paths (FREEP).

(6) Block 6. Calculate the number of lanes under work (LWORK) and the number of major items excluded (REAL 1, REAL 2).

(7) Block 7. Set IMOD to 2.

(8) Block L50. Calculate the depth of the minefield cleared (DOPEN) and keft to clear (DLEFT).

(9) Block 8. If the unit is not through the field (DLEFT > 0), transfer to block L100).

(10) Block 9. Determine the new status of the field.

(11) Block 10. Call routine PUTRCD to return Barrier - Facility file record to Data File 2.

(12) Block 11. Set IFORM to 90.

(13) Block 12. Set the required data and control words for the unit's passage through the minefield.

(14) Block 13. Call routine PSTHRU to handle the unit's passage through the minefield. Transfer to block 40.

(15) Block L100. Initialize the required variables.

(16) Block 14. Begin loop (A1) on 3 consumables.

(17) Block 15. Get the first/next consumable item code (N).

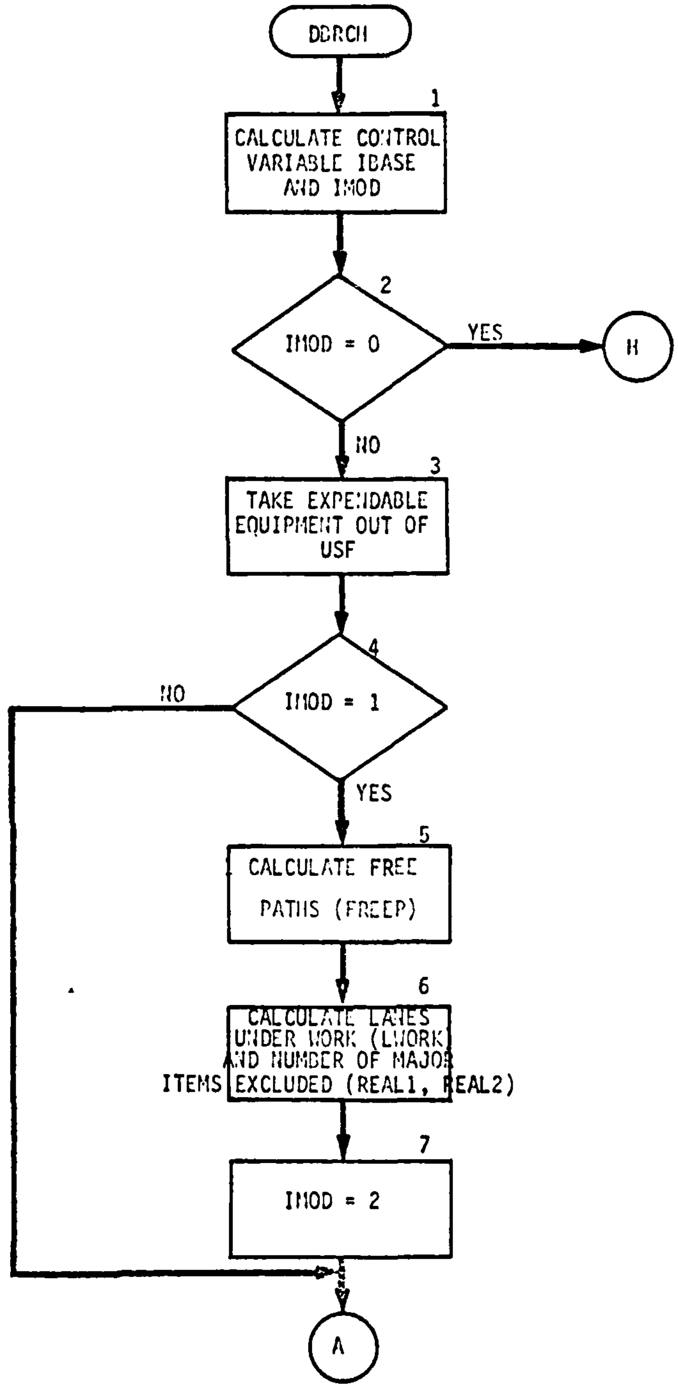
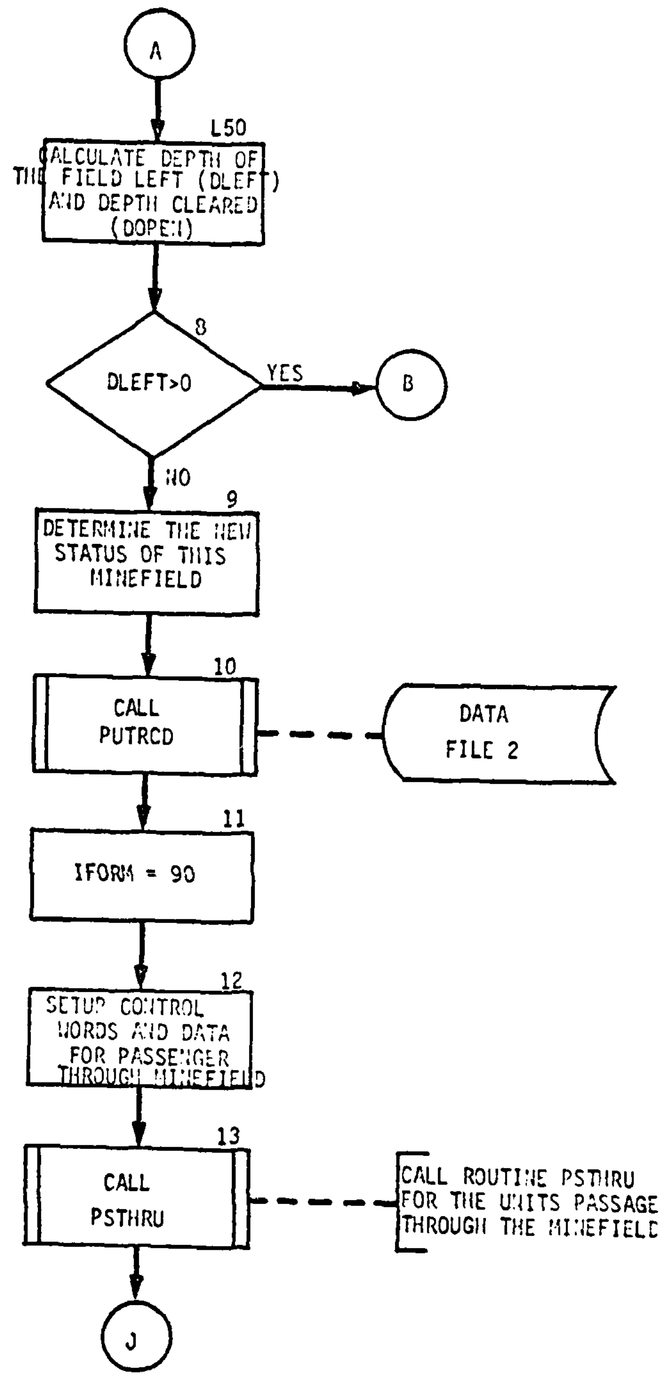
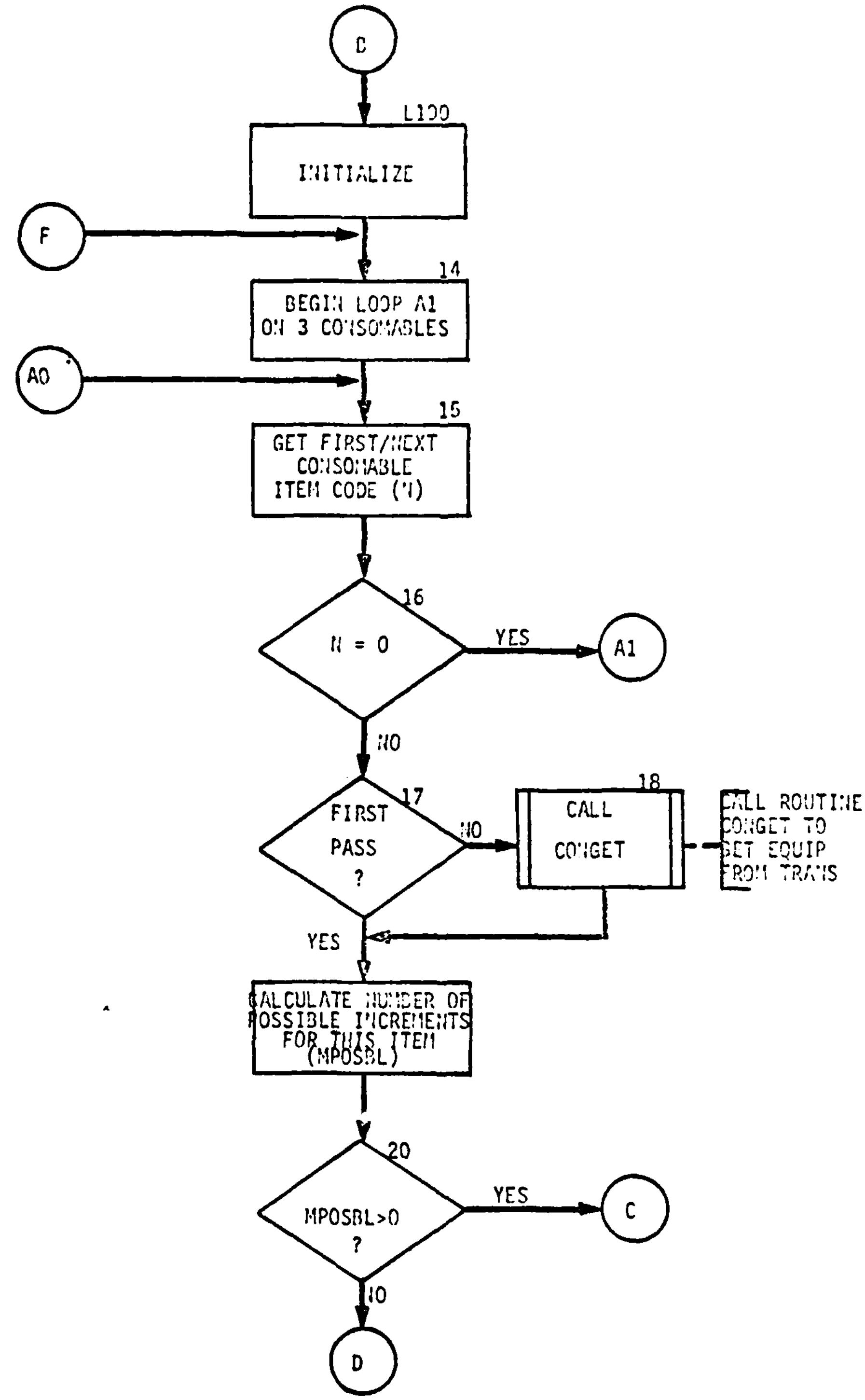
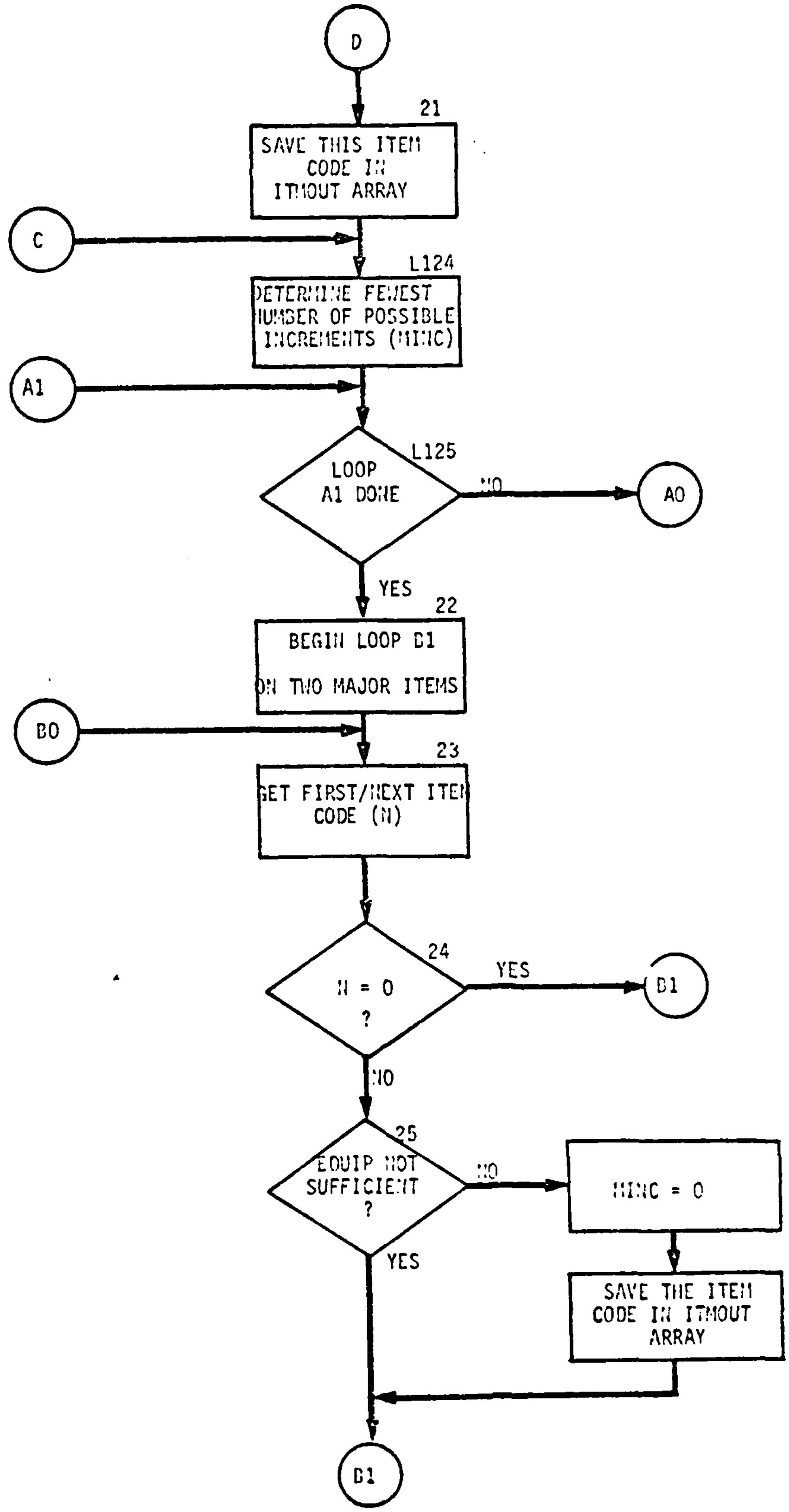
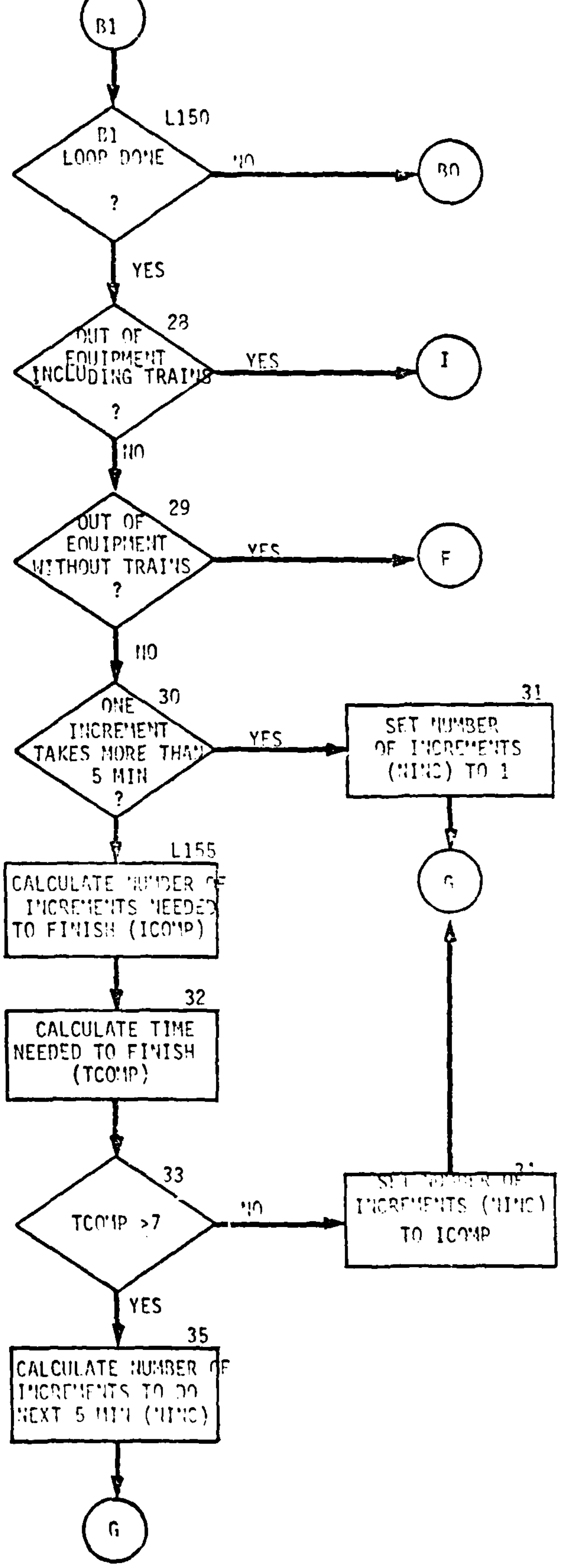


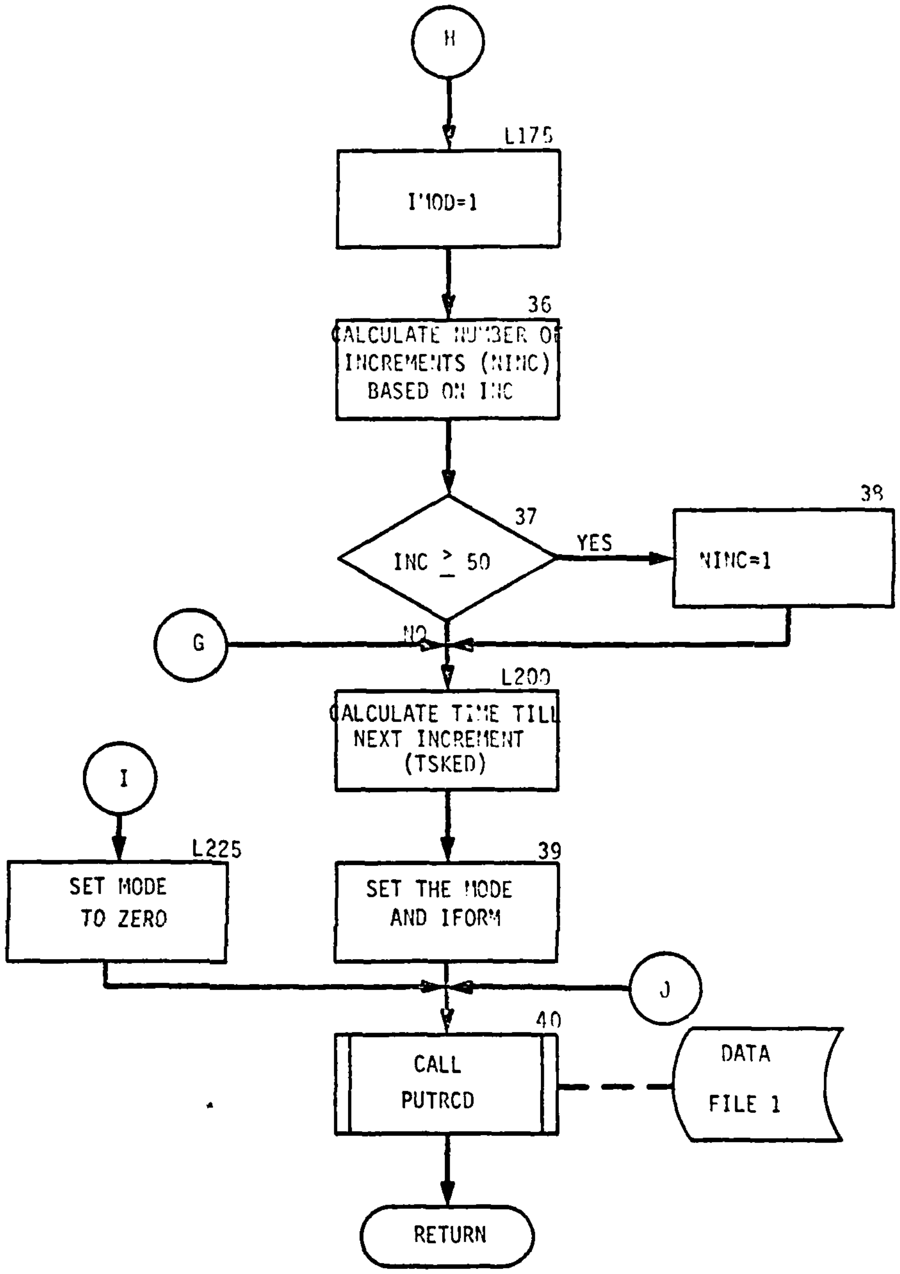
FIGURE IV -7-B-64 ROUTINE DBRCH


A
L50
CALCULATE DEPTH OF THE FIELD LEFT (DLEFT) AND DEPTH CLEARED (DOPEN)
8
DLEFT>0
YES
B
NO
9
DETERMINE THE NEW STATUS OF THIS MINEFIELD
10
CALL PUTRCD
DATA FILE 2
11
IFORM = 90
12
SETUP CONTROL WORDS AND DATA FOR PASSENGER THROUGH MINEFIELD
13
CALL PSTHRU
CALL ROUTINE PSTHRU FOR THE UNITS PASSAGE THROUGH THE MINEFIELD
J


B
L100
INITIALIZE
F
14
BEGIN LOOP A1
ON 3 CONSUMABLES
A0
15
GET FIRST/NEXT
CONSUMABLE
ITEM CODE (N)
16
N = 0
YES
A1
NO
17
FIRST
PASS
?
NO
18
CALL
CONGET
CALL ROUTINE
CONGET TO
GET EQUIP
FROM TRANS
YES
CALCULATE NUMBER OF
POSSIBLE INCREMENTS
FOR THIS ITEM
(MPOSBL)
20
MPOSBL>0
?
YES
C
NO
D


D
21
SAVE THIS ITEM CODE IN ITMOUT ARRAY
C
L124
DETERMINE FEWEST NUMBER OF POSSIBLE INCREMENTS (MINC)
A1
L125
LOOP A1 DONE
NO
A0
YES
22
BEGIN LOOP B1 ON TWO MAJOR ITEMS
B0
23
GET FIRST/NEXT ITEM CODE (N)
24
N = 0 ?
YES
B1
NO
25
EQUIP NOT SUFFICIENT ?
NO
MINC = 0
SAVE THE ITEM CODE IN ITMOUT ARRAY
YES
B1


B1
L150
B1 LOOP DONE ?
NO
B0
YES
28
OUT OF EQUIPMENT INCLUDING TRAINS ?
YES
I
NO
29
OUT OF EQUIPMENT WITHOUT TRAINS ?
YES
F
NO
30
ONE INCREMENT TAKES MORE THAN 5 MIN ?
YES
31
SET NUMBER OF INCREMENTS (NINC) TO 1
G
L155
CALCULATE NUMBER OF INCREMENTS NEEDED TO FINISH (ICOMP)
32
CALCULATE TIME NEEDED TO FINISH (TCOMP)
33
TCOMP >7
NO
INCREMENTS (NINC) TO ICOMP
YES
35
CALCULATE NUMBER OF INCREMENTS TO DO NEXT 5 MIN (NINC)
G


H
L175
IMOD=1
36
CALCULATE NUMBER OF INCREMENTS (NINC) BASED ON INC
37
INC ≥ 50
YES
38
NINC=1
NO
G
L200
CALCULATE TIME TILL NEXT INCREMENT (TSKED)
I
L225
SET MODE TO ZERO
39
SET THE MODE AND IFORM
J
40
CALL PUTRCD
DATA FILE 1
RETURN

AD-A112 652 ARMY COMBINED ARMS COMBAT DEVELOPMENTS ACTIVITY FORT--ETC F/G 15/7
DIVWAG MODEL DOCUMENTATION. VOLUME II. PROGRAMMER/ANALYST MANUA--ETC(U)
JUL 76
UNCLASSIFIED CACDA-TR-8-76-VOL-2-PT-3 NL

6 OF 7

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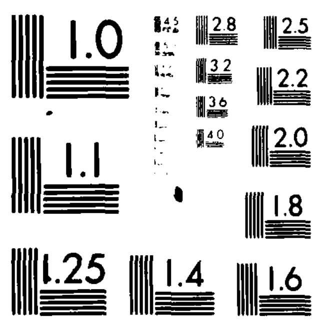


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(18)	Block 16.	If the item code (N), is ZERO, transfer to block L125.
(19)	Block 17,18	If this is not the first pass through this logic (have not called routine CONGET), call routine CONGET to obtain additional equipment from trains.
(20)	Block 19.	Calculate (for this consumable) the number of possible increments (MPOSBL).
(21)	Block 20.	If MPOSBL is greater than ZERO, transfer to block L124.
(22)	Block 21.	Save the expended consumables item code in ITMOUT array.
(23)	Block L124.	Determine the fewest number of possible increments (MINC).
(24)	Block L125.	If loop (A1) is not done, transfer to block 15.
(25)	Block 22.	Begin loop (B1) on two major items.
(26)	Block 23.	Get the first/next item code (N).
(27)	Block 24.	If the item code (N) is ZERO, transfer to block L150.
(28)	Block 25.	Considering exclusion, if there is a sufficient amount of this item, transfer to block L150.
(29)	Block 26.	Set the number of possible increments (MINC) to ZERO.
(30)	Block 27.	Save the expended major item's item code in the ITMOUT array.
(31)	Block L150.	If loop (B1) is not done, transfer to block 23.
(32)	Block 28.	If the equipment has been expended, including that which was in trains, transfer to block L225.
(33)	Block 29.	If the equipment has been expended, but that in trains has not been considered, transfer to block 14 for another try.
(34)	Block 30.	Does one increment take more than 5 minutes? If not, transfer to block L155.

(35)	Block 31.	Set the number of increments (NINC) to 1. Transfer to block L200.
(36)	Block L155.	Calculate the number of increments needed to finish (ICOMP).
(37)	Block 32.	Calculate the time required to finish (TCOMP).
(38)	Block 33.	If TCOMP is more than 7 minutes, transfer to block 35.
(39)	Block 34.	Set the number of increments (NINC) to ICOMP. Transfer to block L200.
(40)	Block 35.	Calculate the number of increments to do next 5 minutes (NINC). Transfer to block L200.
(41)	Block L175.	Set IMOD to 1.
(42)	Block 36.	Calculate the number of increments (NINC) based on the standard increment size (INC).
(43)	Block 37.	If INC is less than 50, transfer to block L200.
(44)	Block 38.	Set NINC to 1.
(45)	Block L200.	Calculate the time till the next event (TSKED).
(46)	Block 39.	Set the mode and .FORM. Transfer to block 40.
(47)	Block L225.	Set the mode to ZERO.
(48)	Block 40.	Call routine PUTRCD to return the unit's Unit Status File to Data File 1. RETURN to the calling routine.

65. ROUTINE NOWHAT.

a. Purpose. NOWHAT selects and sets up the reaction of a unit which has aborted a deliberate breach attempt.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
IDBP	TWO	File 39 index control word, located at IDUM (5).
ITBL(5,10)	DF39	Countermine decision table, located at IDUM (151).
ICMDTA(20,20)	DF39	Countermine data, located at IDUM (201).
LOPEN	TWO	Lanes open, located at IDUM (12).
FREEP	TWO	Free path, located at IDUM (13).
LWORK	TWO	Lanes under work, located at IDUM (9).
INC	TWO	Standard deliberate breach increment size, located at IDUM (27).
TINC	TWO	Time for a standard deliberate breach increment.
DLEFT	TWO	Depth left to clear, located at IDUM (6).
DOPEN	TWO	Depth cleared, located at IDUM (7).

c. Output Variables:

Name	Destination	Contents
M	CALL	Mode.
TSKED	CALL	Time until next event.
DEPFLD	TWO	Depth left to clear, located at IDUM (9).

IDBP	TWO	File 39 index control word, located at IDUM (5).
IFORM	TWO	GCM barrier encounter control word, located at IDUM (3).
INC	TWO	Standard deliberate breach increment size, located at IDUM (27).
IPART	TWO	Depth left to clear, located at IDUM (4).
LDES	TWO	Lanes desired, located at IDUM (10).
LSUF	TWO	Lanes sufficient, located at IDUM (11).
LWORK	TWO	Lanes under work, located at IDUM (9).
NINC	TWO	Number of increments, located at IDUM (29).
RMISS	TWO	Miss rate, located at IDUM (28).

d. Logical Flow (Figure IV-7-B-65)

(1) Block 1. Calculate the control words J and LL using IFORM.

(2) Block 2. If LL is 10, transfer to block L4000.

(3) Block 3. Call routine GETWRD to obtain the countermine decision table (ITBL) and other data (ICMDTA) from Data File 39.

(4) Block 4. Increment index (LL) into ITBL table and IDBP.

(5) Block 5. Determine the countermeasure mode (ICM).

(6) Block 6. If ICM is ZERO, transfer to block L4000.

(7) Block 7. If the mode (M) is 5, transfer to block L25.

(8) Block 8. Determine the number of lanes sufficient (LS1) and number of lanes desired (LD1).

(9) Block 9. If sufficient lanes exist, transfer to block L3000 for passage tgrough the minefield.

(10) Block 10. If there are not sufficient lanes, even considering those lanes under work, transfer to block L25.

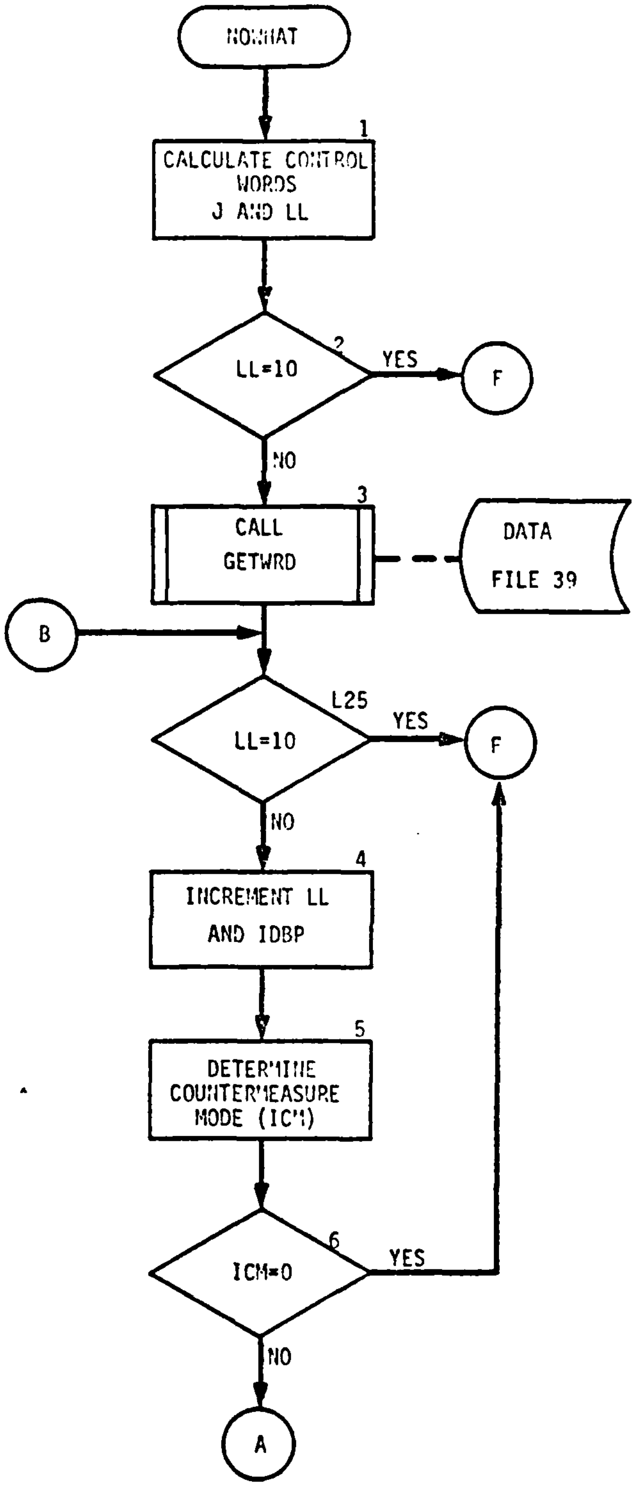
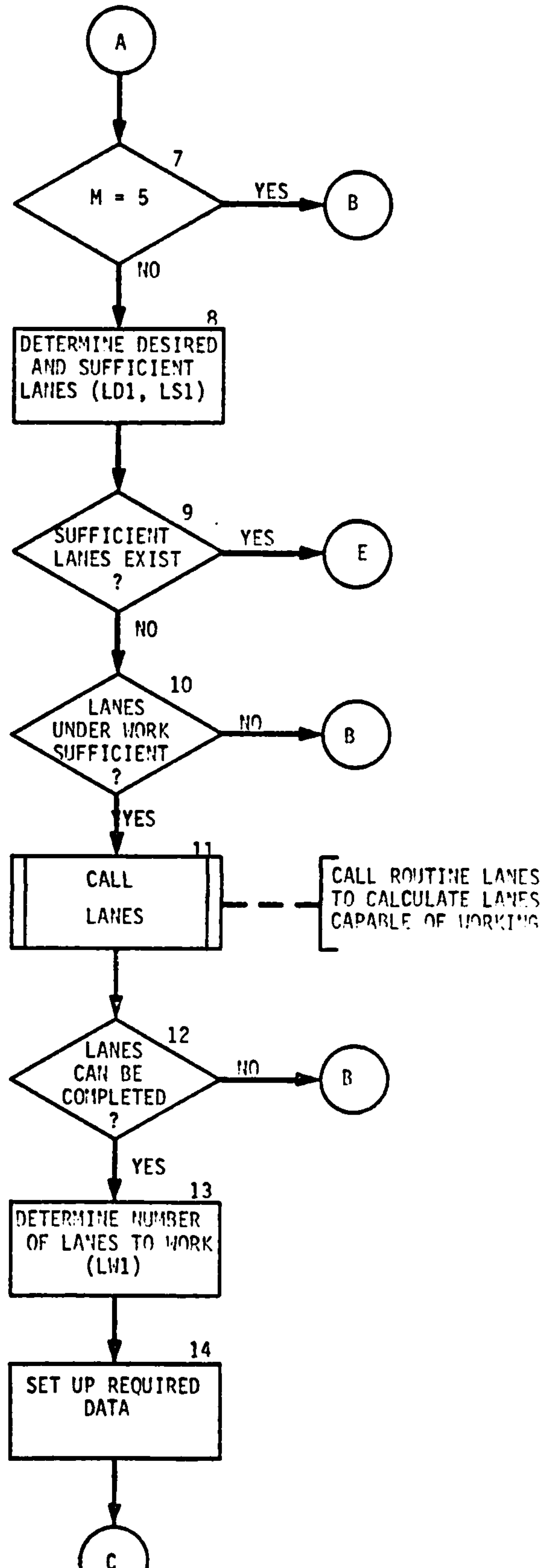
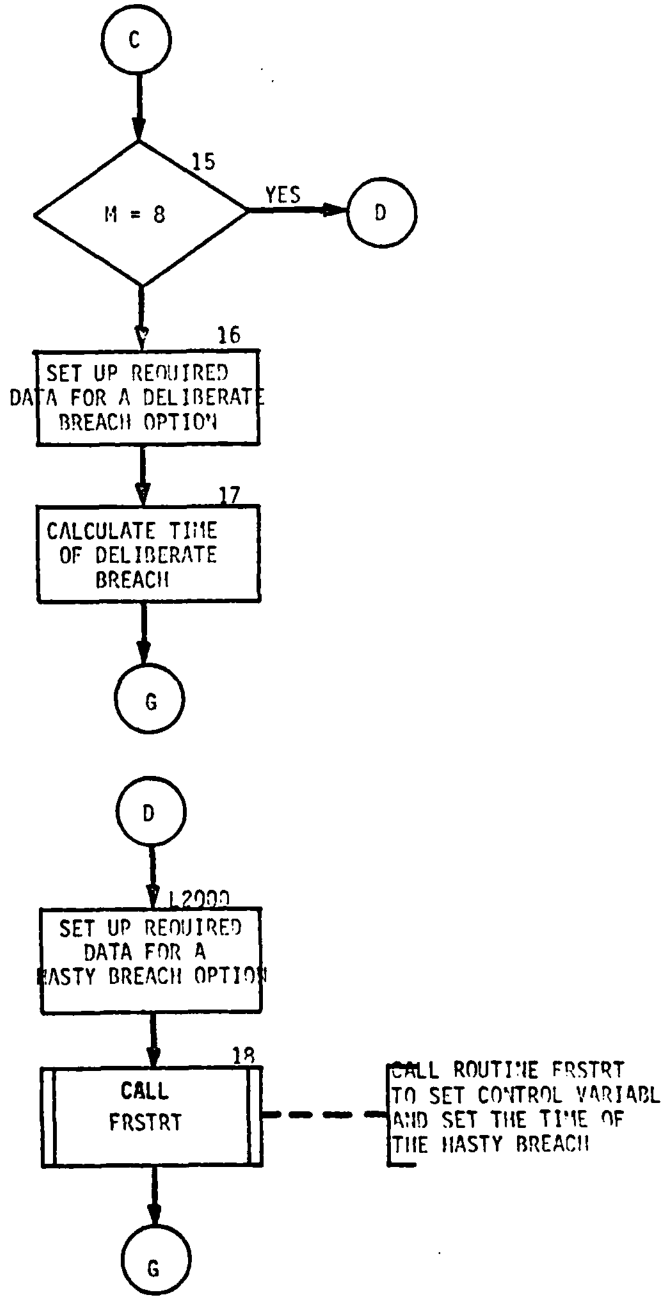
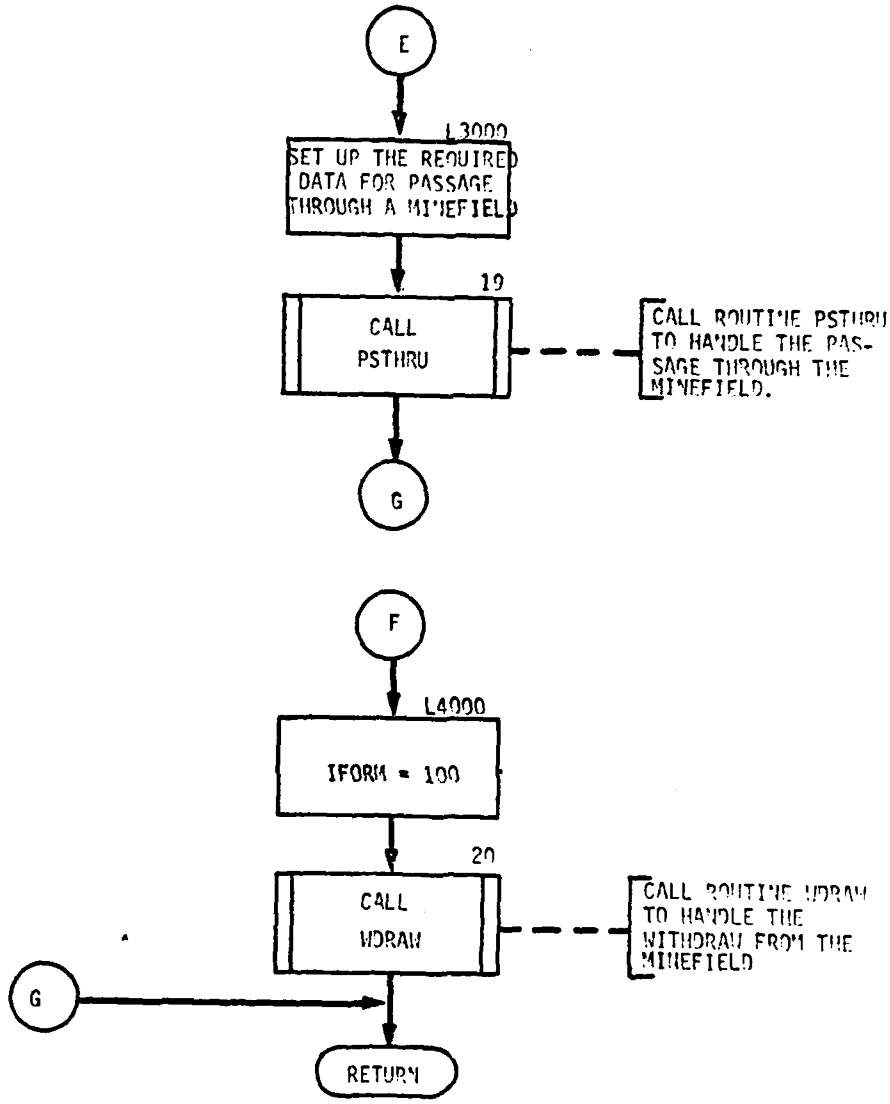


FIGURE IV-7-B-65 ROUTINE NOWHAT


A
7
M = 5
YES
B
NO
8
DETERMINE DESIRED AND SUFFICIENT LANES (LD1, LS1)
9
SUFFICIENT LANES EXIST ?
YES
E
NO
10
LANES UNDER WORK SUFFICIENT ?
NO
B
YES
11
CALL LANES
CALL ROUTINE LANES TO CALCULATE LANES CAPABLE OF WORKING
12
LANES CAN BE COMPLETED ?
NO
B
YES
13
DETERMINE NUMBER OF LANES TO WORK (LW1)
14
SET UP REQUIRED DATA
C


C
15
M = 8
YES
D
16
SET UP REQUIRED DATA FOR A DELIBERATE BREACH OPTION
17
CALCULATE TIME OF DELIBERATE BREACH
G
D
L2000
SET UP REQUIRED DATA FOR A HASTY BREACH OPTION
18
CALL FRSTRT
CALL ROUTINE FRSTRT TO SET CONTROL VARIABL AND SET THE TIME OF THE HASTY BREACH
G


E
L3000
SET UP THE REQUIRED DATA FOR PASSAGE THROUGH A MINEFIELD
19
CALL PSTHRU
CALL ROUTINE PSTHRU TO HANDLE THE PASSAGE THROUGH THE MINEFIELD.
G
F
L4000
IFORM = 100
20
CALL WDRAW
CALL ROUTINE WDRAW TO HANDLE THE WITHDRAW FROM THE MINEFIELD
G
RETURN

(11) Block 11. Call routine LANES to calculate the lanes that can be worked with equipment available.

(12) Block 12. If there is insufficient equipment available to complete the lanes, transfer to block L25.

(13) Block 13. Calculate the number of lanes to work (LW1).

(14) Block 14. Set up the required data for options.

(15) Block 15. If the mode is 8, transfer to block L2000.

(16) Block 16. Set up the required data for a deliberate breach attempt.

(17) Block 17. Calculate the time of the deliberate breach. RETURN to the calling routine.

(18) Block L2000. Set up the required data for a hasty breach attempt.

(19) Block 18. Call routine FRSTRT to set up the control variable for, and calculate the time of the hasty breach attempt. RETURN to the calling routine.

(20) Block L3000. Set up the required data for passage through the minefield.

(21) Block 19. Call routine PSTHRU to handle the unit's passage through the minefield. RETURN to the calling routine.

(22) Block L4000. Get IFORM to 100.

(23) Block 20. Call routine WDRAW to handle the withdraw from the minefield. RETURN to the calling routine.

66. ROUTINE GC9CON

a. Purpose. GC9CON updates the unit's Unit Status File and schedules mortar fire.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
ITBL(16,4)	TWO	GCM Battle Control Table, located at IDUM (4035).
ITALLY(256)	DF21	GCM battle records, located at IDUM (131).
LOSS(10,200)	DF6	Secondary equipment file, located at IDUM (801).
WMPARM(36,11)	DF25	Tacfire data, located at IDUM (401).
IEOHS(10)	DF16	Item codes required by USFUP, located at IDUM (51).

c. Output Variables:

Name	Destination	Contents
EQP(50)	TWO	Equipment item codes, located at IDUM (1).
IDXATT	TWO	Attacker's index into ITBL, located at IDUM (4033).
IDXDEF	TWO	Defender's index into ITBL, located at IDUM (4032).
ITBL(16,4)	TWO	GCM Battle Control Table, located at IDUM (4035).
UMAIN(500)	DF1	Unit Status File.

d. Logical Flow (Figure IV-7-B-66)

(1) Block 1. Initialize required variables.

(2) Block 2. Begin loop (A1) on attackers in ITBL.

(3) Block 3. Determine the first/next attacker's IUID (if any).

(4) Block 4. Call routine GETRCD to obtain this unit's Unit Status File from Data File 1.

(5) Block 5. Call routine GETRCD to obtain the GCM battle records from Data File 21.

(6) Block 6. If this is not the first time through this loop

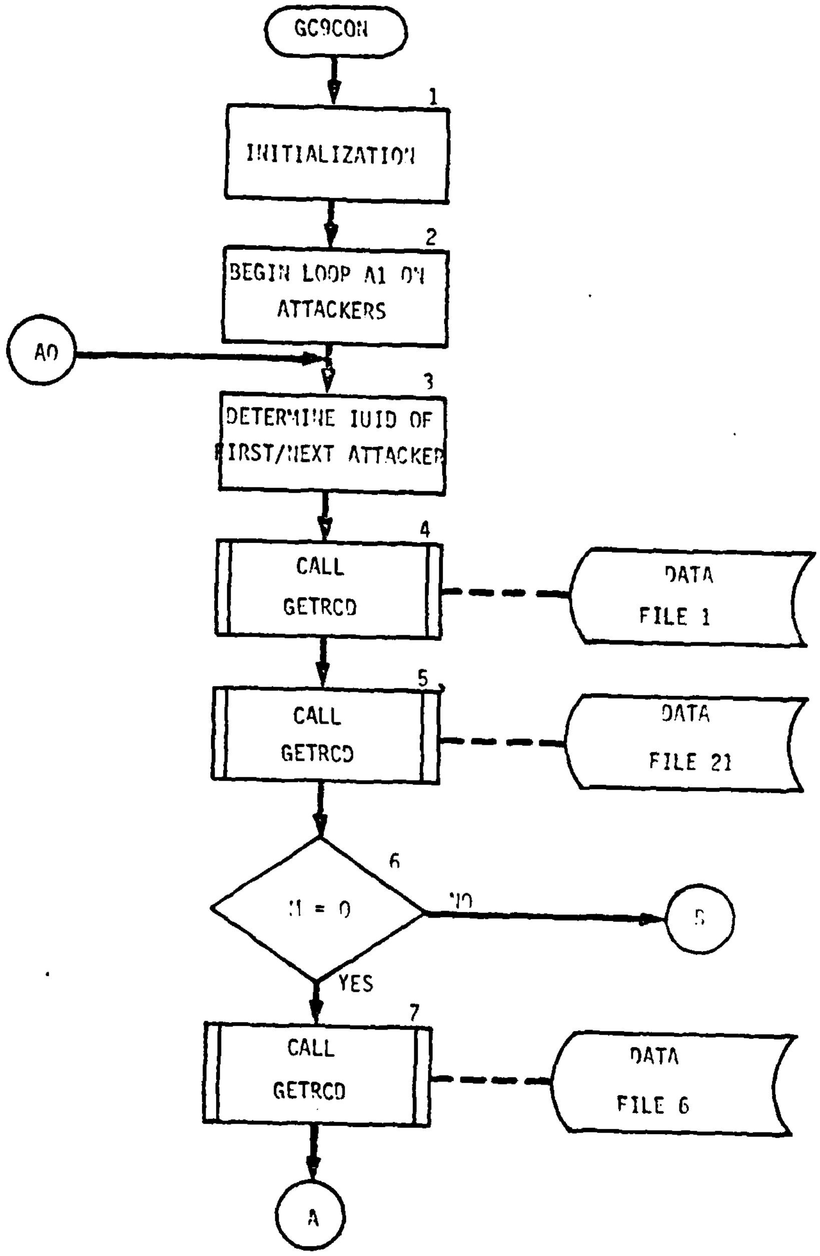
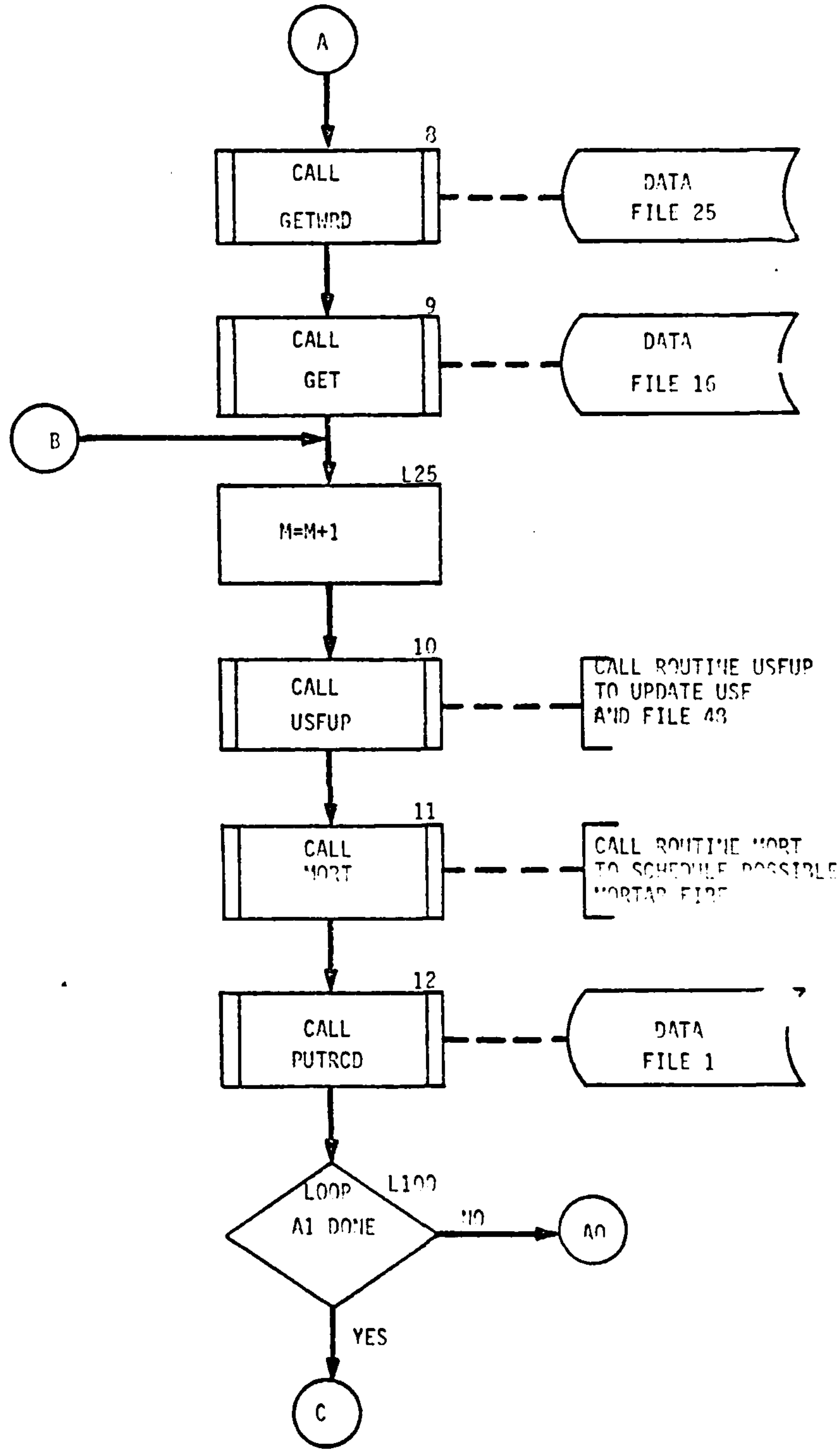
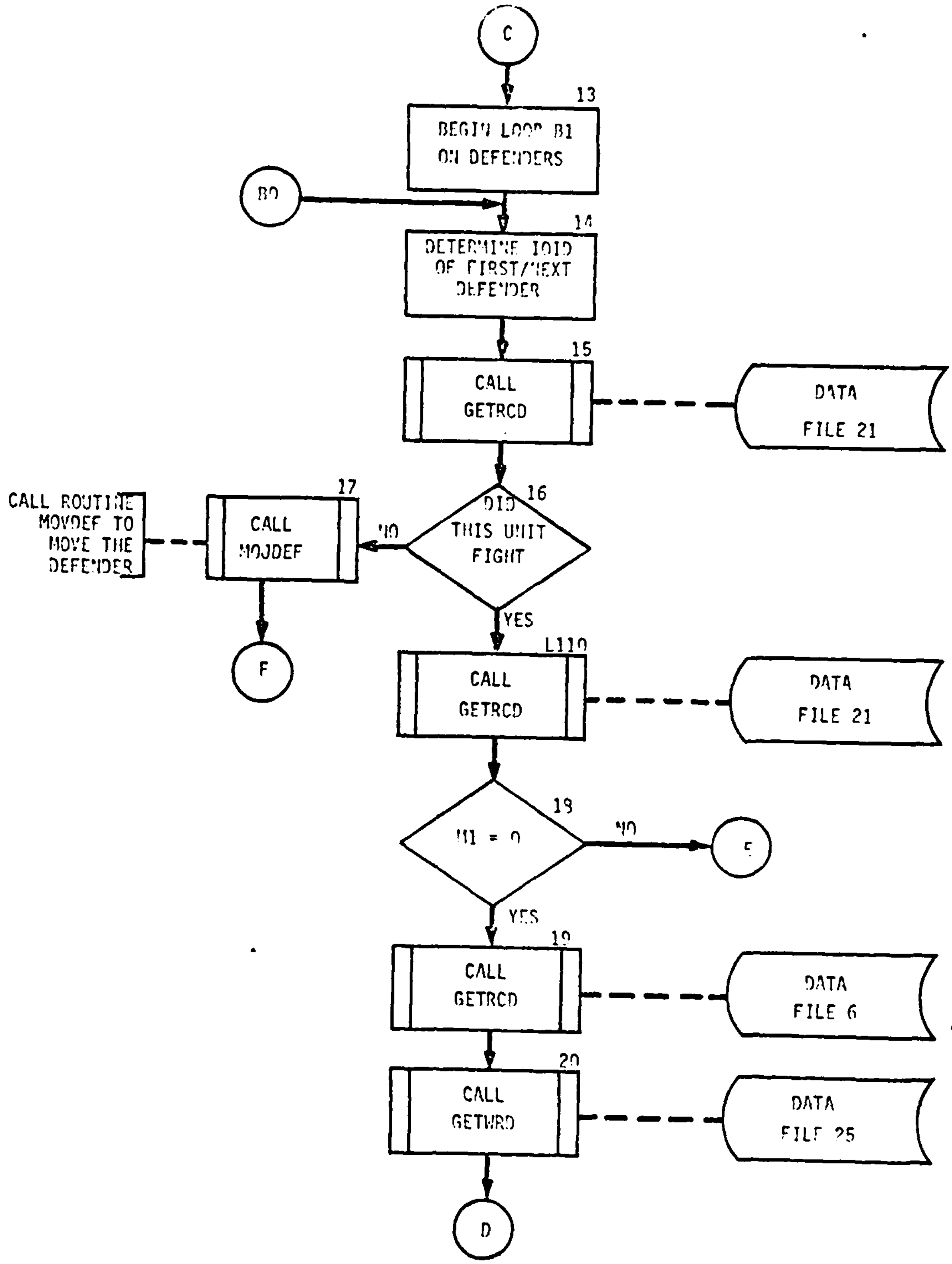
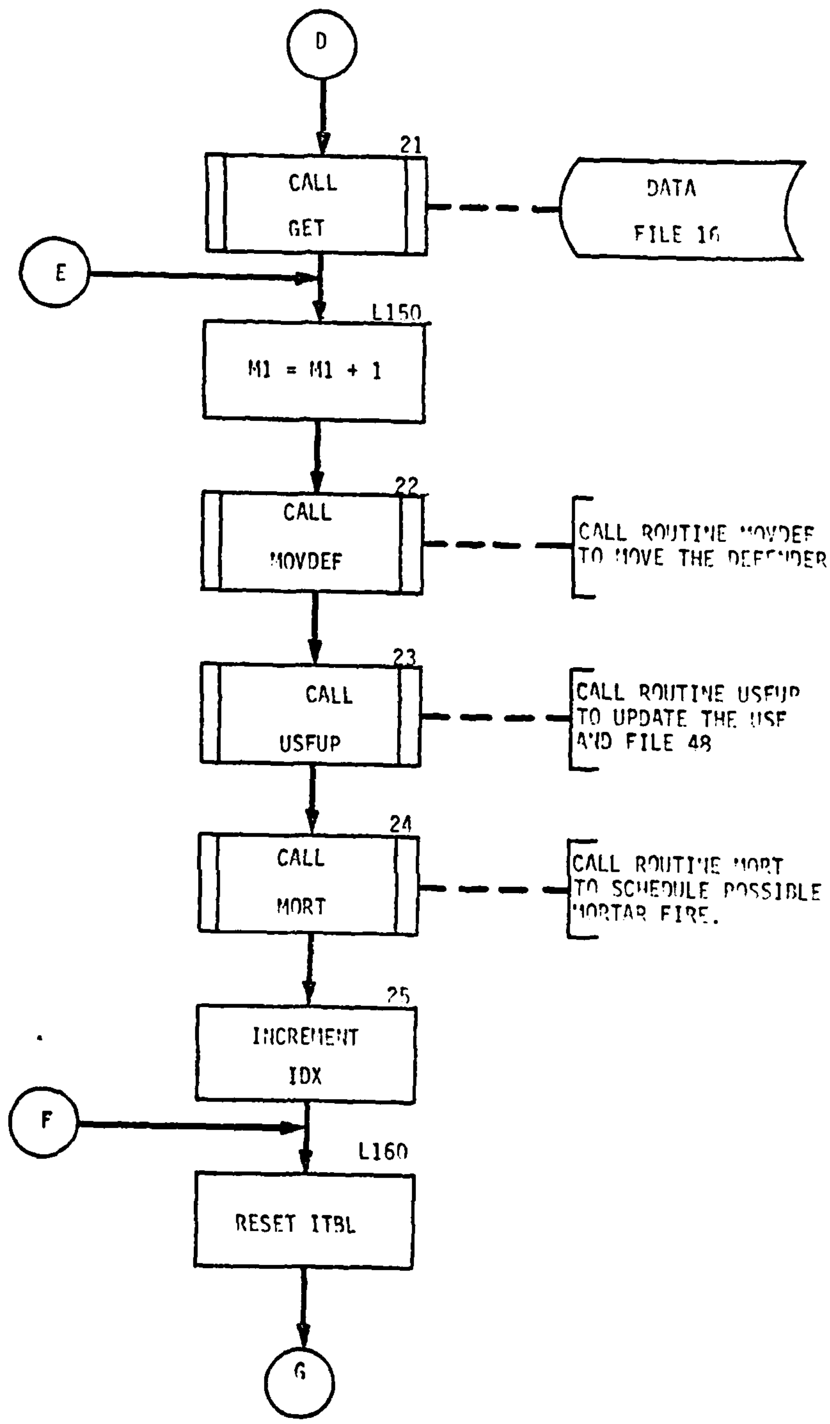


FIGURE IV-7-B-66 ROUTINE GC9CON

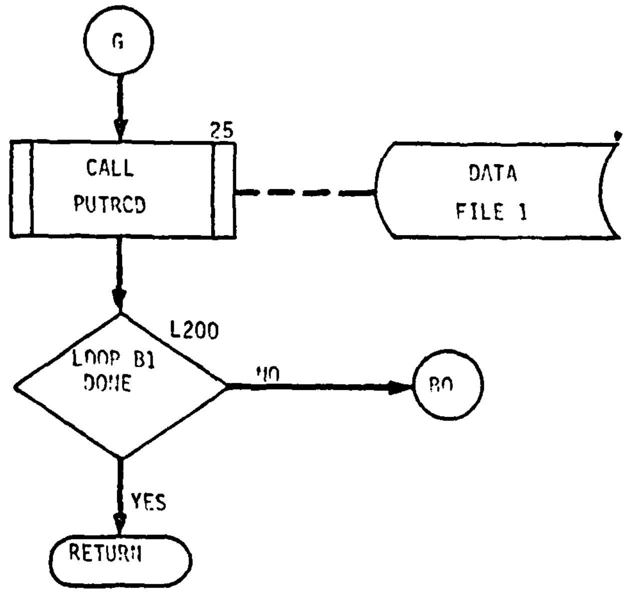


A
CALL
GETWRD
8
DATA
FILE 25
CALL
GET
9
DATA
FILE 16
B
L25
M=M+1
10
CALL
USFUP
CALL ROUTINE USFUP
TO UPDATE USF
AND FILE 48
11
CALL
MORT
CALL ROUTINE MORT
TO SCHEDULE POSSIBLE
MORTAR FIRE
12
CALL
PUTRCD
DATA
FILE 1
L100
LOOP
A1 DONE
NO
AO
YES
C


C
13
BEGIN LOOP B1
ON DEFENDERS
B0
14
DETERMINE IOID
OF FIRST/NEXT
DEFENDER
15
CALL
GETRCD
DATA
FILE 21
17
CALL ROUTINE
MOVDEF TO
MOVE THE
DEFENDER
CALL
MOVDEF
NO
16
DID
THIS UNIT
FIGHT
F
YES
L110
CALL
GETRCD
DATA
FILE 21
18
N1 = 0
NO
YES
19
CALL
GETRCD
DATA
FILE 6
20
CALL
GETWRD
DATA
FILE 25
D



D
21
CALL
GET
DATA
FILE 16
E
L150
M1 = M1 + 1
22
CALL
MOVDEF
CALL ROUTINE MOVDEF TO MOVE THE DEFENDER
23
CALL
USFUP
CALL ROUTINE USFUP TO UPDATE THE USF AND FILE 48
24
CALL
MORT
CALL ROUTINE MORT TO SCHEDULE POSSIBLE MORTAR FIRE.
25
INCREMENT
IDX
F
L160
RESET ITBL
G


G
25
CALL
PUTRCD
DATA
FILE 1
L200
LOOP B1
DONE
NO
BO
YES
RETURN

(M ≠ 0), then the working data for this force is already available (transfer to block L25).

(7) Block 7. Call routine GETRCD to get the secondary equipment file from Data File 6.

(8) Block 8. Call routine GETWRD to obtain the tacfire data from Data File 25.

(9) Block 9. Call routine GET to obtain the item code lists from Data File 16.

(10) Block L25. Increment M (loop counter).

(11) Block 10. Call routine USFUP to update the Unit Status File of this attacker, File 48 scoreboard, and history tape records.

(12) Block 11. Call routine MORT to schedule possible mortar fire against opposing unit.

(13) Block 12. Call routine PUTRCD to returning the updated Unit Status File for this attacker to Data File 1.

(14) Block L100. If loop (A1) is not done, transfer to block 3.

(15) Block 13. Begin loop (B1) on defenders in ITBL.

(16) Block 14. Determine the IUID of the first/next defender.

(17) Block 15. Call routine GETRCD to get the Unit Status File for this defender from Data File 1.

(18) Block 16. If this defender engaged in battle this increment, transfer to block L110.

(19) Block 17. Call routine MOVDEF to move the defending unit. Transfer to block L160.

(20) Block L110. Call routine GETRCD to obtain the GCM battle records from Data File 21.

(21) Block 18. If this is not the first time throught this loop (M1 ≠ 0), then the working data for this force is already available (transfer to block L150.)

(22) Block 19. Call routine GETRCD to obtain the secondary equipment file from Data File 6.

(23)	Block 20.	Call routine GETWRD to obtain the tacfire data from Data File 25.
(24)	Block 21.	Call routine GET to obtain the item code lists from Data File 16.
(25)	Block L150.	Increment M1 (loop counter).
(26)	Block 22.	Call routine MOVDEF to move the defender.
(27)	Block 23.	Call routine USFUP to update the Unit Status File, File 48 scoreboard, and history tape records.
(28)	Block 24.	Call routine MORT to schedule possible mortar fire.
(29)	Block 25.	Increment IDX array to indicate the defender was updated.
(30)	Block L100.	Reset ITBL array.
(31)	Block 26.	Call routine PUTRCD to return the Unit Status File of the defender to Data File 1.
(32)	Block L200.	If loop (B1) is not done, transfer to block 14, otherwise RETURN to the calling routine.

67. ROUTINE USFUP.

a. Purpose. USFUP updates the Unit Status File and File 48 scoreboard, and creates a history tape record.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
IEOHT(8)	TWO	Item codes for target weapon systems, located at IDUM (61).
TOTCL(8)	TWO	Total losses to weapon systems, located at IDUM (163).
IEOHW(16)	TWO	Ammo item codes, located at IDUM (69).
TOTRL(16)	TWO	Total round losses, located at IDUM (131).

c. Output Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Destination	Contents
TOTPL	TWO	Total personnel losses, located at IDUM (69).
TOTCL(8)	TWO	Total weapon system losses, located at IDUM (163).
TOTRL(16)	TWO	Total ammo losses, located at IDUM (131).

d. Logical Flow (Figure IV-7-B-67).

(1) Block 1. Initialize required variables.

(2) Block 2. Put weapon system losses into IOUT array limiting losses to the amount on hand.

(3) Block 3. Subtract one-half the ammo losses from the amount of ammo on hand.

(4) Block 4. Call routine EOH2OT to calculate number of secondary equipment losses and put them in IOUT array.

(5) Block 5. Update the current personnel strength (can not lose more than there are currently).

(6) Block 6. Call routine SCORE to store the losses on Data File 48 (Scoreboard File).

(7) Block 7. Subtract equipment losses from the Unit Status File (can not lose more than is on hand).

(8) Block 8. Subtract ammo losses from the Unit Status File (can not lose more than is on hand).

(9) Block 9. Call routine OUTSET to create a history tape record (#321) using information in IOUT array. RETURN to the calling routine.

68. ROUTINE MORT.

a. Purpose. Upon request from the GCM submodel this routine reviews the incoming sensing report on a GCM opposed unit and determines if mortar

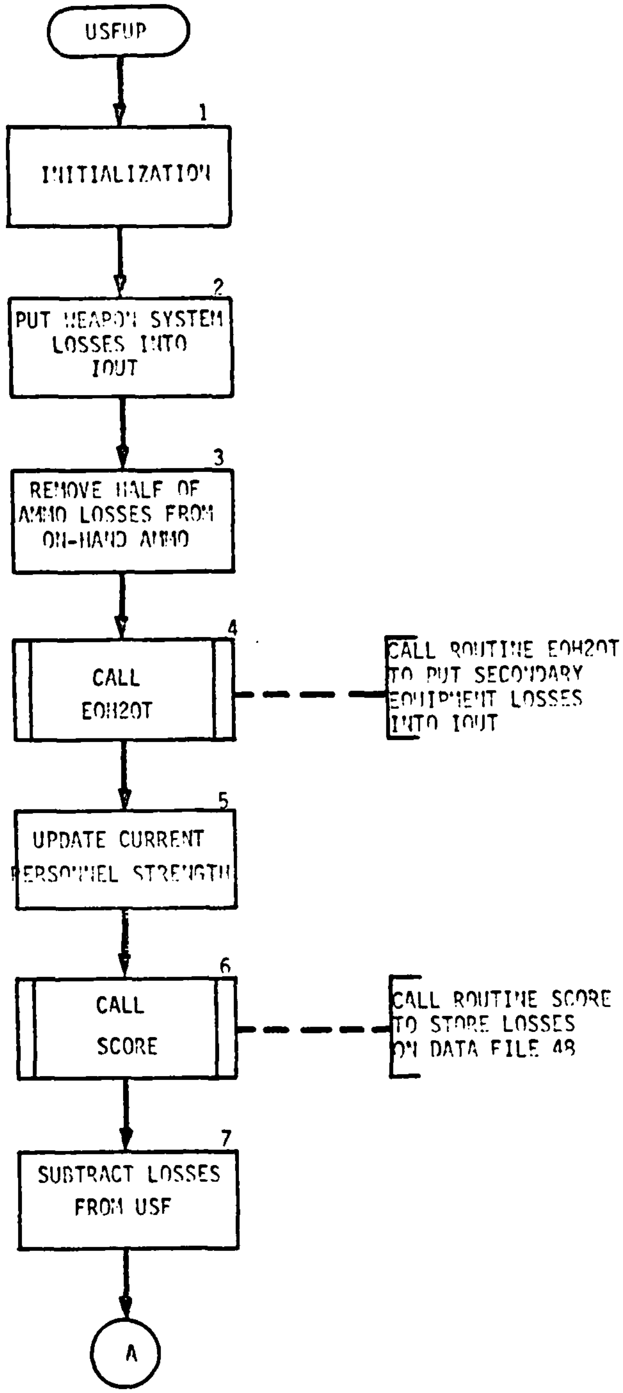
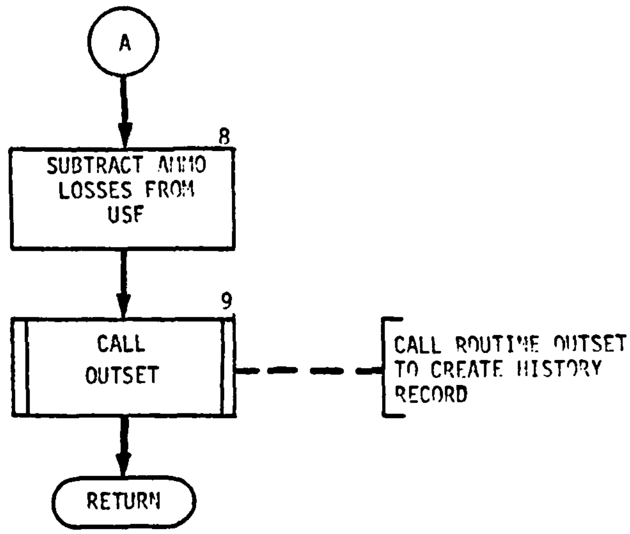


FIGURE IV-7-B-67 ROUTINE USFUF


A
8
SUBTRACT AMMO LOSSES FROM USF
9
CALL OUTSET
CALL ROUTINE OUTSET TO CREATE HISTORY RECORD
RETURN

fire should be directed against it. If so, and mortars are available to fire, a mortar fire event is scheduled.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
SENSD(7,17)	TWO	Sensing report information on the target unit.
WMPARM(36,11)		Mortar weapon characteristics.

c. Output Variables.

Name	Destination	Contents
FILE12(35)	DF12	Information on the mortar fire mission.

d. Logical Flow (Figure IV-7-B-68).

(1) Block 1. Get the weapon/munition parameter table from Data File 25.

(2) Block L1000. Identify the type and quantity of mortars and respective rounds which are avaible to fire.

(3) Block L1050. If no mortars are available abort request, otherwise continue processing.

(4) Block 2. From the sensor detection data determine the number of personnel sensed in the opposing unit.

(5) Block 3. If the number of detected personnel is less than 5 abort request.

(6) Block 4. Based on the time of the last GCM iteration for this attacker/defender pair and the quantity of personnel detected, determine the detection time.

(7) Block 5. Determine which mortar will fire as a function of range to the target, mortar characteristics, and number of available rounds.

(8) Block 6. Determine the number of tubes and rounds to participate in firing event.

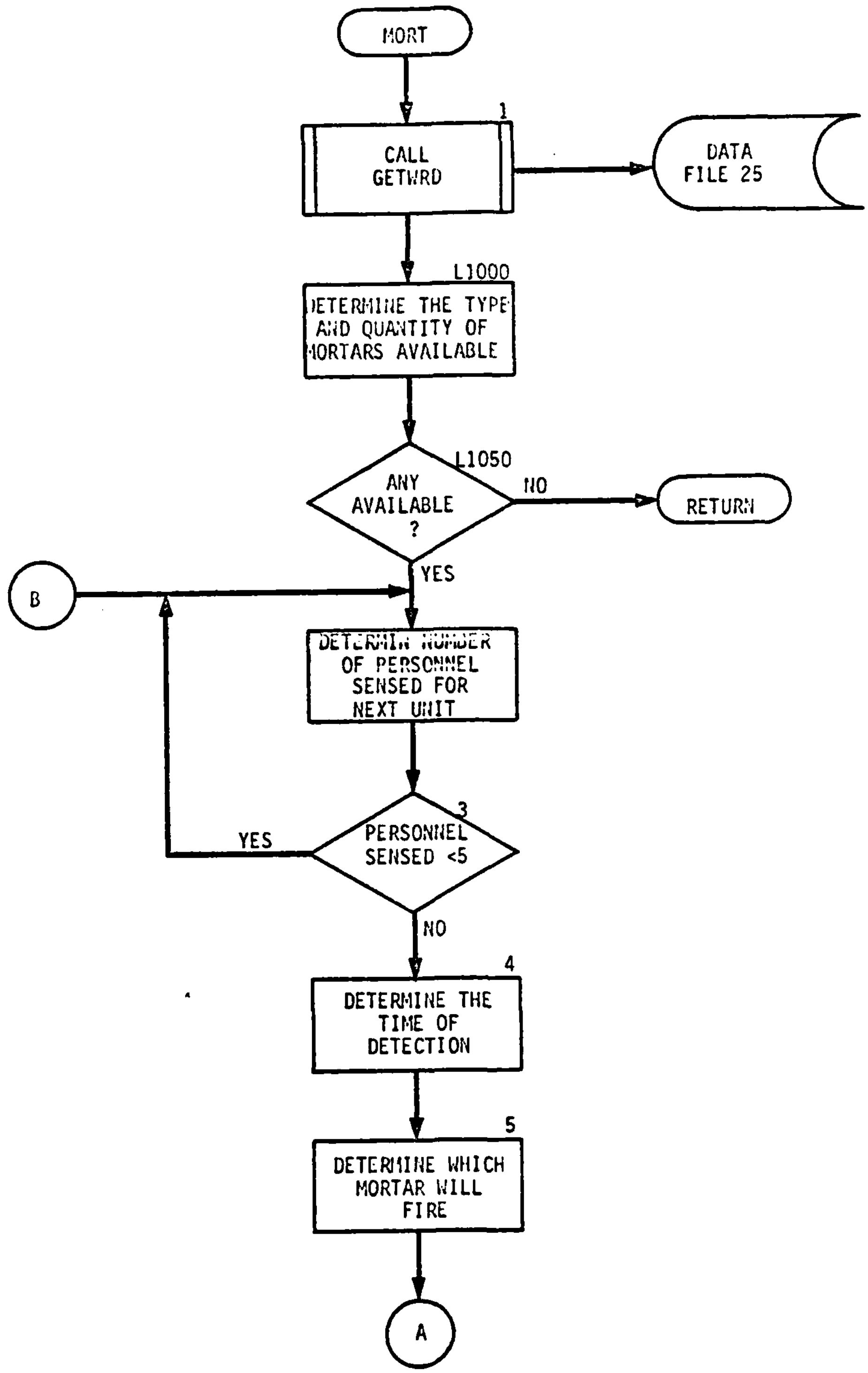
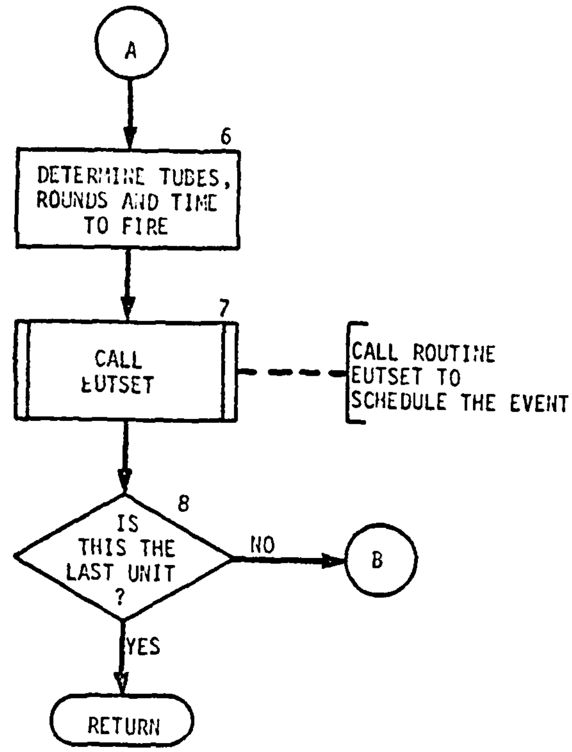


FIGURE IV-7-B-68 ROUTINE MORT


A
6
DETERMINE TUBES, ROUNDS AND TIME TO FIRE
7
CALL EUTSET
CALL ROUTINE EUTSET TO SCHEDULE THE EVENT
8
IS THIS THE LAST UNIT ?
NO
B
YES
RETURN

(9) Block 7. Build a data array containing pertinent information about the target and mortar data required by the assessment routines.

(10) Block 8. If any other target units were indicated by the sensing report branch to block 2 and repeat logic steps above, otherwise terminate processing.

69. ROUTINE MOVDEF.

a. Purpose. MOVDEF moves a defender based on his movement rate and time of movement.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
ITLST	CALL	Time of last GCM increment.

c. Output Variables.

(1) Standard Common Block Variables.

(2) Other Variables:

None.

d. Logical Flow (Figure IV-7-B-69).

(1) Block 1. Set the unit's previous coordinates (XACTL, YACTL) to (XACT, YACT).

(2) Block 2. If the unit is not moving (MURATE = 0) or the time of the last GCM increment is more than TCLOCK, RETURN to the calling routine.

(3) Block 3. Calculate the distance to the objective (DIST).

(4) Block 4. Calculate the time of this move segment (TMOV).

(5) Block 5. Calculate the distance to move this move segment (DMOV).

(6) Block 6. Calculate the fraction of the total move to the objective which can be completed this move segment (FRAC).

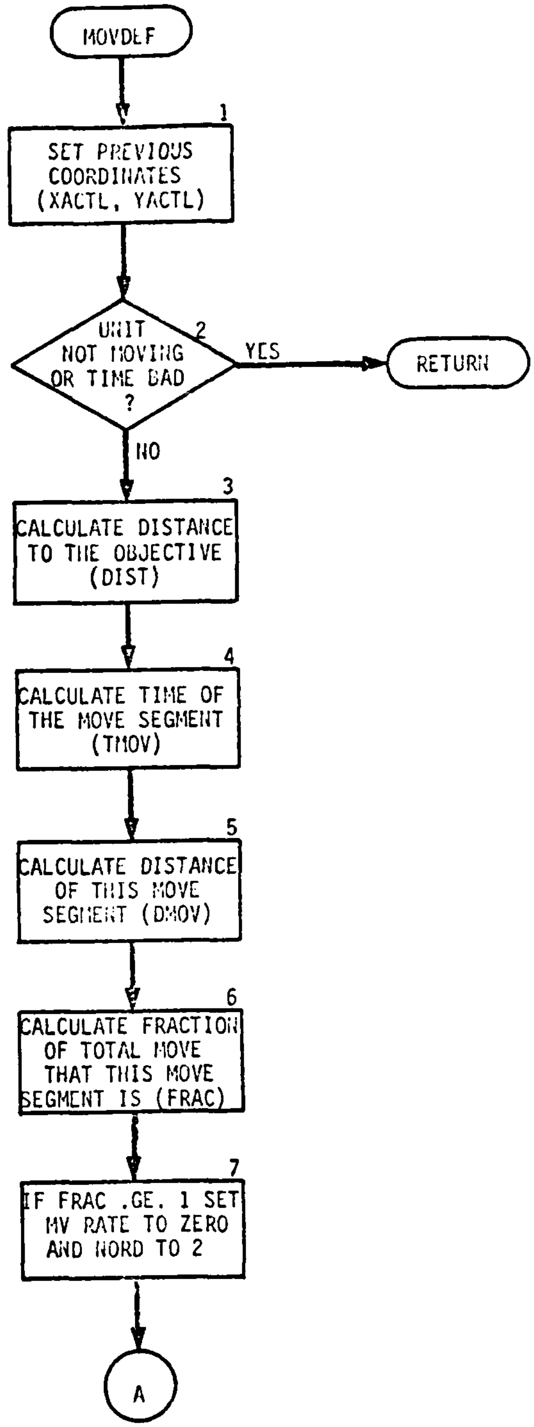
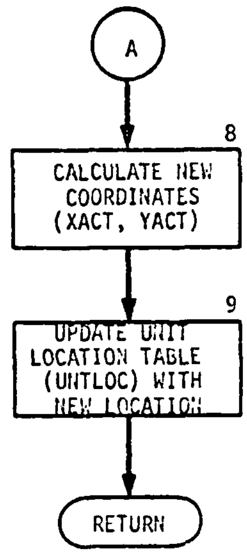


FIGURE IV-7-B-69 ROUTINE MOVDEF


A
8
CALCULATE NEW COORDINATES (XACT, YACT)
9
UPDATE UNIT LOCATION TABLE (UNTLOC) WITH NEW LOCATION
RETURN

(7) Block 7. If FRAC is greater than or equal to 1 (move can be completed this move segment), set the unit's movement rate to ZERO and give him a PREPARE order (NORT = 2).

(8) Block 8. Calculate the new coordinates (XACT, YACT).

(9) Block 9. Update the unit's location in the Unit Location Table (UNTLOC). RETURN to the calling routine.

70. ROUTINE OUTSET.

a. Purpose. OUTSET fills the array IOUT and calls the routine PUTOUT to create the history record with this data.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
EQP(50)	TWO	Equipment item code types, located at IDUM (1).
PERS	CALL	Present strength.

c. Output Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

None.

d. Logical Flow (Figure IV-7-B-70).

(1) Block 1. Fill IOUT (1-16) and ZERO out IOUT (231-242).

(2) Block 2. Total the amounts of 5 different categories (Tanks, APCs, Vehicles, Aircraft, and AD weapons) on hand initially and finally and put in IOUT (232-236, 238-242).

(3) Block 3. Determine the number of personnel on hand initially and finally and out in IOUT (231) and IOOT (237).

(4) Block 4. Call routine OUTPUT to actually create the history tape record using this data in IOUT array. RETURN to the calling routine.

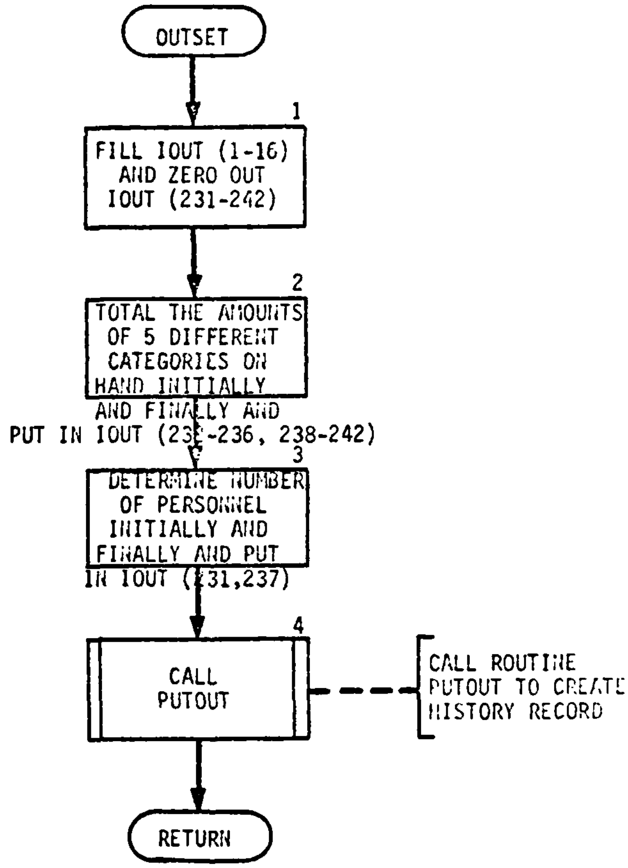


FIGURE IV-7-B-70 ROUTINE OUTSET

71. ROUTINE GEND.

a. Purpose. GEND is responsible for the final operations of the GCM model prior to completion of the battle increment. GEND updates the Unit Status Files (if necessary) and schedules the next events for the engaging units.

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
IGO	TWO	Termination condition flag, located at IDUM (4101).
ITBL(64)	TWO	GCM Battle Control Table, located at IDUM (4035).

c. Output Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Destination	Contents
ITBL(64)	DF21	GCM Battle Control Table, located at IDUM (4035).

d. Logical Flow (Figure IV-7-B-71).

(1) Block 1. Is IGO 1 or 2? If not, RETURN to the calling routine.

(2) Block 2. If IGO is not 2, transfer to block 3.

(3) Block L300. Call routine TRMCK to check for battle termination, RETURN to the calling routine.

(4) Block 3. Save the battle ID (BATID).

(5) Block 4. Call routine DBSR to check for battle completion.

(6) Block 5. If the battle is completed, transfer to block L200.

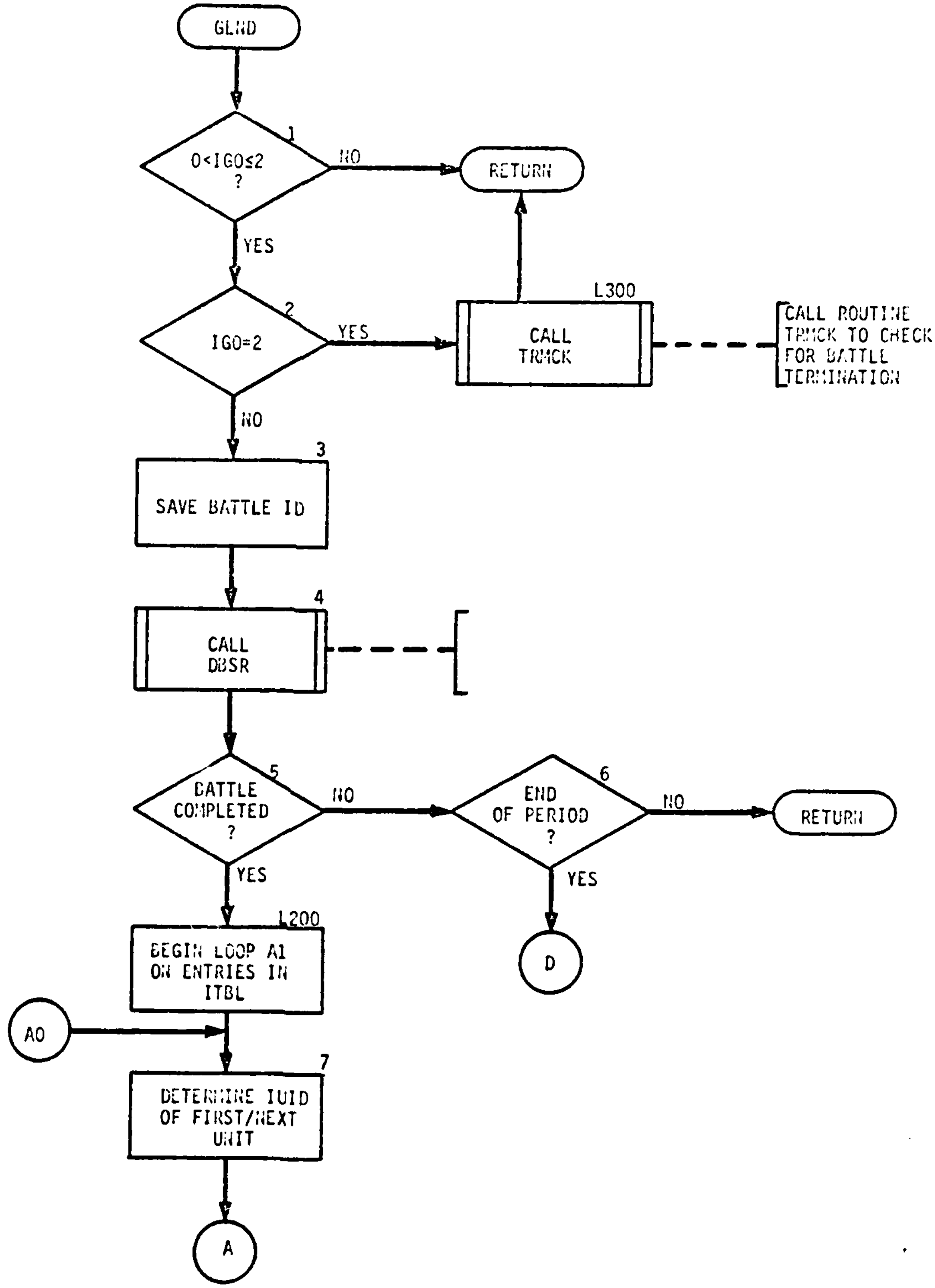
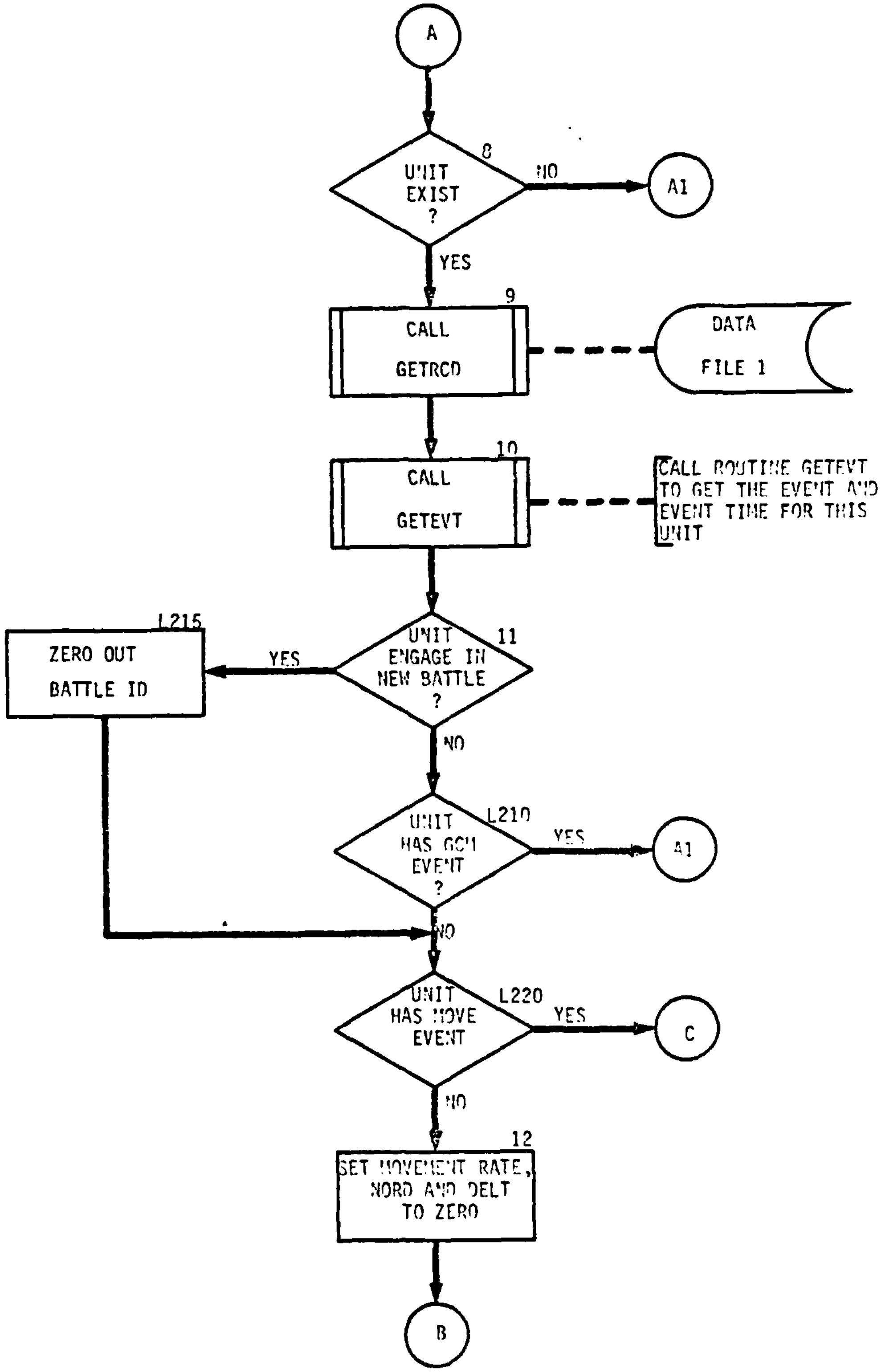
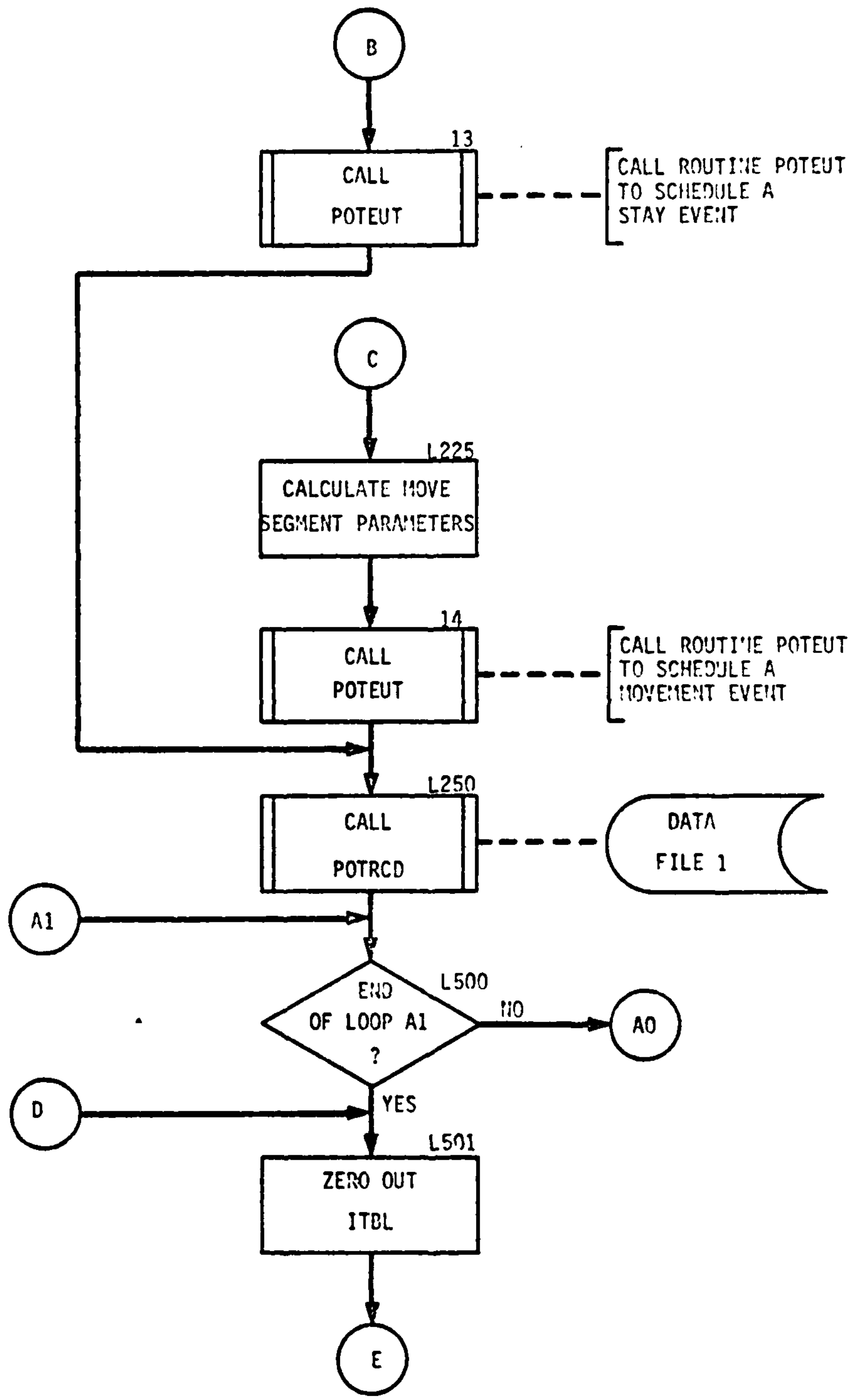
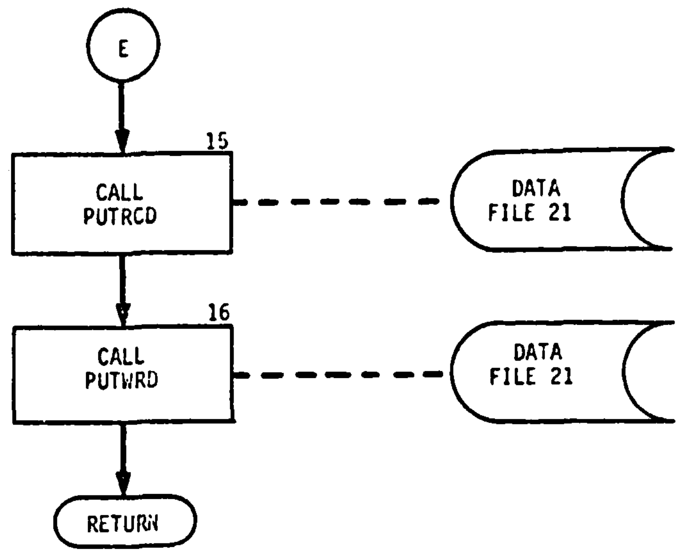


FIGURE IV-7-B-71 ROUTINE GEND


A
8
UNIT EXIST ?
NO
A1
YES
9
CALL GETRCD
DATA FILE 1
10
CALL GETEVT
CALL ROUTINE GETEVT TO GET THE EVENT AND EVENT TIME FOR THIS UNIT
L215
ZERO OUT BATTLE ID
YES
UNIT ENGAGE IN NEW BATTLE ?
11
NO
UNIT HAS GCM EVENT ?
L210
YES
A1
NO
UNIT HAS MOVE EVENT
L220
YES
C
NO
12
SET MOVEMENT RATE, NORD AND DELT TO ZERO
B


B
13
CALL
POTEUT
CALL ROUTINE POTEUT
TO SCHEDULE A
STAY EVENT
C
L225
CALCULATE MOVE
SEGMENT PARAMETERS
14
CALL
POTEUT
CALL ROUTINE POTEUT
TO SCHEDULE A
MOVEMENT EVENT
L250
CALL
POTRCD
DATA
FILE 1
A1
END
OF LOOP A1
?
L500
NO
A0
YES
D
L501
ZERO OUT
ITBL
E


E
15
CALL
PUTRCD
DATA
FILE 21
16
CALL
PUTWRD
DATA
FILE 21
RETURN

(7) Block 6. If it is the end of the period, transfer to block L501; otherwise RETURN to the calling routine.

(8) Block L200. Begin loop (A1) on attackers and defenders in ITBL array.

(9) Block 7. Determine the first/next unit in ITBL.

(10) Block 8. If there is no unit (IUNT = 0), transfer to block L500.

(11) Block 9. Call routine GETRCD to get the unit's Unit Status File from Data File 1.

(12) Block 10. Call routine GETEVT to obtain this unit's next event (LKE) and event time (LKT).

(13) Block 11. If the unit is engaged in a new battle, transfer to block L215.

(14) Block L210. If the next event for this unit is a GCM event, transfer to block L500. If it is not a GCM event, transfer to block L220.

(15) Block L215. ZERO out the Battle ID (BATID).

(16) Block L220. If the unit's next event is a movement event, transfer to block L225.

(17) Block 12. Set the units movement rate, NORD, and DELT to ZERO.

(18) Block 13. Call routine PUTEVT to schedule a STAY event for this unit. Transfer to block L250.

(19) Block L225. Calculate the movement segment parameters.

(20) Block 14. Call routine PUTEVT to schedule a MOVE event for this unit.

(21) Block L250. Call routine PUTRCD to return the unit's Unit Status File to Data File .

(22) Block L500. If loop (A1) is not done, transfer to block 7.

(23) Block L501. ZERO out ITBL.

(24) Block 15. Call routine PUTRCD to return the GCM Battle Control Table to Data File 21.

(25) Block 16. Call routine PUTWRD to return control words to Data File 21. RETURN to the calling routine.

72. ROUTINE TRMCK.

a. Purpose. TRMCK determines if the indicated battle is completed (IOVER = 1 - YES IOVER = 0 - NO).

b. Input Variables:

(1) Standard Common Block Variables.

(2) Other Variables:

Name	Source	Contents
BID(2)	CALL	Battle ID.
UBT(4,1)	DF55	Battle pointers, located at IDUM (21).
OARY(21,1)	DF55	Battle paragraph, located at IDUM (1000).
BATPT	DSL	Index into File 55.
UNTPT	DSL	Index into File 55.

c. Output Variables:

Name	Destination	Contents
IOVER	CALL	Termination condition flag.

d. Logical Flow (Figure IV-7-B-72).

(1) Block 1. Calculate index into Data File 55.

(2) Block 2. Call routine GETRCD to get the Battle pointers (URT) and Battle Table from Data File 55.

(3) Block 3. Find the Battle ID (BID) in the Battle Table.

(4) Block 4. If the Battle ID was not found, RETURN to the calling routine.

(5) Block L2050. Save the Battle pointers.

(6) Block 5. Call routine GETRCD to get the Battle paragraph from Data File 55.

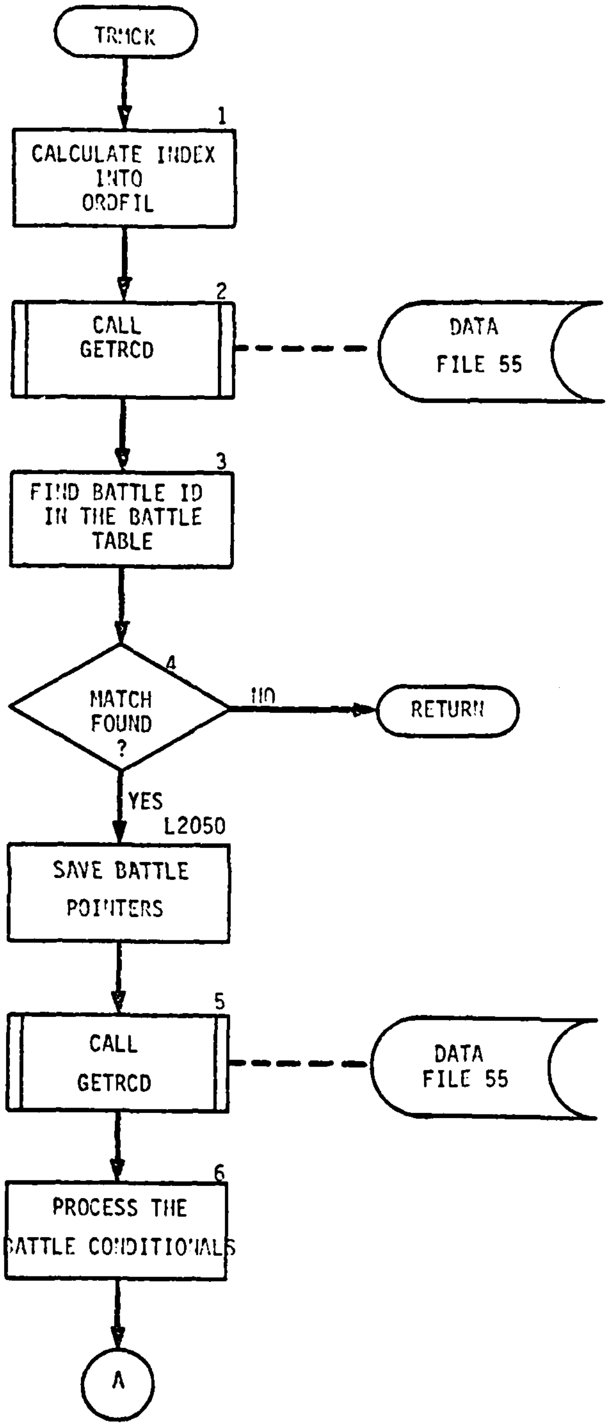
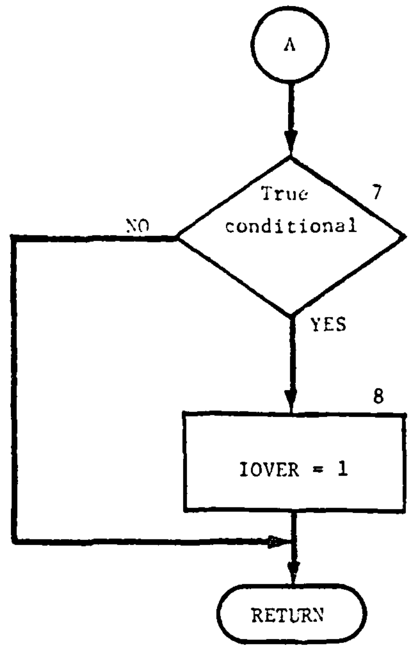


FIGURE IV-7-B-72 ROUTINE TRMCK


A
True conditional
7
NO
YES
8
IOVER = 1
RETURN

(7) Block 6. Process the conditionals in the Battle paragraph for true conditions.

(8) Block 7. If a true conditional was not found, RETURN to the calling routine.

(9) Block 8. Set IOVER = 1 (battle is completed) and RETURN to the calling routine.

APPENDIX C

GROUND COMBAT MODEL OUTPUT DESCRIPTIONS

1. INTRODUCTION. This appendix contains samples and detailed descriptions of printed output from the Ground Combat Model of the Period Processor. Ground Combat Model print statements appear in the Period Processor printout as one complete set for each battle increment. For the purpose of discussion this set of prints will be divided into three segments. Each segment gives information on a particular phase of the ground combat battle. A figure depicts the format of each segment. In the figures, a number or an alphabetical character (descriptor) designates an appropriate line, group of lines, or column that is explained in the following paragraphs.

2. UNIT GEOMETRY AND TARGET ACQUISITION. This segment has printouts in two basic formats. Figure IV-7-C-1a gives information about both attacker and defender initial size, velocity, strength, and relationship to each other. This format is printed only at the beginning of each battle increment. Figure IV-7-C-1b gives updated information about the battle in progress including coverage regions, sensing reports, and unit orientation. This format will be repeated once for each iteration within a battle increment. An explanation of each print statement by number is as follows:

Output Descriptor	Explanation
MECH2	This entry gives the name of the battle to be simulated in this iteration. This print statement can be found in routine GCM.
4032	Entries 1 and 2 are the attacker's objective position. Entries 3 and 4 are the defender's objective position. Entry 5 is the relative velocity. Entries 6 through 9 are the attacking unit's initial X, Y velocity components and the defending unit's initial X, Y velocity components. Entry 10 is the time remaining to fulfill the scheduled engagement. Entries 11 and 12 are the final attacking and defending unit's velocities. This print statement can be found in routine GCDRVR.
7003	The first entry is the battle pair IUID table index for the attacker. The second entry is the attacking unit's IUID. This print statement can be found in routine GCM.
7005	First entry is the battle pair IUID table index for the defender. The second entry is the defending unit's IUID. This print statement can be found in routine GCM.

```
MECH2
7003        . 1        835
7005          1        227
7007   1256.461
7103   2000.006    700.000    83.600  4000.300   730.000     0.000
7105        545        434     3.817     3.855     2.145
7115      29.77       0.00      9.81      0.00       .99       .83     10.00       .83
           1.45       0.00      3.30     28.72      3.00      0.00     11.17      2.39
7117          2        375        38        15        39        48        20         1         8       840
7119     1.9    3.0   12.6     8.6    39.3     0.0   297.0   297.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
         4.8    0.0    0.0    15.0    47.9     0.0     0.0     0.0   498.6   498.6     0.0     0.0     0.0     0.0     0.0     0.0
         2.0    3.0   15.0     9.0    40.0     0.0   300.0   300.0     0.0     0.0     0.0     0.0     3.0     6.0     0.0     0.0
         5.0    0.0    0.0    15.0    48.0     0.0     0.0     0.0   500.0   500.0     0.0     0.0     3.0     0.0     0.0     0.0
7127          1       3.39 113675.22  85134.32 113183.56  97072.93         2
7129 6011    6   0
7129 5009    5   0
7131       5.50       2.50      0.30
7127          2        .18 113319.32  86618.33 113735.44  82682.95         3
7129 5009    5   0
7129 5011    6   0
7129 5009    5   0
7131       5.33       2.67      3.00
7023    296.120   1713.206     2.530    12.500
4032     -201.30     -50.33       0.00       3.00      83.00     -80.52     -20.13       0.00       0.00      12.50
           83.00       0.00    1491.67       1.00
7310   14728.675  27725.593   6359.643    591.397    766.047    893.553
         257.914    114.214    427.391       .262       .538     16.000
7310   55232.532 103970.975  23848.659    591.397    766.047    893.563
         257.914    428.332    427.391       .262       .538      5.000
7310  220930.128      0.030      0.000    591.397    766.047    893.563
         257.914   1713.206    427.391       .262       .538      1.000
7310   55232.532 103970.975  23848.659    591.397    766.047    893.563
         257.914    428.302    427.391       .262       .538      5.000
7318   73643.376 138627.966  31798.213    591.397    766.047    893.563
         257.914    571.069    427.391       .262       .538      4.000
7888      582073    1000000    1300030      25919    1300000    1000000      37624      46215          0          0
               0          0          0          0          0          0          0          0          0          0
               0          0          0          0          0          0          0          0          0          0
               0          0          0          0          0    1000000    1300000    1030000    1000000    1033000
         1000000    1000000    1033030          0          0          0          0          0          0          0
               0          0          0          0          0          0          0          0          0          0
               0          0          0          0          0          0          0          0          0          0

4032     -201.30     -50.33       0.00       3.00      83.00     -80.52     -20.13       6.00       0.30      12.50
           83.00       0.00    1491.67       1.00
4032     -201.30     -50.33       0.00       3.00      83.00     -80.52     -20.13       0.00       0.38      12.50
           83.00       0.00    1491.67       1.00
7025      30.682      0.000
```

Figure IV-7-C-1a. Unit Geometry and Target Acquisition Sample Output From Ground Combat Model (Continued on Next Page)

```
7889      835       2       0     0  835001   227  112617  85426     0       0
           41       0      18     1       0    28      13      0     0       0
            0       0     315     0       0     1       0      0     0       0
            0       0       0     0       0   227       2      0     0  227001
          835  114072   86305     0       0    48      47    339    12       0
           38      10       0     0       0     0       0    315     0       0
            1       0       0     0       0     0       0      0     0       0

GCM CHECK - OBSIZE, OBFACC, ALT, AIRSPD  374     374   250   266     0     0   550   533
GCM CHECK - OBSIZE, OBFACC, ALT, AIRSPD   15       2
```

Figure IV-7-C-1a. Unit Geometry and Target Acquisition Sample Output From Ground Combat Model (Continued)

```
7127            1      3.32 116772.90  84201.13 116417.98  86169.38          2
7129 5039    5    0
7129 5039    5    0
7131         5.60      3.00        3.00
7127            2       .18 118540.29  84302.17 119614.47  78399.11          4
7129 5110    5    1
7129 5039    5    0
7129 5112    6    1
7129 5309    5    0
7131         5.25      2.75         .50
7323      121.592   678.375      3.014       0.030
4032      -881.99   -718.66       3.03        0.00       47.40      -36.75      -29.94        0.00        3.00        0.00
            47.43      0.00    2487.98        1.00
7310    39571.903 79143.807  39571.903     370.851     618.301     865.751
          134.151   226.125    268.301        .113        .142       4.000
7310   118715.710     3.000      0.000     370.851     618.301     865.751
          134.151   679.375    268.301        .113        .142       1.000
7310   118715.710     0.000      3.060     370.851     618.301     865.751
          134.151   678.375    268.301        .113        .142       1.000
7310    39571.903 79143.807  39571.903     370.851     618.301     865.751
          134.151   226.125    268.301        .113        .142       4.000
7888       712767   1000000    1000000      219114     1000000     1000000      254865      277783           0           0
                3         3          3           0           0           3           0           0           3           0
                0         3          3           0           0           0           0           0           0           0
                0         0          0           0           0           0     1000000           0     1000000           0
                0         0          0           0           0           0           0           0           0           0
                0         0          3           0           0           0           0           0           0           0
                0         0          0           0           0           0           0           0           0           0

4032      -881.99   -718.66       3.03        0.00       47.40      -36.75      -29.94        0.00        0.00        0.00
            47.43      0.00    2487.98        1.00
4032      -881.93   -718.66       0.00        0.00       47.40      -36.75      -29.94        0.00        0.00        0.00
            47.40      0.00    2487.98        1.00
7025       44.538     0.000
```

Figure IV-7-C-1b. Unit Geometry and Target Acquisition Sample Output From Ground Combat Model (Concluded)

Output Descriptor	Explanation
7007	Visible range in meters. (If the defending unit described above has an order number other than 2, 5, 6, or 15, a new unit pair is selected before 7007 is printed). This print statement can be found in routine GCM.
7023	Front-to-front separation mid way through the engagement iteration, frontage shared by the unit pair, length of the iteration, and time remaining to fulfill the scheduled engagement. (If, following unit rotation, the unit pair shares no common frontage, another unit pair is selected before 7023 is printed). This print statement can be found in routine GCM.
7025	The first entry is the velocity of the attacker. The second entry is the velocity of the defender.
7103	Attacking unit width, depth, and velocity; defending unit width, depth, and velocity. (The depth specified is the front band depth. The velocity is the initial value. All dimensions are in meters, and the velocities are in meters per second. If the front-to-front separation of a unit pair cannot be less than 3000 meters at the conclusion of the scheduled engagement period, a new unit pair is selected before 7103 is printed). This print statement can be found in routine GSETUP.
7105	First entry is the current game time. The second entry is the time (KTIME) reflecting the direction of the sun. If game time is morning, KTIME = sunrise. If game time is afternoon, KTIME = sunset. If game time is night, KTIME = 0. The third entry is the angle used to determine the direction of attacker facing defender. Fourth and fifth entries are the sky/ground ratio looking toward the attacker and defender, respectively. This print statement can be found in routine GSETUP.
7115	The first eight entries are the initial numbers for each transport type in the attacking unit's front band; the second eight entries are the initial numbers for each transport type in the defending unit's front band. This print statement can be found in routine GSETUP.
7116	This entry lists the secondary equipment list for an attacker weapon system. This entry is printed only if the weapon being processed is not found in the secondary equipment table. This print statement can be found in routine GSETUP.

Output Descriptor	Explanation
7117	This entry lists the secondary equipment list for a defender weapon system. This entry is printed only if the weapon being processed is not found in the secondary equipment table. This print statement can be found in routine GSETUP.
7119	The first sixteen entries are initial ammunition per transport for attacking unit transports; second sixteen entries are initial ammunition per transport for defending unit transports; third sixteen entries are attacker authorized values; and fourth sixteen entries are defender authorized values. This print statement can be found in routine GSETUP.
7127	The first entry is an attacker/defender index. (If the index equals one, an attacker is being processed. If the index equals two, a defender is being processed). The second entr is the unit's orientation from the X axis in radians. Entrie 3 through 6 give the X, Y coordinates of the leading edge of the attacking unit in the position where the engagement is to be simulated. Entry 7 is the number of terrain cells intersected by the unit's leading edge. This print statement can be found in routine STRBAR.
7129	First entry is the terrain identification. (A 7129 is printed for each cell corresponding to entry 7 in 7127). At this point, output 7127 and 7129 are repeated for the defending unit. If the model generates internal iterations the entire set of 7127s and 7129s is repeated. The final set corresponds to the actual values used. This print statement can be found in routine STRBAR.
7131	First word of this entry is the average roughness and vegetation index. The second word is the average vegetation class. The third word is the forest type index. This print statement can be found in routine STRBAR.
7310	First entry is the area of a section of each coverage region type. The second entry is the range to each coverage region type. This print statement can be found in routine GCFIRE.
7888	Sensing reports. The first 35 entries correspond to attacking unit's report. The second 35 entries are the defending unit's report. This print statement can be found in routine GCTDET.
7889	Sensing reports. The first 35 entries correspond to attacking unit's report. The second 35 entries are the defending unit's report. This print statement can be found in routine GCM.

Output Descriptor	Explanation
GCM CHECK - OBSIZE, OBFACC, ALT, AIRSPD	The first two words of this entry are the length of this GCM iteration. The third and fourth words are the average vegetation classes for the attacker and defender. The fifth and sixth words are not used. The seventh and eighth words are the roughness and vegetation indexes for the attacker and defender. The ninth and tenth words are the order numbers of the attacker and defender. This print statement can be found in routine GCM.

3. ENGAGEMENT RESULTS. This segment is a summary of the engagement results for each iteration of the battle increment. The summary is in the form of two tables each containing two matrices, one for attacker and one for defender. One table gives rounds fired by ammunition type against a specific target type and the other table gives killer/victim results. The matrices are illustrated in Figure IV-7-C-2 and explained as follows:

Output Descriptor	Explanation
A	This entry first shows the type of data--rounds fired or killer/victim--contained in the matrices followed by the length of time represented by this iteration of ground combat. The time must be less than or equal to 15 minutes. The front-to-front separation given in this entry is an average of the initial separation and the final separation for this iteration.
B	INITIAL SEPARATION = X: The front-to-front separation at the beginning of this iteration. FINAL SEPARATION = X: The front-to-front separation at the end of this iteration. INITIAL VELOCITY = X: The relative velocity of the units at the beginning of this iteration. FINAL VELOCITY = X: The relative velocity of the units at the end of this iteration.
C	ATTACKER (UID) VS. DEFENDER (UID): This print gives the UID of the opposing units. If the battle has more than two units involved, there will be a set of attacker-defender matrices for each attacker-defender pair. BATTLE A: A is the battle identification. All attacker - defender pairs will be assessed for this battle before continuing.

Ⓐ ROUNDS FIRED DURING 7.234 MINUTE ITERATION WITH 111.[illegible] METER FRONT TO FRONT SEPARATION

KILLS DURING 7.234 MINUTE ITERATION WITH 111.239 METER FRONT TO FRONT SEPARATION

Ⓑ INITIAL SEPARATION = 152.158, FINAL SEPARATION = 73.409 INITIAL VELOCITY = 11.302, FINAL VELOCITY = 11.302

Ⓒ ATTACKER R2120ZTK VS. DEFENDER 3B3012AR BATTLE MECHS DAY 1 HOUR 5 MINUTE 45

Ⓓ DEF TARGET INDEX

ATT FIRER INDEX	31	34	35	37	41	45	185	156	TOTALS
24	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
26	0.00000	0.00000	0.00000	.01565	0.00000	0.00000	.00383	.00068	(.02813)
28	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
24	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
12	.00406	0.00000	0.00000	4.62696	0.00000	0.00000	1.03199	.21371	(5.87672)
37	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
7	.03586	0.00000	0.00000	0.00000	0.00000	0.00000	1.21139	.21145	(1.45789)
7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
TOTALS	(.0391(	0.0303(	0.0001(	4.6431(	0.0601(	0.0001(	2.2471(	.4261)	(7.35474)

Ⓔ ATT TARGET INDEX

DEF FIRER INDEX	35	36	161	163	32	23	25	27	TOTALS
32	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
36	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
36	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
38	.60432	0.00000	.16963	0.00000	.01822	0.00000	0.00000	0.00000	(.79180)
39	.83349	0.00000	.12499	0.00000	.00232	0.00000	0.00000	0.00000	(.96080)
40	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
42	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
43	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
9	0.00000	0.00000	.58564	0.00000	.05936	.02790	.08362	.01449	(.75108)
9	0.00000	0.00000	.19979	0.00000	.02004	.00322	.03278	.06570	(.26153)
44	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	(0.00000)
TOTALS	(1.4381(	0.0001(	1.0801(	0.0001(	.1001(	.0311(	.1161(	.0201)	(2.76530)

Figure IV-7-C-2. Engagement Results Sample Output From Ground Combat Model

Output Descriptor	Explanation
	DAY I HOUR I MINUTE I: The game time which this iteration ended.
D - E	This entry is a matrix of rounds fired by ammunition type fired against a specific target type. The top line (target index) lists the targets by item code. The first column on the left (firer index) lists the item code of the munition being fired. The totals on the bottom line give total rounds fired at a target type for this iteration. The totals given in the right column are the total munitions fired by type for this iteration. Entries D and E are in identical format with D giving defender targets and attacker munitions and E giving attacker targets and defender munitions. Immediately following this pair of matrices will be another pair in identical format. This second set is a killer/victim matrix, lists kills against a specific target by a munition type in place of rounds fired.

4. MORTAR SCHEDULING. The Ground Combat Model schedules the firing of area fire weapons (mortars) organic to the unit and involved in combat. This segment prints target detection results and fire mission data including mortars to be fired and number of rounds. The format for this segment is shown in Figure IV-7-C-3. A detailed explanation of this segment is as follows:

Output Descriptor	Explanation
MTRCHK1	The first word in this entry is the UID of the friendly unit. The remaining seven words are the data items in the sensing report on the selected enemy unit. These seven words are as follows: (1) unit identification code (UID), (2) estimated X coordinate of the target, (3) estimated Y coordinate of the target, (4) engagement frontage, (5) rate of movement, (6) direction, and (7) number of personnel detected.
MTRCHK2	The words in this entry are as follows: (1) a random detection time selected within the 15-minute battle increment, (2) time at the end of the Ground Combat Model increment, (3) random detection time divided by the time unit was detected, (4 and 5) unit's X and Y coordinates at time of detection, (6) time at the end of the Ground Combat Model increment minus random detection time, (7) direction of movement, and (8 and 9) final X and Y coordinates.

```
MTR CHK1      836      286   115761    90133     2000        0        10         7
MTR CHK2   774.601  1500.000            .516  117629.435  90370.565     0.000     0.000  115761.300   90133.000
MTR CHK3     3.268    -7.865            .127  117629.435  90370.565   350.000 117282.230   90326.419    1533.477
      (A)     33        34      240        4        22        15         0         0     7100       500     210
              50        51      240       10        20         6         0         0    15300       000     210
              50        59      240      900       900       999         0         0    17600      4650     210
              50        51      240       10        20         6         0         0    15300       000     210

               0         0        0        0         0         0         0         0        0         0       0
               0         0        0        0         0         0         0         0        0         0       0
               0         0        0        0         0         0         0         0        0         0       0
7209       200        28         1         0
7201     0.000      .175      .025      .266      .044     0.000     0.000     0.000
         0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
         0.000    27.460     0.000     0.000     0.000     0.000     0.000     0.000
         0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
            0.00      0.00      0.00         1

MTR CHK4     2.000   925.000  1363.663   325.000  5000.000  82957.602      .060   340.255         21
MTR CHK5       25        27     1.991   225.947     3.000     0.335         6   714.761
MTR FIRE      206      4321         0         0       0         3    117110     90394   114770    91090
                X         6       244      A001
MTR CHK5       29        30     1.332    81.570     6.000    13.336         6   714.761
MTR FIRE      206      4321         0         0       0         0    117110     90394   114770    91090
                X         0       282      A003
7209       661         5         0         1

(B)** OBSR ** BATTLE  MECH1A     IOVER =   1
(C)UPDVUL, IUIO= 836 UID=R1320ZTK UTD=GEMT IEV=   4 NORD=   2
   IORENT=  236 WIDTH=  2000 DEPTH=  2100 NBAND= 3 RADU=     0 IACTX= 4 IREC28= 218
   UPDVUL, IUIO= 206 UID=88011ZMI UTD=FMMI IEV=   1 NORD=   2
   IORENT=   22 WIDTH=  6000 DEPTH=  2600 NBAND= 4 RADU=     0 IACTX= 5 IREC28= 146
(D)4032     -562.00    562.00     0.00     0.00    45.00   -32.38    32.38     0.00     0.00     0.01
            45.00      0.00  3620.45     1.00
```

Figure IV-7-C-3. Mortar Scheduling Sample Output From Ground Combat Model

Output Descriptor	Explanation
MTRCHK3	The words in this entry are as follows: (1) angle of a line connecting the target with the mortar, (2) slope of a line from the estimated target to the mortar center, (3) slope of a line from the mortar center to the target center, (4 and 5) points on the line from the mortar center to the target center, (6) distance from the back to the front of the front band, (7 and 8) coordinates of a point on the back line of the front band directly opposite the target, (9) distance from the point on the back line (see word 7-8) to the target.
A	This entry is the mortar data as contained in the area fire weapon/munition table (WMPARM) from data file 25.
MTRCHK4	The words in this entry are as follows: (1) a count of mortar types, (2) total lethal area, (3) total weighted lethal area, (4) total radius of effects, (5) target area, (6) area of effects of the average mortar, (7) number of effects areas, (8) number of rounds required to achieve required damage on each effects area, and (9) total number of rounds.
MTRCHK5	The words in this entry are as follows: (1) weapon type index, (2) munition type index, (3) number of mortars available, (4) number of rounds available, (5) number of rounds required per mortar, (6) sustained rate of fire, (7) maximum number of rounds required per mortar, and (8) time available to fire.
MTRFIRE	This entry is the 13-word FILE12 buffer being passed to the area fire assessment routine. The second word in this entry will have a value of 4321 meaning a mortar fire event. The first word on line 2 will be an X because it is an alphanumeric character being printed with an integer format. Its actual value is the fourth word on line 2.
7201	The first 16 words of this entry (lines 1 and 2) are the total rounds lost for 16 ammunition types. The next eight words (line 3) are the total weapon system transport losses for eight types. The next 10 words (line 4) are the total sensors lost for 10 sensor types. The first word of line 5 is the total personnel lost. The second and third words on line 5 are the total distances moved in the X and Y direction respectively. The fourth word on line 5 is a count of movements. This print statement can be found in routine GUPDAT.

Output Descriptor	Explanation
7209	The first word of this entry is the present strength. The second word of this entry is the sum of the fractions of personnel killed. The third and fourth words are attacker and defender indexes. If word 3 is set to one, the assessment is for the attacker. If word 4 is set, the assessment is for the defender. This print statement can be found in routine GUPDAT.
B	This entry occurs at the end of each battle increment. The entry gives the battle name and its status. If IOVER = 1, the battle is over. If IOVER = 0, the battle will continue.
C	Routine UPDVUL is called from routine GCLAST in the Ground Combat Model.
D	Entries 1 and 2 are the attacker's objective position. Entries 3 and 4 are the defender's objective position. Entry 5 is the relative velocity. Entries 6 through 9 are the attacking unit's initial X, Y velocity components and the defending unit's initial X, Y velocity components. Entry 10 is the time remaining to fulfill the scheduled engagement. Entries 11 and 12 are the final attacking and defending unit's velocities. This print statement can be found in routine GCDRVR.

APPENDIX D

SOURCE LISTINGS FOR PERIOD PROCESSOR GROUND COMBAT MODEL

(AVAILABLE UNDER SEPARATE COVER)

NOTES

APPENDIX E

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NOTES

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(Pages 8-1 to 8-22)

CHAPTER 8

AREA FIRE MODEL

1. MILITARY ACTIVITY REPRESENTED. The Area Fire Model represents the scheduling, delivery, and assessment of nonnuclear area fire munitions by cannon systems, missile systems, and multiple rocket launchers, and the assessment of mortar fires generated by the Ground Combat Model.

2. MODEL DESIGN:

a. Submodels of the Area Fire Model. The Area Fire Model consists of two submodels designed to represent the employment of area fire conventional field artillery systems. These submodels are the DSL Fire Order Scheduling Submodel (FIREDT), and the Delivery and Assessment Submodel (AREAFR). The Delivery and Assessment Submodel is also executed in response to fire missions scheduled by the TACFIRE Model (Chapter 9 of this section) and the Ground Combat Model (Chapter 7 of this section). A macroflow of the relationships among these submodels and between these submodels and other models and/or external DSL gamer control is shown in Figure IV-8-1. The individual submodel structures are discussed in detail in paragraph 3.

b. Fire Units in the Area Fire Model. Fire units used in the model may be at a battalion or at a battery level of resolution, at the user's discretion. Each fire unit may contain up to four weapon/ammunition combinations, although only one combination can be used for one fire mission. The number of rounds or rockets fired per volley is equal to the number of integral tubes or launchers. No limit is set on the number of fire units used in the DSL mode. For each weapon system defined there is also defined a corresponding munition load representative of the munitions delivered by the weapon system. In the case of a multiple rocket launcher weapon system firing multiple rounds in a small time interval, the "equivalent round" is the total number of rounds fired during the interval. Elements such as lethal areas, weights, and firing times, and all bookkeeping in the model, are represented in terms of this equivalent round.

c. DSL Planned Fires. The model's representation of planned fires on areas or points is accomplished in response to DSL fire orders. These fires are planned prior to each game period and correspond to scheduled fires delivered at specific times during the operation of the supported forces. The DSL ordered fires take priority over any fires developed within the "automatic" or TACFIRE model. With the DSL fire order the gamer can specify the number of rounds or volleys and the munition type to be used. The locations specified for the fire are derived from the previous period's output intelligence report and the gamer's coordination of fire support with the plan of operation for the next period.

d. Assessment Effects. The modeling of the effects of area fire munitions is performed in the Delivery and Assessment Submodel. The submodel

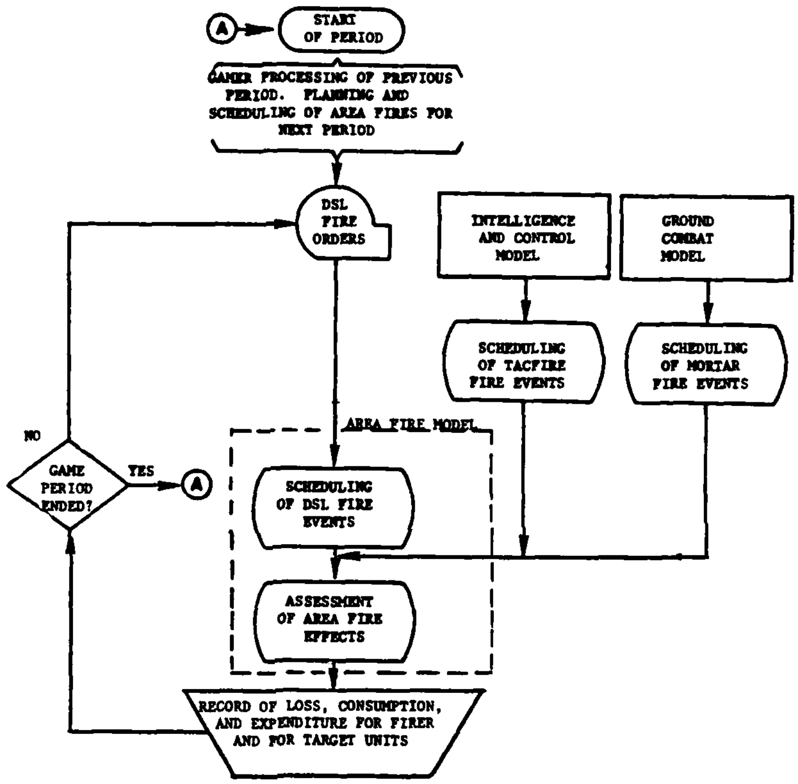

Figure IV-8-1. DIVWAG Area Fire Model Macroflow is also responsible for identifying all units and individual sensors within the effects of the munitions.

(1) Target Geometry. Target assessment is based on the expected coverage by each volley of killable target elements clustered within the bands of a rectangular target unit. The geometry of all units is rectangular with up to four variable-density, equal-area bands per unit. This representation of each unit is set dynamically within the DIVWAG system and is based on the unit's movement and present activity. Unit geometry is discussed in detail in Chapter 5 of this section.

(2) Clustering of Target Elements. The effects of individual volleys are not assessed against all target elements located within the target band containing the center of impact of the volley. This is avoided since the lethal effects area of a volley is typically measured in hundreds of square meters, whereas the target band area in DIVWAG typically covers millions of square meters. If the killable target elements in the band are assumed uniformly distributed over this large area, even the assessment of multiple volleys produces negligible casualties. Since area fire generally is not employed against targets of such size, the assumption is made that target elements are clustered into several small units within the large band areas, and that relatively large gaps exist between these target element "clusters." It is one of these small clusters that is attacked and assessed by area fire within DIVWAG. The number and size of these clusters depends on the size, type and activity of the target unit, and are provided by the gamers as input data using the DIMLOAD data load program (card type 2807).

(3) Target Location Errors. Target location errors are included in the estimated location information provided by the INCS model output. The systematic errors for each volley (volley-to-volley dispersion) are assumed to be zero for purposes of computing the assessment effects of the rounds in the coverage problem.

(4) Equipment Losses. Computation of equipment losses is achieved in two steps. The primary equipment items are assessed using a modification of the DIVTAG II assessment equation (reference 4). The lethal areas of the round or equivalent round against primary equipment items are specified as input data. The loss of secondary equipment contained on or in primary items is accounted for by using the secondary loss tables. Fractional losses are carried for all items and are rounded only for periodic output summary reports.

(5) Casualty Assessments. Casualty assessments are determined by a dynamic assignment of the present personnel strength of a unit to various protection categories afforded by equipment types present in the unit and consistent with the activity of a unit. Personnel not afforded equipment protection are distributed in standing, prone, or foxhole postures and in warned and unwarned states. Personnel protected by primary equipment items are assessed if losses occur, and unprotected personnel are assessed using

lethal area values specified in the input data. Details are given in the specifications of the Delivery and Assessment Submodel.

e. Area Fire Model Interaction with Other Models. The Area Fire Model interacts or is constrained by the TACFIRE Model, Ground Combat Model, Intelligence and Control Model, Combat Service Support Model, Suppression Model, and the Movement Model.

(1) TACFIRE Model Interaction. Targets detected and reported by the Intelligence and Control Model that qualify for area fire missions are passed to the TACFIRE Model. The TACFIRE Model selects the best fire unit and schedules the Area Fire Delivery and Assessment event.

(2) Ground Combat Model Interactions. The interaction with the Ground Combat Model is derived through ground combat sensing reports processed by the Intelligence and Control Model, which lead to requests for direct support fire missions. The assessment portion also performs the assessment of damage due to mortar fire generated in the Ground Combat Model.

(3) Intelligence and Control Model Interactions. Every volley of area fire is potentially detectable by countermortar or counterbattery radar. The countermortar/counterbattery conditional detection routine of the Intelligence and Control Model is called by the Area Fire Delivery and Assessment Submodel for each volley of fire.

(4) Combat Service Support Model Interactions. A fire unit is not permitted to fire a volley if it does not contain a sufficient number of rounds of the appropriate ammunition type on hand. The Combat Service Support Model periodically resupplies all fire units that expended ammunition.

(5) Suppression Model Interactions. A Suppression Model event is scheduled for every unit assessed casualties while performing a suppressable activity (i.e., moving, firing, engineering).

(6) Movement Model Interactions. Fire units are constrained by the Movement Model by not allowing moving fire units to fire; i.e., no echelon movement is modeled. Detection of moving targets is also dependent upon movement rates supplied by the Movement Model.

(7) Environment Interactions. The Area Fire Model's interaction with the environment is in the assessment of casualties. The lethal areas specified in the input data include forest and unforested values and are used in the model depending on the current terrain cell forest condition in which the target unit is located.

3. SUBMODEL SPECIFICATIONS. The submodels of the Area Fire Model are represented in the Period Processor of the DIVWAG system by the routines FIREDT and AREAFR. The technical aspects of these routines as they relate to the scheduling of artillery fire support and the delivery and assessment

of fires are described in the following subparagraphs. The DSL Fire Scheduling Submodel performs the planning, allocation, and scheduling of artillery fire support. The Delivery and Assessment Submodel performs the delivery and assessment of fires.

a. DSL Fire Scheduling Submodel. All planning, allocation, and scheduling of DSL fire missions is performed in the gamer input phase.

(1) DSL Fire Orders. DSL fire missions are input in DSL Fire orders. A typical DSL Fire order has the following form:

```
ID:  R12141MB.
     STAY FOR 30 MINUTES.
     FIRE MUNITION TYPE A001 ON 0141000-0113000
     NUMBER OF VOLLEYS 3.
```

The munition type, A001, identifies the munition as a conventional area fire munition by the letter A. The particular weapon system and munition type is identified by the last two digits (01) and corresponds to the weapon/munition combination index (01) specified in the pregame preparation of the weapon munitions characteristics table. The fire unit specified is identified initially in the DSL order string (i.e., R12141MB in the example). The aim point for the volleys is contained in the easting-northing coordinates specified in meters from the model's map grid origin (e.g., 0141000-0113000). The number of volleys or number of rounds in the fire mission must also be specified in the fire order. (In the example three volleys are indicated.) The number of rounds in each volley is always equal to the current number of weapon systems on hand in the fire unit.

(2) DSL Fire Mission Priority. DSL fire missions have priority over area fires developed in the TACFIRE submodels. They are always executed if the fire unit's weapon systems are intact and munitions are available. Fire units are withdrawn from the TACFIRE mode for the length of time necessary to complete the DSL fire mission. They are returned to the TACFIRE mode if they receive no subsequent DSL order or receive a DSL stay order.

(3) Fire Mission Volleys. The volleys of the fire mission are scheduled individually and are subject to checks on the fire unit's weapon system strength and munitions supply prior to each volley. The starting time of the fire mission is usually specified by giving the fire unit a stay order until the time at which the fire mission is to be executed. When the game time reaches the end time of the stay order, the pending fire order is processed by the DIVWAG System event sequencing routine, and routine FIREDT is called to schedule the impact time of the first volley. A simplied macroflow of FIREDT is shown in Figure IV-8-2.

(a) The time to fire the initial volley (which simulates the delay from receipt of the fire order until impact of first volley on target) is obtained from the weapon/munitions characteristics data, Figure IV-8-3, for the weapon/munition combination specified in the fire order. This time

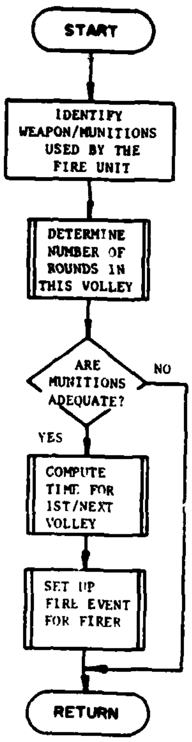

Figure IV-8-2. FIREDT Macroflow

Characteristic	Example data		
Weapon/munitions combination index	01	02	03....
Weapon item code index	29	29	
Munitions item code index	30	31	
Maximum range of combination (meters) R_{mx}	26,500	26,500	
Minimum range of combination (meters) R_{mn}	2,500	2,500	
Time to fire initial FFE volley (seconds) (simulates receipt of mission, aiming, loading, firing, time of flight)	90	90	
Time between volleys (seconds) to be used for first N volleys (fired at maximum rate)	15	15	
Time between volleys at sustained rate (seconds)	60	60	
Nth round cutoff	30	30	
Munition precision error of round at R_{mx} (CEP)	383	383	
Munition precision error of round at 0.8 $(R_{mx} - R_{mn}) + R_{mn}$	237	237	
Munition precision error of round at 0.6 $(R_{mx} - R_{mn}) + R_{mn}$	165	165	
Munition precision error of round at 0.4 $(R_{mx} - R_{mn}) + R_{mn}$	88	88	
Munition precision error of round at 0.2 $(R_{mx} - R_{mn}) + R_{mn}$	59	59	
Munition precision error of round at R_{mn}	35	35	
Radius of effects of battalion volley	200	200	

Figure IV-8-3. Weapon Munitions Characteristics Table is used to schedule the subsequent delivery and assessment event within the Delivery and Assessment Submodel.

(b) As soon as the assessment event has been completed, the next volley is scheduled using the time between rounds data.

(4) Munition Expenditure. Update of the fire unit's status for munitions expenditure is accomplished within the Delivery and Assessment Submodel following each volley.

(5) Target Location Errors. Target location errors are not played discretely in the Delivery and Assessment Submodel. They are implied by the amount that the aim point coordinates in the DSL Fire order are displaced from the actual target center. Since the model distributes (as a function of weapon error) the rounds of a volley about the aim point specified in the DSL order, care must be taken by the gamers to avoid repeated designations of opposing unit's target centers as aim points. These aim points must be selected realistically, based on the limited intelligence data supplied in end-of-period reports, to avoid the play of unrealistically accurate artillery fire.

(6) Range Constraints. The range limitations of the weapon systems of the fire units are checked in the Delivery and Assessment Submodel; and, if the designated coordinates of the fire request are not within the range limits of the weapon system, the volley is not fired.

b. Delivery and Assessment of Area Fires. The Area Fire Delivery and Assessment Submodel determines the units and discrete sensor systems that are located within the effects area surrounding the center of impact of the volley, and computes the expected damage effects of the impacting rounds on equipment and personnel. A macroflow of the routine AREAFR, which performs these activities, is shown in Figure IV-8-4. All assessment of personnel casualties and equipment losses is accomplished on a per-volley basis. The assessment equations used to describe unit target damage are discussed in the following paragraphs.

(1) Preliminary Search Radius Screen. The center of impact of the volley is used in the submodel as the center of a preliminary screening circle of radius R_S. This screening radius is dependent upon the weapon-munition combination type being considered. The units whose centers lie within this screening circle are then subjected to further screening for possible casualties and equipment loss or failure. To identify units that are potential candidates for further screening, the screening radius is set to 3500 meters plus the effects radius of the munitions combination used in the fire mission. Units centered within the screening radius are considered for assessment. The effects radius is defined for model purposes as the radius of a circle in which 99 percent of the effects of the volley are expected to occur, and is part of the constant input data load. This is the only use made of the effects pattern radius in the assessment of non-nuclear artillery fires in DIVWAG, and in the event precise input values

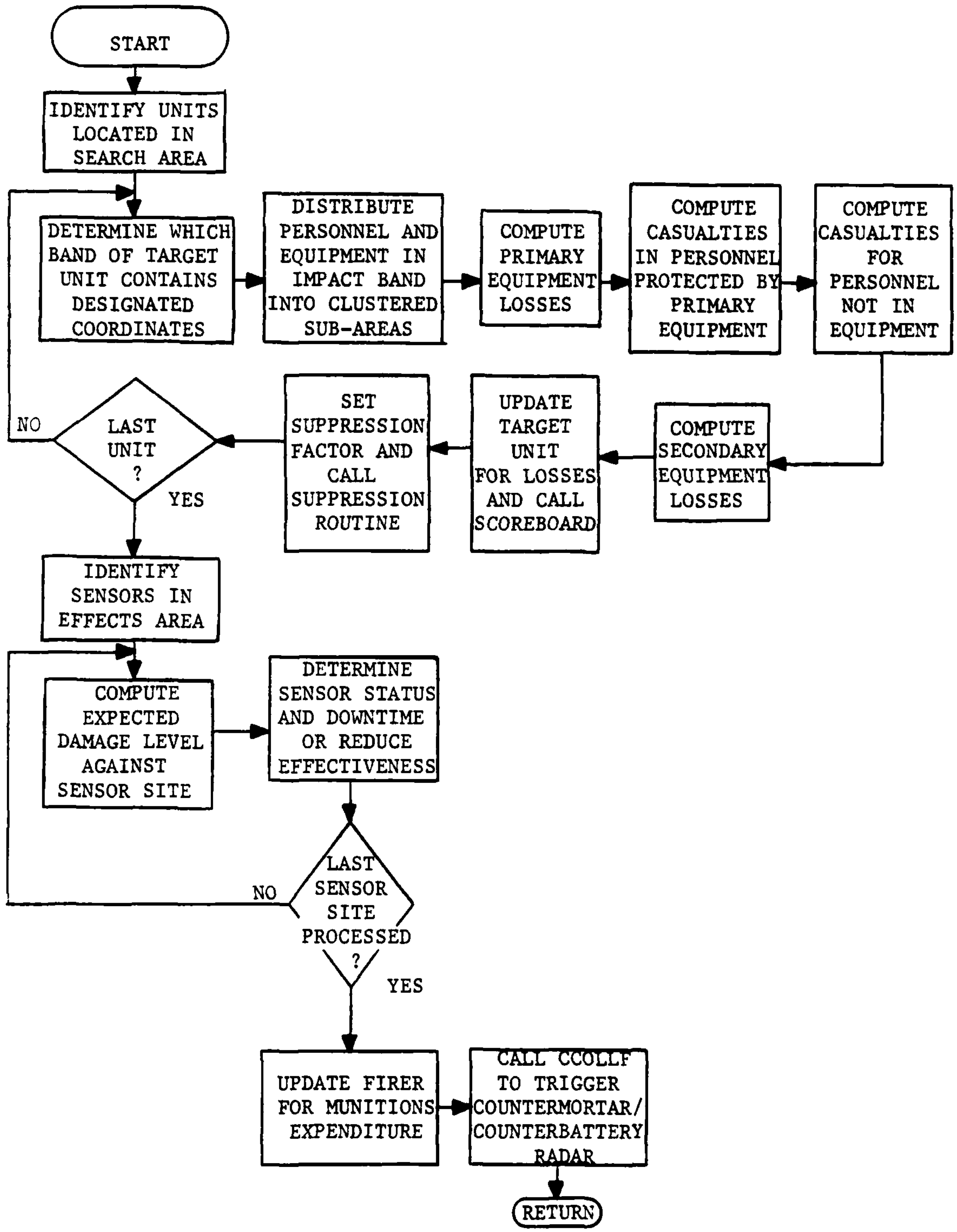

Figure IV-8-4. AREAFR Macroflow

for each munition type cannot be located, an inflated estimate is acceptable to preclude exclusion of likely targets located in the vicinity of the impact area. Moving units are projected to their expected locations at the time of impact to ensure a timely assessment of area fire effects.

(2) Potential Target List. Application of the preliminary search radius results in a list of those targets whose centers are in the vicinity of the impact area. Each of these targets is then examined further to determine if the center of impact of the volley falls within its unit rectangle, and if so, in which band the center of impact occurs. If the center of impact does not lie within a unit's boundary, that unit is not assessed. If it does, the unit is subjected to an artillery assessment, but only those personnel and equipment items located in the band that contains the impact center are considered in the assessment. Two (or more) targets will be assessed by a single volley only if their target boundaries overlap, and the area in common contains the impact center. If the center of impact falls precisely on the boundary separating two adjacent bands within a target, the assessment will be made only against the band located nearest the front of the unit.

(3) Determination of Band Containing Center of Impact. Figure IV-8-5 portrays the geometry associated with a typical artillery assessment in DIVWAG, and will assist in understanding the following description of how the model determines which band of a potential target unit contains the center of impact. This determination is accomplished through a series of several steps.

(a) Step 1. Compute the angles of orientation shown in Figure IV-8-5.

$$\beta = \text{ARCTAN}\left(\frac{\text{width of unit}}{\text{depth of unit}}\right) \qquad \text{(IV-8-1)}$$

$$\gamma_1 = \alpha + \beta; \text{ if } \gamma_1 > 2\pi,\ \gamma_1 = \alpha + \beta - 2\pi \qquad \text{(IV-8-2)}$$

$$\gamma_2 = \pi - \beta + \alpha; \text{ if } \gamma_2 > 2\pi,\ \gamma_2 = -\pi - \beta + \alpha \qquad \text{(IV-8-3)}$$

$$r = \frac{1}{2}\left(\text{width}^2 + \text{depth}^2\right)^{\frac{1}{2}} \qquad \text{(IV-8-4)}$$

(b) Step 2. Determine the target unit's corner coordinates:

$$P_1(x_1,\ y_1) \quad x_1 = x_0 + r\cos\gamma_1 \qquad \text{(IV-8-5a)}$$

$$y_1 = y_0 + r\sin\gamma_1 \qquad \text{(IV-8-5b)}$$

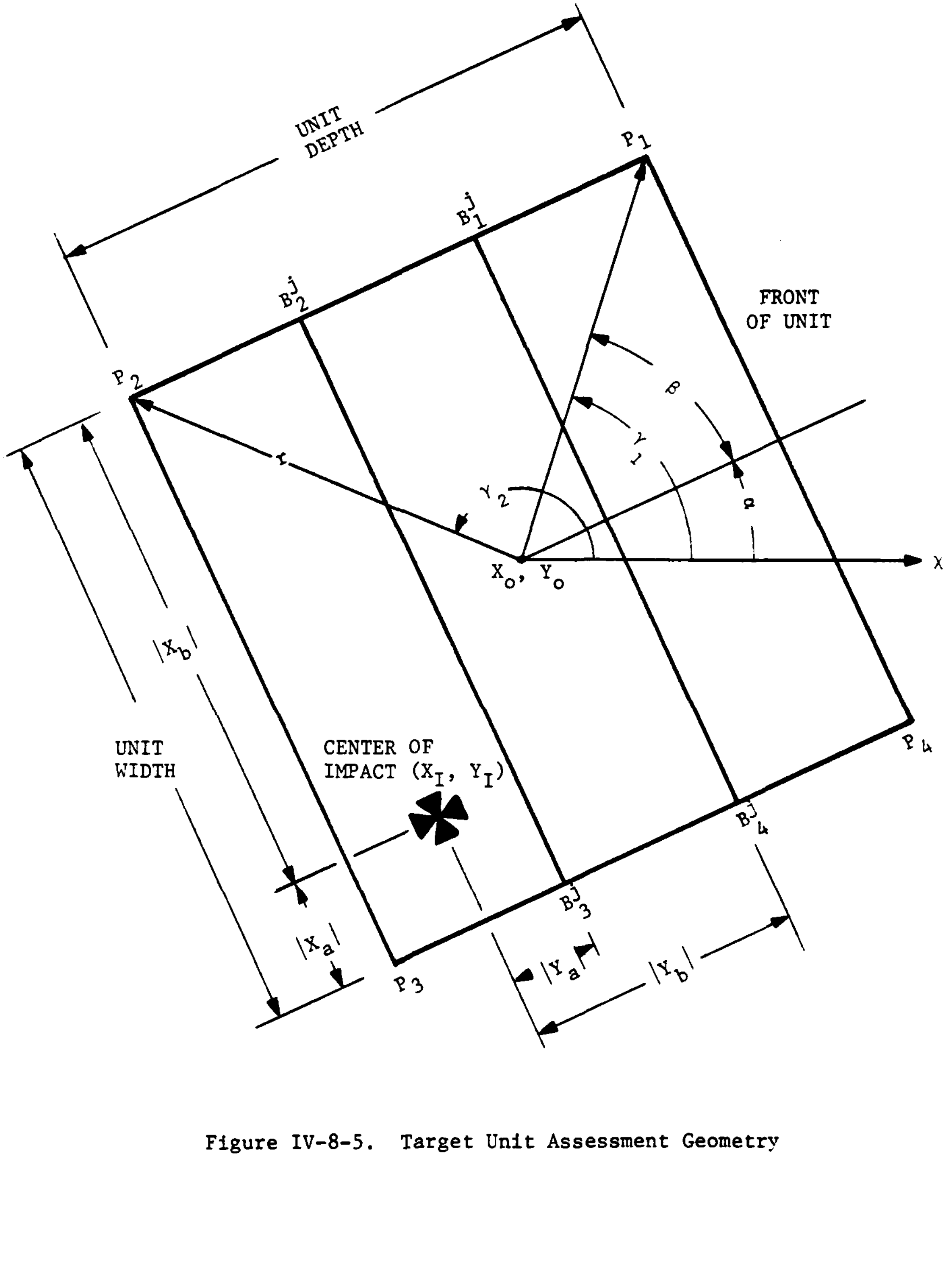

Figure IV-8-5. Target Unit Assessment Geometry

$$P_2(x_2, y_2) \quad x_2 = x_0 + r\cos\gamma_2 \qquad \text{(IV-8-5c)}$$

$$y_2 = y_0 + r\sin\gamma_2 \qquad \text{(IV-8-5d)}$$

$$P_3(x_3, y_3) \quad x_3 = 2x_0 - x_1 \qquad \text{(IV-8-5e)}$$

$$y_3 = 2y_0 - y_1 \qquad \text{(IV-8-5f)}$$

$$P_4(x_4, y_4) \quad x_4 = 2x_0 - x_2 \qquad \text{(IV-8-5g)}$$

$$y_4 = 2y_0 - y_2 \qquad \text{(IV-8-5h)}$$

(c) Step 3. Compute the corner coordinates of the jth band of the unit:

$$B_1^j \quad x_1^j = x_1 + [(j-1)/n](x_2 - x_1) \qquad \text{(IV-8-6a)}$$

$$y_1^j = y_1 + [(j-1)/n](y_2 - y_1) \qquad \text{(IV-8-6b)}$$

$$B_4^j \quad x_4^j = x_4 + [(j-1)/n](x_3 - x_4) \qquad \text{(IV-8-6c)}$$

$$y_4^j = y_4 + [(j-1)/n](y_3 - y_4) \qquad \text{(IV-8-6d)}$$

$$B_2^j \quad x_2^j = x_1 + (j/n)\ (x_2 - x_1) \qquad \text{(IV-8-6e)}$$

$$y_2^j = y_1 + (j/n)\ (y_2 - y_1) \qquad \text{(IV-8-6f)}$$

$$B_3^j \quad x_3^j = x_4 + (j/n)\ (x_3 - x_4) \qquad \text{(IV-8-6g)}$$

$$y_3^j = y_4 + (j/n)\ (y_3 - y_4) \qquad \text{(IV-8-6h)}$$

where: n = number of bands.

(d) Step 4. Determine the perpendicular distance from the center of impact to the lines forming the band edges of each band:

$$|x_a| = \text{Distance from } (x_I, y_I) \text{ to line } \overline{B_3^j\ B_4^j} \qquad \text{(IV-8-7)}$$

$|x_b|$ = Distance from (x_I, y_I) to line $\overline{B_1^j B_2^j}$ (IV-8-8)

$|y_a|$ = Distance from (x_I, y_I) to line $\overline{B_2^j B_3^j}$ (IV-8-9)

$|y_b|$ = Distance from (x_I, y_I) to line $\overline{B_1^j B_4^j}$ (IV-8-10)

(e) Step 5. The center of impact is concluded to lie in the jth band if

$|x_a|$ and $|x_b|$ < width of jth band, and

$|y_a|$ and $|y_b| \leq$ depth of jth band.

(4) Determination of Band Contents. Once the band containing the center of impact of the volley has been determined, the data file containing the unit dimensions and distribution is accessed to determine the number of personnel and items of equipment present in the impact band. The distribution of equipment and personnel within the t arget bands are set dynamically in the DIVWAG System depending upon the type of unit and current mission or activity, i.e.:

- Stay
- Move
- Fire
- Attack
- Defend
- Engineer
- Withdraw.

A loss in personnel and/or equipment within various bands of the unit will reduce the density within these bands, but the band areas and percent distribution among bands will remain constant, regardless of the current strength of the unit. An example of a typical distribution of target elements among the bands of a unit is depicted in Figure IV-8-6.

(5) Selection of Lethal Area. At this point, the model examines the terrain cell that contains the center of the target unit to see if the target is residing in predominantly forested or unforested terrain. It also accesses the unit status file of the target unit to determine whether the unprotected personnel in the target are in a warned or unwarned posture, which is dependent on the length of time that has elapsed since this target was last subjected to an artillery assessment. One of four possible lethal areas is then retrieved from the data base to be used in the assessment of unprotected personnel, depending on whether the target is in forested or

ACTIVITY INDEX 4 (ATTACK)

WIDTH = 400 DEPTH = 600 NO. BANDS = 3

PERSONNEL	DISTRIBUTION :	32230500 :	52 %	38 %	10 %
EOH ITEM 8	DISTRIBUTION :	6200 :	0 %	0 %	100 %
EOH ITEM 10	DISTRIBUTION :	42200000 :	68 %	32 %	0 %
EOH ITEM 16	DISTRIBUTION :	32230500 :	52 %	38 %	10 %
EOH ITEM 18	DISTRIBUTION :	35220300 :	58 %	36 %	6 %
EOH ITEM 19	DISTRIBUTION :	6200 :	0 %	0 %	100 %
EOH ITEM 62	DISTRIBUTION :	620000 :	0 %	100 %	0 %
EOH ITEM 65	DISTRIBUTION :	1204100 :	2 %	32 %	66 %
EOH ITEM 66	DISTRIBUTION :	6200 :	0 %	0 %	100 %
EOH ITEM 75	DISTRIBUTION :	6200 :	0 %	0 %	100 %
EOH ITEM 76	DISTRIBUTION :	42200000 :	68 %	32 %	0 %
EOH ITEM 77	DISTRIBUTION :	27260500 :	46 %	44 %	10 %
EOH ITEM 78	DISTRIBUTION :	620000 :	0 %	100 %	0 %

ALL OTHER ITEMS DISTRIBUTED UNIFORMLY AMONG BANDS

Figure IV-8-6. Typical Unit Band Density unforested terrain, and whether the personnel are in a warned or unwarned state. Lethal areas against the equipment types located in the impact band are also retrieved in preparation for the assessment calculations.

(6) Allocation of Target Elements into Platoon Areas.

(a) Since DIVWAG is a division-level war game, its maneuver units are normally played at a battalion level of resolution. This results in units that occupy large areas, generally 4-8 million square meters. To provide for the clustering effect (see paragraph 2d(2) above) of targets into smaller entities within this large area that more realistically represent the type of units for which artillery fire would normally be requested, the Dimensions Load (card type 2807) is used to define the number and size of the component sub-units that make up the larger unit. These sub-units are called "platoons," although that term is not precise for all target types (artillery units, for example). The number and size of the platoons constituting the larger unit are specified in the DIMLOAD data load (card type 2807), and are a function of the size, type and activity of the target. In the Delivery and Assessment Submodel, the assessment is made only against the target elements assumed to reside in one of these platoons (which can be thought of as batteries or fire teams in the case of targeted artillery battalions).

(b) The platoons specified in the DIMLOAD data load are assumed to be equally divided among the bands of the target unit (fractions being permitted). The model then distributes the number of target elements contained in the entire unit into the individual platoon areas for assessment purposes. This distribution is conservative in nature, to insure that no over-assessment results from assigning the small platoon areas an overly-dense population. To insure this conservatism, the number of equipment items of each type in each platoon area is calculated in three ways, and the minimum of the three values is assumed as the number of items in the platoon area for assessment purposes. These three calculations are performed as follows, to obtain N_i, the number of equipment items of type i assumed present in the platoon:

N_i = minimum of (A, B, C) where

$$A = \frac{\text{number of equipment items of type i in entire target}}{\text{number of platoons in entire target}}$$

$$B = \frac{\text{number of equipment items of type i in impact band}}{\text{number of platoons in impact band}}$$

C = number of equipment items of type i in impact band

(c) The values B and C will be zero if no equipment items of type i are present in the impact band; thus, the target will sustain no losses to this item of equipment in this assessment. The value C is included in the determination of N_i to prevent an assessment against more items in the impact band than are actually present, which could happen if the number of bands of a target exceeds the number of platoons specified for that target.

(d) The calculation of the number of unprotected personnel present in the platoon is accomplished in a manner similar to that just described for items of equipment.

(e) In the event a target type is encountered for artillery assessment for which no data have been provided in the 2807 cards of the DIMLOAD data load, the model provides default values to accomplish the assessment. These values currently are set at 19,999 square meters for the area of one platoon, and 9 platoons per target unit. These values are easily changed should others be desired.

(7) Calculation of Fraction of Rounds Impacting in Platoon Area.

(a) The fraction of rounds of the volley that actually impact in the platoon area is a function of the weapon dispersion error and the size of the platoon. To determine the weapon dispersion error, the model first calculates the range from the center of the firing unit's rectangle to the designated center of impact. The dispersion of the weapon at this range is obtained by interpolation among the range-dependent dispersion errors that were entered as gamer input on the 2903 card type. This error is in terms of a standard deviation (σ). (In the event the data were loaded as circular probable errors (CEP) instead of in standard deviation units, the data load program automatically converts the CEP to a standard deviation before loading the data file, using the relationship $\sigma = CEP/\sqrt{2 \ln 2}$.)

(b) Once the dispersion (σ) of the rounds about the center of impact is obtained, the expected fraction of the rounds from this volley that will impact within the boundary of the platoon area is calculated. This calculation is based on the following two assumptions:

1. The platoon area is circular.

2. The center of impact of the volley coincides with the center of the circular platoon area.

(c) The fraction (PHIT) of rounds of the volley expected to fall within the platoon area then is calculated as:

$PHIT = 1 - \exp(-APLAT/2\pi\sigma^2)$, where APLAT is the area

(in square meters) of the platoon area.

(8) Assessment of Primary Equipment Items. The model now calculates the expected number of losses to each primary equipment type located in the platoon area. This is accomplished as follows:

$$CAS_i = N_i * [1 - \exp (\frac{-PHIT*LA_i*NOR}{APLAT})], \qquad \text{(IV-8-11)}$$

where CAS_i = number of losses of equipment type i;

N_i = number of equipment type i initially in platoon area;

PHIT = fraction of rounds of the volley impacting in platoon area;

LA_i = lethal area (square meters) of this type round against equipment type i;

NOR = number of rounds in this volley; and

APLAT = area of platoon (square meters).

The model repeats this calculation for each different type of equipment that is located in the platoon area, selecting the appropriate value for LA_i and N_i before each execution of the equation.

(9) Assessment of Secondary Equipment Items. The assessment of equipment items is computed directly or indirectly, depending upon the identification of an equipment item as either primary or secondary. All primary items have an associated lethal area specified in the input data and are assessed using Equation IV-8-11. Once the primary items have been assessed, the secondary losses are computed from the secondary tables as:

$$CAS_j^{(2)} = \sum_i CAS_i^{(1)} f_{ij} \left(\frac{E_j^{(2)}}{A_j^{(2)}} \right) \qquad \text{(IV-8-12)}$$

where:

$CAS_j^{(2)}$ = losses of secondary equipment item j

$CAS_i^{(1)}$ = losses of primary equipment item i

f_{ij} = number of secondary equipment items type j authorized to primary equipment item type i

$E_j^{(2)}$ = secondary type j equipment on hand in unit

$A_j^{(2)}$ = secondary type j equipment authorized in unit

(10) Assessment of Casualties. Personnel casualties are determined in a two-step process involving categories of personnel not protected by equipment on hand in the unit and personnel afforded protection by equipment. Figure IV-8-7 illustrates the breakdown of the two categories for a typical unit activity. The protection afforded is determined in the following steps.

(a) Personnel are associated with equipment using the protection priority index to establish the order in which protection is given. The number protected by an equipment on hand item i, N_p^i, is:

$$N_p^i = E_i n_i^k \qquad \text{(IV-8-13)}$$

where:

E_i = number of equipment type i on hand in unit

n_i^k = personnel afforded protection by one equipment item type i when the unit is in an activity k (obtained from input data)

The total number afforded protection, N_p^t is:

$$N_p^t = \text{Minimum} \left[\sum_i N_p^i \, , \, N^t \right] \qquad \text{(IV-8-14)}$$

where: N^t = the present strength of the unit.

The number of casualties assessed when the equipment providing protection is lost, C_p, is given by:

$$C_p = \sum_i L_i \, l_i^k \qquad \text{(IV-8-15)}$$

where:

L_i = number of losses of equipment item i

l_i^k = casualties per each equipment on hand item i loss in activity k (obtained from input data).

and the summation over i is performed in order of the protection priority index and stops as soon as all personnel have been accounted for.

BLUE PERSONNEL PROTECTION DATA

ACTIVITY INDEX 4 (ATTACK)

PERSONNEL NOT PROTECTED BY EQUIPMENT

	STANDING	PRONE	FOXHOLE
POSTURE BREAKDOWN, UNWARNED :	95 %	4 %	1 %
POSTURE BREAKDOWN, WARNED :	9 %	90 %	1 %

TIME TO RETURN TO UNWARNED POSTURE : 2 (MINUTES)

PROTECTION OF PERSONNEL BY EQUIPMENT

PROTECTION PRIORITY	EOH INDEX	PERSONNEL PER ITEM	CASUALTIES PER LOSS
1	23	4	4
2	91	4	4
3	90	2	2
4	20	4	4
5	19	3	3
6	18	11	11
7	41	5	5
8	39	4	4
9	63	5	5
10	61	5	5
11	62	5	5
12	29	4	4
13	32	2	2
14	43	4	4
15	73	2	2
16	75	5	5

Figure IV-8-7. Typical Unit Personnel Protection

(b) The personnel located in the entire target that are not protected by equipment, N^t_{up}, is:

$$N^t_{up} = N^t - N^t_p \qquad \text{(IV-8-16)}$$

The model needs the number of personnel in the platoon area being attacked that are unprotected. This is accomplished in a manner similar to that used for equipment items [see paragraph 3b(6)(b)]. Again the value is calculated in three ways, and to insure conservatism, the smaller of the three values is used for assessment purposes. Thus, the number of unprotected personnel in the platoon area is determined by

Minimum (A, B, C), where

$$A = \frac{\text{number of unprotected personnel in entire target}}{\text{number of platoons in entire target}}$$

$$B = \frac{\text{number of unprotected personnel in impact band}}{\text{number of platoons in impact band}}$$

C = number of unprotected people in impact band.

If the minimum value is greater than zero, these personnel are distributed in the posture categories warned or unwarned with standing, prone, or foxhole protection. The warned category is in effect if a prior volley had impacted within the unit before a time cutoff established in the data preparation has elapsed (in the example in Figure IV-8-7, this time is 2 minutes). The distribution between standing, prone, and foxhole is also specified from input data as shown in Figure IV-8-7. The casualties sustained in each posture are computed using Equation IV-8-11. The number of casualties is added to the protected casualties to obtain the total casualties.

c. Target Loss Update and Firer Expenditure Update. After the assessments have been computed, the unit's personnel and equipment on hand strength is updated. The fire unit is also updated for munitions:

$$M_k \text{ (updated)} = M_k - N^k_r \qquad \text{(IV-8-17)}$$

where:

M_k = number of rounds prior to fire mission of equipment on hand type k in fire unit

N^k_r = number of rounds type k fired in the fire mission

d. Target Suppression. Following the assessment of losses and expenditures, the model determines if the target's current activity should be suppressed as a result of this volley. If the target is engaging in an activity capable of being suppressed, an event is scheduled for the unit which triggers a call to the Suppression Model, which in turn causes the unit's current activity to cease for a short period of time. In DIVWAG, suppression is simulated by temporarily interrupting the fires of a firing artillery unit who receives incoming counterbattery fire; by temporarily halting a moving unit, provided that unit is not actively engaged in close ground combat with an opposing maneuver unit; or by temporarily interrupting a unit's work on an engineering task.

e. Sensor Assessment. A final function simulated in the Delivery and Assessment Submodel is to call a sensor assessment routine. This routine determines whether enemy ground sensors are located in the vicinity of the impact area of the volley, and if so, the level of damage suffered by those sensing systems.

4. HISTORY TAPE OUTPUT. The Area Fire Model writes the following event records onto the period history tape.

Record Type	Title	Frequency
111/112	Area Fire Assessment	One pair of records for each unit assessed personnel casualties.
121	Area Fire Event	One record for each volley fired.

The detailed description of the record formats is presented in paragraph 2c of Appendix A to Chapter 1 of Section VI.

5. PLAY OF ARTILLERY-DELIVERED SCATTERABLE MINES. The discussion in previous paragraphs has dealt only with the scheduling, delivery and assessment of conventional artillery munitions. The DIVWAG model also plays artillery-delivered scatterable mines. The method of simulating the employment of these weapons is described briefly below.

a. Scheduling. All scheduling of artillery-delivered scatterable mine missions is accomplished by the gamer in his pre-game or pre-period analysis. He selects the location to be mined, the type mines to be used, the number of mines to be emplaced, the fire unit to accomplish the task, and the time to initiate the mission. His plan is then implemented using the DSL "EMPLACE" order to begin establishing the field at the desired time. The field is constructed one volley at a time, until the desired density is achieved. Thus, the construction of the field is under strict gamer control, and no means exist for the model to automatically schedule and emplace artillery-delivered (or other types) of minefields.

b. Delivery.

(1) The Delivery and Assessment Submodel performs those functions necessary to simulate the volley-by-volley construction of an artillery-emplaced minefield. When the EMPLACE order is encountered in an artillery unit's set of orders, control branches ultimately to the Delivery and Assessment Submodel, much the same as though the order had been a conventional FIRE order. The submodel checks to see that the requested munition type is available, and then, sensing that a scatterable mine mission has been requested rather than conventional artillery fire, bypasses the assessment equations. Instead, the submodel branches to a section of program logic that performs a few bookkeeping functions before scheduling a call to the Engineer Model, which actually creates the minefield.

(2) The bookkeeping logic first creates a history record (record number 151), and calls routine PUTOUT to place this history record on the history tape, so that the delivery of the rounds is duly recorded for output purposes. Next, the file 12 record is established, which contains data concerning the emplacement of this volley which will be required by the Engineer Model to properly establish the minefield. A call to the Engineer Model then is scheduled that will actually create the minefield as the next scheduled DIVWAG event. Finally, the Delivery and Assessment Submodel updates the fire unit's amount of on-hand ammunition, to account for the expenditure of the current volley.

(3) A pass is made through the Delivery and Assessment Submodel for each volley fired in the scatterable mine mission, just as for conventional missions. One difference between the two types of missions is that the conventional missions require integral numbers of volleys to be fired, while any number of rounds may be specified for scatterable mine missions.

c. Assessment. Once the minefield has been emplaced, equipment losses resulting from encounters are assessed by the Ground Combat Model if the encountering unit is actively engaged in ground combat; otherwise, the Engineer Model calculates the losses resulting from the encounter.

APPENDIX A

AREA FIRE MODEL INPUT REQUIREMENTS

1. INTRODUCTION. The Area Fire Model is concerned with the delivery of nonnuclear area fire munitions and the assessment of their effects. The effects of the area fire events upon targets in the impact area are calculated, and adjustments are made to strengths in terms of personnel and equipment losses. Since understanding of the model performance and its data base is tied closely to an understanding of the TACFIRE Model, it is suggested that the reader may wish to scan Chapter 9 prior to commencing study of this appendix. The purpose of this appendix is to provide the necessary instructions for data entry into the data base for the Area Fire Model. The Area Fire Model data base may be loaded at any time after the TOE load has been performed. (See Chapter 3 for the TOW load information.) Data loading for the Area Fire Model is independent of the data loading for other models, and no other models are dependent upon Area Fire Model data loading.

a. Data Required. The model requires information on the physical geometry of the unit on the battlefield, with the distribution of personnel and equipment inside that area plus data on the weapon and munition lethal areas when employed against enemy equipment and personnel. Both of these major arrays of data will be explained in more detail in subsequent subparagraphs in this chapter. A considerable amount of the data needed to fill these arrays will be obtained from standard Army publications and from intelligence sources. The amount of research required to collect these data is sizeable. It is important that when the task has been completed the reader know the degree of confidence that he has in the data thus gathered. The validity of the information to be entered in the data base is important to the performance of the model. For this reason, and to simplify the task of data acquisition, two forms are provided (Distributing Personnel and Equipment and Lethal Areas of Weapon/Munition) for use in obtaining an overview of data and as a validation tool.

b. Arrangement of Appendix. The first paragraph of this appendix introduces the model, the type of data needed, and the organization of the appendix. The second and third paragraphs present work sheets that may be used in accumulating the needed data prior to punch card entry. The remaining paragraphs provide detailed instructions for making the various entries in card columns for loading the files.

c. Area Fire Model Data Base. The data base information flow is illustrated in Figure IV-8-A-1, Area Fire Model Data Base. At the top of the figure are shown six card formats that are used in loading the data base. The file load programs are shown in the center of the figure. Below the files are the accessing programs that provide data to the model on call. Finally, at the bottom of the illustration, are the files classed as common data bases; i.e., they are accessed by two or more of the DIVWAG models.

(1) Data File 29, Lethal Areas for Personnel and Equipment. Data file 29 is depicted in the lower left third of Figure IV-8-A-1. The array of data in this file is primarily that of lethal areas defined by each weapon and its munition for both equipment and personnel. The Area Fire load program loads

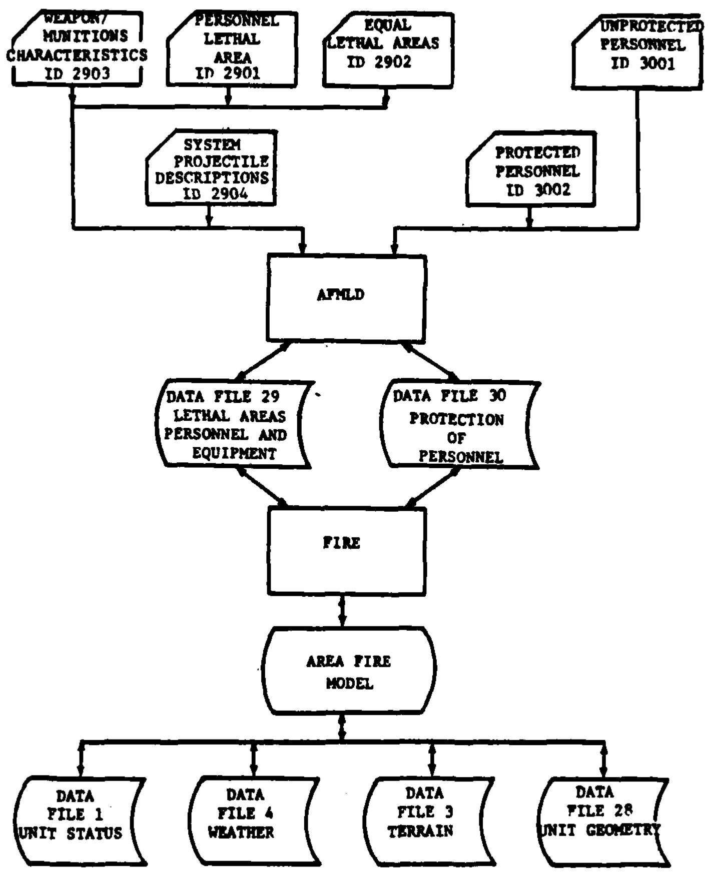

Figure IV-8-A-1. Area Fire Model Data Base this file with the data taken from the three card formats shown at the top left. Each of these cards has an identification (ID) shown, so that cards ID 2901, 2902, 2903, and 2904 all contain data loaded in data file 29. In this file reside all the possible weapon and munition combinations for use with TACFIRE and all possible primary items of equipment with their lethal areas for that weapon and munition combination. Thus, a sizeable quantity of detailed information about the lethality of each delivery system and its munitions is recorded in this file.

(2) Data File 30, Protection of Personnel. Tanks and APCs will afford personnel protection in the field. Other types of equipment will also provide protection for personnel against enemy action. For each force the primary equipment items are listed in order of the protection priority afforded to friendly forces from enemy fire.

2. DATA MATRICES FOR THE AREA FIRE MODEL. The Area Fire Model has two data matrices used to acquire data for entry into the data base. One matrix is used to describe personnel postures at the time that an area fire round lands in their midst. Second is the weapon/munitions characteristics together with definitions of lethal areas and protection provided personnel. Both matrices are used in the calculation of losses for both personnel and equipment.

a. Personnel Postures. At the time a round of area fire munition impacts personnel in the vicinity are considered to be in three possible postures: (1) standing, (2) prone, and (3) in foxholes. Additionally, the consideration of personnel in the different postures is affected by the factor of being warned or unwarned; that is, after receiving the first volley, personnel will be warned until firing stops long enough for them to return to their normal unwarned activities. Figure IV-8-A-2, Personnel Postures, illustrates the data matrix with sample entries.

FORCE________								
Activity		Percent Warned			Percent Unwarned			Minutes to Resume Unwarned Posture
Type (A)	Code (B)	Stand (C)	Prone (D)	Foxhole (E)	Stand (F)	Prone (G)	Foxhole (H)	(I)
Stay	1		50	50	50	50		10
Move	2		60	40	100			6
Fire	3	10	40	50	50	50		4
Attack	4	10	70	20	50	50		4
Defend	5		40	60		50	50	10
Engineer	6	60	40			25	75	10
Withdraw	7	15	25	60	100			5

Figure IV-8-A-2. Personnel Postures

(1) Form Headings. Across the top of the form are listed Activity, Percent Warned, Percent Unwarned, and Minutes to Resume Unwarned Posture. Along the left side are listed the various forms of activities.

(2) Activity. The activities are shown on the form and are defined, for model purposes only, in the following subparagraphs.

(a) Stay: a unit that may be in a marshalling area or assembly area while not in direct contact with hostile forces.

(b) Move: includes both administrative and combat moves in which the unit is traversing across country. For road marches the Movement Model computes both the geometry and rate of movement.

(c) Fire: pertaining to artillery units performing a DSL fire order or in a TACFIRE mode, whether actively firing or awaiting a fire mission.

(d) Attack: infantry, armor, mechanized and other forces are moved up to gain contact with hostile forces.

(e) Defend: the intent of a unit to prevent hostile forces from occupying terrain that is being defended.

(f) Engineer: building roads, preparing obstacles such as minefields, building bunkers, and similar engineer activities. At one time or another all troops may engage in road repair, in developing minefields, and similar engineer type activities; however, for model purposes, only those troops or units that will have the capability of performing the functions enumerated will be given engineer data.

(g) Withdraw: for model purposes, successive delaying positions in which friendly forces are attempting to prevent rapid occupation of terrain currently in their hands.

(3) Percent Warned (Columns C, D, and E). Warned personnel describe the personnel postures that troops normally assume after the first volley. Entries provide the breakdown of personnel among the three basic postures. All entries are in terms of percentages. Reading across a line, all percentages entered for warned personnel must add to 100 percent. Failure to do so will produce proportionate errors in the data output.

(a) Standing (Column C). Enter the percent of personnel unprotected by equipment who would be standing after being warned that area fires were about to come into the area. Usually this will be a very small percentage of personnel and will involve those whose duties require that they be standing.

(b) Prone (Column D). Enter the percentage of personnel who, when warned, would be in a prone position as opposed to standing or in foxholes.

(c) Foxhole (Column E). Assume that not all personnel have access to foxholes and that, in some instances, ditches or other depressions, including shell holes, will provide the same sort of cover as foxholes. Enter the percentage of personnel that would be in foxholes or equivalent after being warned and prior to the arrival of the first round in the area.

(4) Percent Unwarned (Columns F, G, and H). Unwarned personnel postures are those in which troops will normally be, based on their activity when not under fire; i.e., prior to and during the first volley. Enter the percentage that would be found in the various positions (standing, prone, in foxholes) listed herein. The reader is reminded that summing the percentage entries along any one line in this segment must equal 100.

(5) Minutes to Resume Unwarned Posture (Column I). Enter the elapsed time in minutes after all clear has sounded for personnel to regain unwarned postures. The change is from a more protected (warned) environment to a lesser protected (unwarned) environment.

b. Weapons/Munitions Characteristics and Lethal Areas. What effects will a round have on personnel in the open and on their equipment? Questions of this type are to be answered in the Lethal Areas of Weapon/Munition matrix. The form for collecting these data is illustrated in Figure IV-8-A-3. The data to be entered in this table are related to the force and its weapon/munition index. This is the same weapon/munition index referred to earlier in this paragraph and is the same weapon/munition index used in TACFIRE. This fact is of such significance that the instructions and explanation will be repeated in Chapter 9.

(1) Weapon/Munition Index. This index is an arbitrary number from 1 through 36 assigned sequentially to each combination of weapon and ammunition. The table relates the specific weapon identified by its equipment item code with a type of ammunition that can be fired by that weapon. An ammunition item code is also used. The combination of weapon and munition is then used to define the performance parameters, such as maximum and minimum ranges, the curcular error probable, elapsed time to fire first round, and sustained rates of fire, together with similar types of performance information. The area of lethality for equipment (each identified by its item code) and personnel is also specified in terms of the weapon/munitions index number. Calculations later for losses are based on the lethal area for this munition when delivered by the specified weapon. If a new card format is required to obtain the TACFIRE and Area Fire Model data, cross references are immediately established through requiring the weapon/munition index.

(a) Weapons and Ammunition. All indirect fire weapons will be included in the weapon/munition index. Tube artillery, missile artillery, rockets, and mortars qualify for this category of weapons. This list of weapons should be obtained from the TOE primary items list or from the list prepared by DIVWAG model management personnel. It is suggested that each type weapon that is to be included in TACFIRE be listed on the form shown in Figure IV-8-A-4, Weapon/Munition Index. A careful check should be made to ensure that all candidate weapons are included in this list.

WEAPON/MUNITION INDEX 1					FORCE Red
Unforested Terrain Lethal Area (Square Meters)			Forested Terrain Lethal Area (Square Meter)		
Standing	Prone	Foxhole	Standing	Prone	Foxhole
7238	6948	434	4415	4415	217

Enemy Equipment Lethal Area	
Primary Item Code	Lethal Area (Square Meters)
8	3080
52	2980

Figure IV-8-A-3. Completed Lethal Area of Weapon/Munition Matrix

Weapon and Ammunition Combination Index (A)	Weapon		Ammunition	
	Item Code (B)	Nomenclature (C)	Item Code (D)	Nomenclature (E)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				

Figure IV-8-A-4. Weapon/Munition Index

(b) Listing Weapons. In Figure IV-8-A-4 the Weapon/Munition Index has been preprinted in the far left column (A). These indexes are identification numbers and may be randomly applied to any combination weapon and ammunition, but should be used sequentially beginning with one. The item code of the weapon is listed in column B.

(c) Listing Ammunition. Listing ammunition in ascending order will facilitate cross checking later in verifying data entries. If later a type of ammunition is removed from the file the entire list of weapon/munitions must again be resequenced and renumbered so there is no gap in the assigned numbers.

(d) Ammunition Nomenclature. In Figure IV-8-A-4, column E, it is recommended that the nomenclature of the ammunition be written. The data would then include the weapon item code and its nomenclature, the ammunition item code and its nomenclature, together with the weapon/munition index, and could then be clearly understood by those concerned with input, gamer orders, periodic reports, and final status at termination of the game.

(2) Enemy Personnel. Refer now to Figure IV-8-A-3, Lethal Areas of Weapon/Munition. One of the two major segments of this data collection form is for personnel. All entries in this section relate to the weapon/munition index and are for effects on enemy personnel. Listed are unforested terrain and forested terrain; unforested terrain will be discussed first, followed by forested terrain. Each of the following entries is the lethal area in square meters for personnel from one round fired by the specified weapon system.

(a) Standing (Unforested Terrain): For personnel standing in an unforested terrain, enter the lethal area in square meters for this weapon and munition combination.

(b) Prone (Unforested Terrain): Similar information is needed for personnel in a prone position.

(c) Foxhole (Unforested Terrain): For personnel in foxholes, unforested terrain, enter the square meter area of lethality for this round.

(d) Standing (Forested Terrain): Due to the protection that trees and shrubs will provide, this square area may be somewhat smaller than that for personnel in the open. For personnel standing in forested areas, enter the square meters of lethal area for this round.

(e) Prone (Forested Terrain): Enter square meters of lethal area in forested terrain for personnel in prone position.

(f) Foxhole (Forested Terrain): Enter square meters of lethal area when personnel are in foxholes located in a forested area.

(3) Enemy Equipment. The next series of entries is for equipment under fire of the weapon/munition type listed in the top of the form. Each entry requires the lethal area in square meters for the specific enemy item being identified.

(a) Item Code. This is the identification of the specific item of equipment whose performance is to be defined when brought under fire by this weapon/munition.

(b) Equipment Lethal Area. This entry requires data that describe the lethal area in square meters achieved by one round against materiel (equipment) type targets in unforested terrain. The specific piece of equipment is specified such as a PT-76 tank (item code 8), and the lethal area against this tank is entered. Data for these entries may be found in the Legal Mix series of studies, prepared by the USACDC Field Artillery Agency. These studies provide lethal area data for tanks and APCs but do not provide data for other type equipment. If no additional data are available, then the hardness (vulnerability) of other types of equipment should be judgmentally selected (preferably by a qualified artilleryman) by equating the lethal areas of these two equipment types to others. For example, a medium truck could be given the same lethal area of a specific weapon/munition combination against an APC. A radar, relatively soft target, could be given the same lethal area as personnel prone in the forest.

3. WEAPON/MUNITION DELIVERY CHARACTERISTICS DATA CARDS. Each weapon and its ammunition used in Area Fire and/or TACFIRE must have its performance parameters defined. This card format records the data needed for this purpose. After identifying the weapon and specific type of ammunition (by item codes) performance parameters in terms of range, error, and elapsed time in firing are required.

a. Format. The format of this card is illustrated in Figure IV-8-A-5. With the exception of the force indicator, all entries on this card format are numeric. As such, they should be right justified, fractions or decimals should be rounded to the nearest whole number, and that whole number entered in this card format.

b. Type and Force Identification (Columns 1-2). In column 1 the figure 1 has been preprinted, as shown in Figure IV-8-A-5. Make no changes. In column 2 enter only an R or a B, for Red or Blue force respectively.

c. Weapon/Munition Index (Columns 5-6). This two-column entry is to be taken from that developed for TACFIRE and must in all cases be identical. The format for this data entry is shown in Figure IV-8-A-4 and should have been prepared initially in TACFIRE data; however, if this information was not developed in TACFIRE, it will be completed for the Area Fire Assessment submodel and then will be used for the TACFIRE data entries. This same entry is required in additional card formats for this submodel, so adequate preparation in developing this series of indices will pay dividends in accuracy later in model operations.

WEAPON MUNITIONS DELIVERY CHARACTERISTICS																		
					ROUND DISPERSION ERRORS						TIME (SECONDS)							
CARD TYPE	RED OR BLUE	WPN/MUN INDEX	MAXIMUM RANGE (METERS)	MINIMUM RANGE (METERS)	TYPE ERROR	RANGE 1	RANGE 2	RANGE 3	RANGE 4	RANGE 5	RANGE 6	1ST VOLLEY	MAX RATE	SUSTAIN RATE	MAX RNDS	EFFECTS RADIUS (METERS)	CARD ID	CARD SEQ NR
1																	2003	

Figure IV-8-A-5. Weapon Munitions Delivery Characteristics

d. Range (Columns 9-20). The maximum and minimum ranges in meters of this combination weapon and munition are to be stated in these card columns.

(1) Maximum Range (Columns 9-14). A range of up to 999,999 meters may be entered in these card columns. Enter the accurate range and right-justify the numbers.

(2) Minimum Range (Columns 15-20). Enter the minimum range of this weapon and its munition in meters.

e. Errors (Columns 23-47). Several types of errors are inherent in the weapon and its munition. For this series of card columns, the errors information desired is the meter distance in either circular error probable of round dispersion or its sigma. It may be entered in either format (sigma or CEP) but must be so stated with a code entry of C for CEP or S for sigma. The round dispersion errors should be entered for six range points: maximum range, minimum range, and four equally spaced range points between the two extremes. These range points are defined by the equation:

$$R_i = R_{max} - 0.2 * (i-1) * (R_{max} - R_{min}) \qquad \text{(IV-8-A-1)}$$

where:

R_i = specific range desired

R_{max} = maximum range of weapon and munition in meters

R_{min} = minimum range of weapon and munition in meters

i = variation of different ranges from 1 through 6

(1) Type of Error (Column 23). Enter either C for circular error probable (CEP) round dispersion or S for sigma errors in meters of round dispersion.

(2) Round Dispersion Range Point 1 (Columns 24-27). Enter the meters of round dispersion for range point 1 as explained above.

(3) Round Dispersion Range Points 2 Through 6 (Columns 28-47). For each of the remaining range distances enter the round dispersion in meters from the true target. Enter a maximum of six different ranges or as many different range values as are available.

f. Elapsed Time (Columns 50-61). The elapsed time desired in these card columns is for the performance of the weapon with this specific round. The first time required is the elapsed time to fire the first volley, in seconds, from the command to fire to impact of the first round on target. Other times required are the elapsed times between firing rounds at maximum rates of fire and at sustained rates of fire.

(1) Time (Seconds) to Fire First Volley (Columns 50-53). This is the minimum time between fire missions for each firing unit. Enter the elapsed time to fire the first volley from the command to fire to round impact in seconds, round to nearest whole second, and enter the whole number.

(2) Time (Seconds) Between Rounds, Maximum Rate of Fire (Columns 54-57). Enter the elapsed time in seconds between rounds in maximum rate of fire. Maximum rate of fire is the number of rounds (volleys) that a tube or missile type unit can deliver in 3 minutes of firing.

(3) Time (Seconds) Between Sustained Rounds of Fire (Columns 58-61). Sustained rate of fire is that number of rounds that an artillery tube can deliver when firing longer than 3 minutes and up to 1 hour, or the number of rounds that missile unit can deliver in 1 hour. Enter the elapsed time between rounds during sustained rates of fire for this munition and this weapon.

g. Number of Rounds, Maximum Rate (Columns 64-66). Enter the number of rounds/missiles that a unit can fire in 3 minutes (maximum rate of fire). This is the total accumulated from the command to fire until the rate is dropped back to sustained fires.

h. Effects Radius (Columns 67-70). Enter the effects radius in meters of this round on the target. This radius is the radius of a circle in which damage can be expected to occur as a result of the impacting round.

i. Other Weapon/Munition Indices. The card illustrated in Figure IV-8-A-5 will record the performance characteristics of only one weapon and its munition; therefore, each weapon/munition must be defined by a separate card. There may be a maximum of 36 different weapon/munition combinations for each force with a corresponding limit on the number of 2903 type cards. For each force the number of cards prepared should equal the number of entries on the weapon/munition table illustrated in Figure IV-8-A-4, Weapon/Munition Index.

4. WEAPONS/MUNITION PROJECTILE DESCRIPTION. Information supplied in this card format describes the projectile angle of fire, caliber, and length of the round. These data are used in the Intelligence and Control Countermortar/Counterbattery Detection Submodel.

a. Card Format. The card format is depicted in Figure IV-8-A-6.

b. Card Type and Force Designator (Columns 1-2). The number 1 is preprinted in column 1. In column 2 enter only an "R" for Red or "B" for Blue forces.

c. Weapon/Munitions Index (Columns 5-6). This is the same weapon/munition index used in card ID 2903.

WEAPONS/MUNITION PROJECTILE DESCRIPTION										
CARD TYPE	RED OR BLUE		WPN/MUN INDEX		MEAN ANGLE OF FIRE (DEGREES)	PROJEC-TILE LENGTH (MILI-METERS)	CALIBER (MILI-METERS)	COMMENTS:	CARD ID	CARD SEQ. NR
1									2904	

Figure IV-8-A-6. Weapons/Munition Projectile Description

d. Mean Angle of Fire (Columns 9-11). In these card columns enter the angle of fire that is representative or typical of the weapon/munition combination being considered. The entry is in degrees and is the angle of fire measured from the horizontal.

e. Projectile Length (Columns 12-16). Enter the length of the projectile in millimeters, right justified.

f. Projectile Caliber (Columns 17-21). Enter the caliber of the projectile in millimeters, right justified.

5. WEAPON/MUNITION LETHAL AREAS FOR PERSONNEL. The information in this card format is for lethal areas with regard to personnel of enemy forces.

a. Card Format. The card format is depicted in Figure IV-8-A-7.

b. Card Type and Force Designator (Columns 1-2). The number 1 is preprinted in column 1. In column 2 enter only an "R" for Red or "B" for Blue forces.

c. Weapon/Munition Index (Columns 5-6). This is the same weapon/munition index used in the performance parameter card ID 2903 in the TACFIRE Model. No change or deviation is tolerated from those listed in the TACFIRE Model or those entered in card ID 2903.

d. Item Codes of Weapon and Munition (Columns 9-16). In these card columns are entered the item codes of the weapon and its munition. These codes should be copied directly from the form illustrated in Figure IV-8-A-4, Weapon/Munition Index.

(1) Weapon Item Code (Columns 9-11). In these card columns enter the item code of the weapon, right justified.

(2) Munition Item Code (Columns 14-16). Enter the munition item code, right justified.

e. Unforested Terrain (Columns 19-39). The lethal area in square meters against enemy forces personnel in unforested terrain is to be entered in these card columns. Unforested terrain has virtually no trees or low lying shrubs and is not too thickly clumped with short to medium length grass so that a man in the standing position is clearly exposed. The square meters of lethal area are to be entered for each of the postures of personnel indicated below. This information may be extracted directly from Figure IV-8-A-3. Completed Lethal Areas of Weapon and Munition.

(1) Standing (Columns 19-25). Enter the square meters area lethal to personnel standing for this weapon and munition. Figure IV-8-A-3 can be used to extract these data for card column entry.

WEAPONS/MUNITION LETHAL AREA FOR PERSONNEL																	
									LETHAL AREA (SQUARE METERS)								
									OPEN TERRAIN			FORESTED TERRAIN					
CARD TYPE	RED OR BLUE		WPN/MUN INDEX		WPN ITEM CODE		AMMO ITEM CODE		STANDING	PRONE	FOXHOLE	STANDING	PRONE	FOXHOLE		CARD ID	CARD SEQ. NR
1																2901	

Figure IV-8-A-7. Weapons/Munition Lethal Area for Personnel

(2) Prone (Columns 26-32). Enter the square meters area lethal to personnel prone for this weapon and its munition. Refer to Figure IV-8-A-3.

(3) Foxhole (Columns 33-39). Enter the square meters lethal area for personnel in foxholes due to the lethality of this weapon and munition combination from Figure IV-8-A-3.

f. Forested Terrain (Columns 40-60). The square meters lethal area for enemy personnel in forested area must be entered for this weapon and its munition. The data may be extracted from the right half of the top portion of Figure IV-8-A-3.

(1) Standing (Columns 40-46). Enter the square meters area of lethality for standing personnel for this weapon and munition.

(2) Prone (Columns 47-53). Enter the square meters area of lethality for prone personnel for this weapon and its munition.

(3) Foxhole (Columns 54-60). Enter the area in square meters of lethality for personnel in foxholes for this weapon and its munition.

g. Additional Weapon/Munition Index. For each card type 2903 completed there must also be one for ID 2901. Thus, there will be multiple cards for the lethal area of personnel. All will have the type 1 in card column 1 and the ID of 2901 in columns 73-76. Sequence numbers in arithmetic sequence may be stated in columns 77-80.

6. LETHAL AREA FOR ENEMY FORCE EQUIPMENT. Each friendly force weapon and munition combination has a lethal area that has been determined for each of the enemy force items of equipment. Each type of primary equipment issued to enemy forces is to be accounted for in this card format designated by card ID 2902 (Figure IV-8-A-8). Each is to be assigned a lethal area in which it will be destroyed should it be in that area when the indicated friendly weapon and munition combination is fired against it. Secondary items should not be given a lethal area. Referring to Figure IV-8-A-3, Completed Lethal Areas of Weapon/Munitions, if the form illustrated in the lower half of the figure were completed the data for these entires could be obtained from that form.

a. Card Format. The card format is such that it has a repetition of item codes and the square meters of lethal area for this weapon and munition. Up to seven item codes may be listed with their square meters lethal area per card.

b. Card Type and Force (Columns 1-2). Preprinted in card column 1 is the figure 1. Make no changes in this number. In card column 2 enter only an "R" for Red or "B" for Blue forces.

c. Weapon/Munition Index (Columns 5-6). In these two card columns enter the weapon/munition index. Refer to Figure IV-8-A-4, Weapon/Munition Index. If the form illustrated in this figure were filled in, the data needed for weapon/munition index could be copied directly. These data must otherwise agree in every detail with that entered in the TACFIRE data base and in cards ID 2903 and ID 2901.

WEAPON/MUNITION INDEX FOR LETHAL AREAS FOR ENEMY EQUIPMENT																			
CARD TYPE	RED OR BLUE		WPN/MUN INDEX		ENEMY ITEM CODE	LETHAL AREA SQUARE METERS	ENEMY ITEM CODE	LETHAL AREA SQUARE METERS	ENEMY ITEM CODE	LETHAL AREA SQUARE METERS	ENEMY ITEM CODE	LETHAL AREA SQUARE METERS	ENEMY ITEM CODE	LETHAL AREA SQUARE METERS	ENEMY ITEM CODE	LETHAL AREA SQUARE METERS		CARD ID	CARD SEQ. NR
1																		2902	

Figure IV-8-A-8. Weapon/Munition Lethal Areas for Enemy Equipment

d. Item Code of Enemy Equipment (Columns 9-11). Enter the item code of enemy equipment that may prove to be a target for friendly forces. Only primary items of equipment are to be considered. Such items as classes of supply and the like will not be entered in this card format. If the form in Figure IV-8-A-3 were completed the data for this entry could be taken from the column headed equipment item code. In this manner all candidate target items will be entered in the card format.

e. Lethal Area (Columns 12-17). Enter the lethal area in square meters for enemy equipment established for the equipment item code entered in columns 9-11.

f. Additional Item Codes and Lethal Areas (Columns 18-70). Each primary item of the enemy force that is a potential target is to be entered into the data base. Up to seven items may be entered on a single card format. If additional items above the seven indicated are to be entered in the data base, then more cards must be prepared. If additional cards are required, they will be prepared in the same manner as explained for this card.

g. Card Identification (Columns 73-76). The identification of each card in this format is 2902. Additional cards prepared to accommodate the other items will also bear this identification.

7. PERSONNEL POSTURES. What percentage of personnel, in unforested area, might be targets for enemy fire? This question is raised in connection with assessing the losses of personnel. It is data needed for each of the activities in which the unit may be engaged and to which these personnel are assigned. The data to be recorded in this card format are in answer to the foregoing question and others along the lines of what are normal personnel postures, dependent upon the activity of the units. Paragraph 2a discussed personnel postures. The reader is referred to these paragraphs for further details. Data as entered in the samples of these paragraphs will be used to illustrate the data entries for various card columns in this card format.

a. Card Description. The purpose of this card (Figure IV-8-A-9) is to record, for data base entry, the percentage of a unit's personnel that may be in various postures with respect to the activity assigned that unit at any specific time. The data to be used in making entries for this card format may be extracted from the form illustrated in Figure IV-8-A-2, Completed Data on Personnel Postures, provided that the acquired data are entered in that form initially. It is designed to capture the data for three different activities. Thus, each force will require three cards.

b. Type and Designator (Columns 1-2). As in all standard card formats in this volume, column 1 has been preprinted with a number, in this case 1. Make no change. In column 2 enter "R" for Red or "B" for Blue force. Any other entry will cause data rejection.

c. Activity Index (Column 5). A number 1 through 7 may be entered in this column as a code for the type of activity that the unit may be engaged in at any one time. This activity code is shown in Figure IV-8-A-2 in the

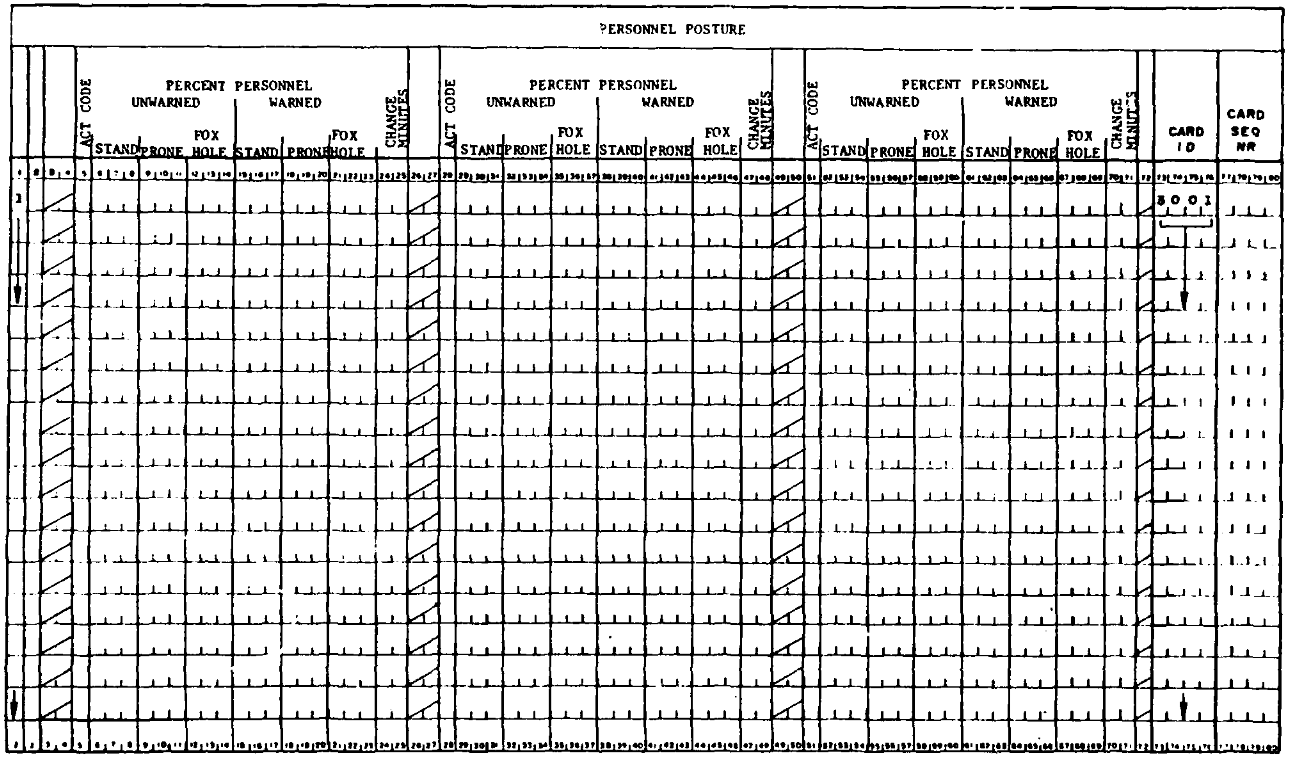

Figure IV-8-A-9. Personnel Posture

second column from the left. There are provisions to enter the percentage of personnel in each posture for three different activities. Detailed explanations will be given for this one activity, and data completion for the others will follow these instructions.

d. Percentage of Personnel in Possible Postures (Columns 6-23). For the activity coded in column 5 enter the percentage of personnel that will be in the three postures indicated for warned and unwarned conditions. The reader is cautioned that the sum of percentages for warned must equal 100 percent for the three postures. The same is true for the unwarned situation.

(1) Unwarned Personnel (Columns 6-14). Assume that personnel have not been warned by either sirens for air alerts, rounds falling into the area from enemy fires, or by observers who would give advanced notice of fire about to fall on the area.

(a) Standing (Columns 6-8). Enter the percentage of personnel, in accordance with the activity coded in card column 5, that would be standing. In the example, referring to Figure IV-8-A-2, for activity 1 (stay) the entry would be 50.

(b) Prone (Columns 9-11). Enter the percentage of personnel, in accordance with the activity coded in card column 5, that would be prone. Referring to Figure IV-8-A-2, for activity 1 (stay) the entry would be 50.

(c) Foxhole (Columns 12-14). Enter the percentage of personnel, in accordance with the activity coded in card column 5, that would be in foxholes. In the example, referring to Figure IV-8-A-2 for activity 1 (stay), the entry would be none. Thus, these card columns may be left blank or zeros entered. The sum of the three entries must be 100 percent.

(2) Warned Personnel. The foregoing situation found personnel who were not warned that enemy fire would be in the area. In this situation they are warned, usually through rounds falling in their midst. The warning may also come from observers or through sirens in the area, which would declare an alert. Personnel in the less protected postures would be there, under conditions of being warned, only because their duties so required. On this basis the percentage in more exposed positions should be less than that experienced for the unwarned positions.

(a) Standing. (Columns 15-17). Enter the percentage of personnel that would be in the standing position even after being warned that enemy fires were to fall in the area. Using the example in Figure IV-8-A-2 the entry would be none. The columns may be left blank or zeros entered.

(b) Prone (Columns 18-20). Enter the percentage of personnel that would be in the prone position after being warned that enemy fires were to fall in the area, in accordance with the activity 1 (stay). From the example Figure IV-8-A-2 this would be 50 percent.

AD-A112 652 ARMY COMBINED ARMS COMBAT DEVELOPMENTS ACTIVITY FORT--ETC F/G 15/7
DIVWAG MODEL DOCUMENTATION. VOLUME II. PROGRAMMER/ANALYST MANUA--ETC(U)
JUL 76
UNCLASSIFIED CACDA-TR-8-76-VOL-2-PT-3 NL

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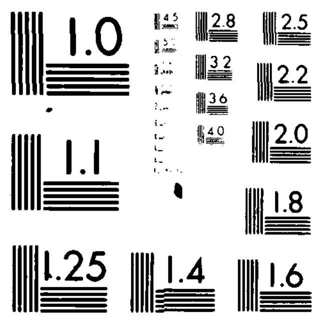

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(c) Foxhole (Columns 21-23). Enter the percentage of personnel that would be in foxholes after being warned that enemy fires were to fall in the area, in accordance with activity 1 (stay). From the example in Figure IV-8-A-2 the number would be 50 percent. The sum of all three entries for warned personnel totals 100 percent in the example.

(3) Minutes to Resume Unwarned Posture (Columns 24-25). Enter the average time lapse, to the nearest minute, between the time rounds cease falling in the vicinity of the personnel until the time at which all personnel can be assumed to have returned to unwarned postures.

e. Additonal Activities (Columns 28-69). Personnel percentages for the three postures can be entered for two additional activities on this card format. The instructions for making these entries are the same as those in the foregoing paragraphs with the exception of the change in activitv. The illustrated completed form in Figure IV-8-A-2 can be used as a sample in filling out the rest of the card columns in this format. It is imperative that each and every activity be given its percentage breakout of personnel in accordance with the postures that they most likely would assume under these environmental conditions.

f. Additional Cards. It was mentioned that three cards would be required for each force in order to record for data base purposes the percentage of personnel in three postures for all activities. Each of these three cards will have the following identical markings: card column 1 will bear the preprinted number 1; columns 73-76 will have the identification of 3001; and column 2 will have "B" inserted for Blue force or "R" for Red force.

8. PERSONNEL PROTECTION BY ORGANIC EQUIPMENT. Equipment issued to the various units affords some protection to personnel, and they are used for this purpose in many instances. Whereas the effects area of a particular type of ammunition may prove lethal to personnel in exposed postures, if they are in organic equipment, they may be protected. On the other hand if the equipment is within the effects radius of the round, and this should prove to destroy the equipment, then in accordance with model ground rules not all on-board personnel must be lost. Only those personnel as stated in the data base would be counted as casualties.

a. Card Format. The essentials of the data to be recorded in this card format (Figure IV-8-A-10), identified by card ID 3002, are: (1) the activity being engaged in, (2) a protection priority, (3) item code of that item affording protection for personnel, (4) the number of personnel that can expect protection from the equipment item, and (5) the number of personnel that would be lost were the item to be destroyed. These data are essential to loss assessment and are used by the Area Fire Assessment submodel as given in the following example. Assume that there were 10 soldiers in a given area, and they had a tank dug in and had been warned. If a given round of ammunition from enemy forces landed in close proximity, suppose according to the data four men would be in shelter of the tank and would be lost according to damage to the tank. The six men would be unprotected but in warned postures.

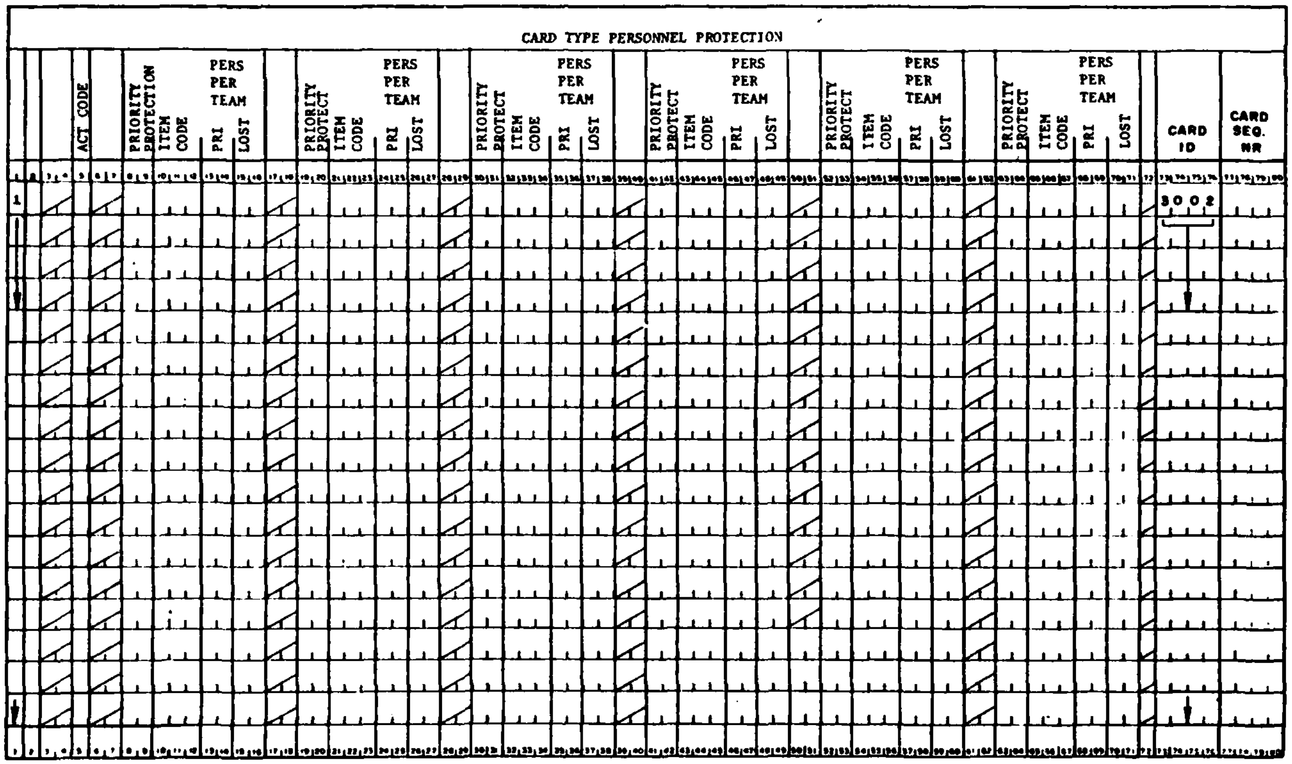

Figure IV-8-A-10. Personnel Protection

From Figure IV-8-A-2 in the warned position we find that 50 percent would be in prone position and 50 percent would be in foxholes; therefore, three men will be subject to the lethal area of the munition to prone personnel, three will be subject to the lethal area of the munition to personnel in foxholes, and the remaining four will be counted casualties in proportion to damage to the tank.

(1) Protection Priority. When personnel have a choice of equipment items to protect them, then a preference must be established that, for example, they would move to the protection of tanks before they would move to trucks. This order of choice will be referred to as protection priority.

(2) Casualties. Prior to determining the total casualties it would have to be determined whether that tank was in the lethal area for equipment with respect to the round that fell in the area. If not, then the tank and those protected by it were still carried as for duty. With the protection priority determined, and the number of personnel that could be aboard the tank stated, the submodel has no difficulty in determining the number of personnel exposed in the personnel lethal area and those given adequate protection.

(3) Summary. The foregoing example is intended to illustrate how the data entered in this card format are to be used by the model. Of course, all the previous data entered by the various card formats will also be used in making loss assessments by this model as the situation changes.

b. Card Type and Force Designator (Columns 1-2). Card column 1 has the preprinted figure 1. Make no change. In card column 2, the force designator is entered.

c. Activity Index (Column 5). Enter the activity code in this column intended for the definition of the entries made in trailing card columns. The codes for these activity indexes are shown in Figure IV-8-A-2.

d. Protection Priority (Columns 8-9). The numerical entry for these card columns is an indication of personnel preference for the order in which they would select equipment as protection from enemy fire. The priority list runs from 1 through 99. If, for example, a truck and a tank were present in the same vicinity, and rounds began to fall in the area, the question is which of these equipments would personnel choose for protection from the fire. It is probable that the tank would be chosen first and the truck second. This is not intended as a solution for data entry, but only to illustrate the type of choice that is open to the user. The priority lis [illegible] ded from 1 through 99 and must be entered in sequence. There will be no [illegible] ate priority assigned to two different items. Each of the items must ha [illegible] its unique and identifiable priority.

e. Item Code (Columns 10-12). Enter the item code of friendly equipment that will afford protection to personnel.

f. Personnel Protection and Losses (Columns 13-16). The number of personnel that can be protected by this item is to be entered with the number of casualties during the event when this item is destroyed. The two numbers need not be the same; and, in some instances, it may be desirable to have the number of personnel protected as being larger than those that would be declared casualties.

(1) Number of Personnel Protected per Item. The number of personnel that can be afforded protection by this equipment item is to be entered here.

(2) Number of Casualties per Item Lost. The number of personnel that will be lost as a result of being on board this item or being protected by it when it was destroyed will be entered here. This number must be equal to or smaller than that entered for number of personnel protected.

g. Additional Protection Items (Columns 20-71). Data entries in the succeeding sets of protection data are to be made in the same manner as explained for the foregoing data. Up to and including six sets of data may be entered. Additional items beyond six requires the preparation of additional cards. As many cards may be prepared as there are protective items, and their data sets are to be entered in the data base within the limit of 100. It is presumed that the number of equipment items that will afford protection for personnel will generally be much fewer than 100.

h. Additional Cards. Each additional card prepared for this type of data will have as standard entries the following three data items: (1) card column 1 will have the preprinted 1, (2) either "R" for Red or "B" for Blue force will be entered in column 2, and (3) in columns 73-76 will be entered the identification of 3002.

9. AREA FIRE DATA DECK STRUCTURE. There are six different card formats in the constant data input deck structure for the area fire and data. This paragraph states the order in which the punched cards should be assembled and outlines the order in which these cards must be grouped after they are assembled.

a. Cards in Loading Constant Data for Area Fire. There are six distinct card formats required by the load program AFMLD, as illustrated in Figure IV-8-A-11. The summarized list in the figure depicts the specific card type number, the force designator, title of the card, and the card identification number. The 2900 and 3000 card series (2901, 2902, 2903, 2904, 3001, and 3002) is loaded onto data files 29 and 30 by AFMLD. The first group of the data in the list is concerned with the characteristics and performance of the weapons and munitions that are to be employed, and the last group of the data list consists of posture and protection data that units may find on the combat field.

b. Creating Area Fire Constant Data Input Files. Figure IV-8-A-12 illustrates the alignment of the subdecks required by the load program, AFMLD. After the insertion of the proper system control cards in the assembled data deck, it is ready to be read in to the constant data input files by the appropriate load program.

Card Type	Force	Card Title	Card ID
1	B	Blue Munition Lethal Areas on Personnel	2901
1	B	Blue Munition Lethal Areas on Equipment	2902
1	B	Blue Munition Delivery Characteristics	2903
1	B	Blue Weapons/Munition Projectile Description	2904
1	R	Red Munition Lethal Areas on Personnel	2901
1	R	Red Munition Lethal Areas on Equipment	2902
1	R	Red Munition Delivery Characteristics	2903
1	R	Red Weapons/Munition Projectile Description	2904
1	B	Blue Personnel Posture Breakdown	3001
1	B	Blue Personnel Protection Data	3002
1	R	Red Personnel Posture Breakdown	3001
1	R	Red Personnel Protection Data	3002

Figure IV-8-A-11. Area Fire Card Formats, Load Routine AFMLD

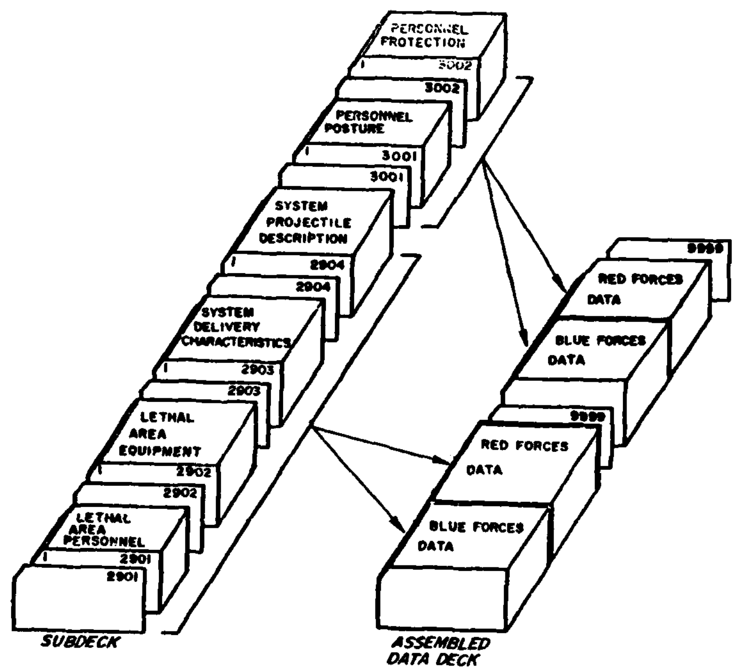

Figure IV-8-A-12. Area Fire Model Data Deck Structure

(1) Subdeck Structure. At the left of Figure IV-8-A-12 is the subdeck structure required for a single force. Composition and order of the subdecks is described in the following subparagraphs.

(a) Characteristics and Performance of Weapons and Munitions. The first subdeck is illustrated at the left foreground of Figure IV-8-A-12. This subdeck contains the data to be loaded in data file 29 and consists of the characteristics and performance of weapons and munitions. The alignment of cards for this subdeck is as illustrated. The first card has the identifier 2901 punched in card columns 73-76. Immediately behind this card is the data on lethal areas for personnel. Blue force data are collected first and assembled into one segment of the subdeck. Red force data are likewise assembled into a separate deck. Behind the last card in lethal area for personnel ID 2901, is the leader card for lethal area for equipment, ID 2902. The same arrangements of cards are made for ID 2902 as for 2901, and the same procedure is also carried out for ID 2903 and 2904. Behind the last card with ID 2904 is placed an end of file card (9999 in columns 73-76).

(b) Data for Personnel. The second subdeck is illustrated in the left background of Figure IV-8-A-12. This subdeck contains the data on personnel for loading in data file 30. This subdeck is constructed exactly as explained for the other subdeck. Each card identifier has a lead card, and the last series of cards in the 3002 series is followed by the end of file card.

(2) Main Deck Structure. Each of the subdecks is assembled as explained in the preceding subparagraph. Blue force data are assembled in one subdeck and Red force data in another. Referring to the assembled decks in Figure IV-8-A-12 it is noted that Blue force data always precede the same type data for Red forces. This scheme is continued through the series of both subdecks.

c. Updating Area Fire Model Constant Data Input Files. In updating an Area Fire Model constant data file, it is essential that the entire data deck used to initially load the file be available. The updating performed for Area Fire Model constant data input consists of correcting an existing error, deleting data from the files, and adding data to the files.

(1) Correcting an Error. An error may be detected in the data entered in the file. The card in error is removed from the data deck and replaced by a newly punched card with corrected data. The entire data deck is then read in to the DIVWAG Area Fire Model constant data file. This procedure corrects the detected error.

(2) Deleting Data from Constant Data Files. The data to be deleted are identified with the punch cards that originally entered the data into the files. These cards are removed from the data deck and the remaining cards consolidated into the assembled deck. With the unwanted cards and respective data removed from the data deck, the remaining data deck should then be resubmitted for rerun in the DIVWAG Area Fire constant data files. The recreation of the files without the unwanted data performs the deletion function.

(3) Addition of Data. The data to be added are inserted into the data deck after the existing cards but integrated into the proper place so that weapon characteristics data are not commingled with personnel posture and protection. When the deck is properly assembled it is submitted for rerun in the DIVWAG Area Fire Model constant data input. The recreation of the existing files and their expansion with the added data performs the function of adding data to the constant data files.

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APPENDIX A1

ADDITIONAL DATA REQUIRED BY AREA FIRE MODEL

1. INTRODUCTION. The basic inputs required to execute the Area Fire Model were presented in Appendix A. This appendix describes one additional set of data required. While these data are loaded as a part of the unit dimension and distribution data (using the DIMLOAD data load program) and stored in data file 28, they are used exclusively by the Area Fire Model.

2. DESCRIPTION OF REQUIRED DATA.

a. As described in Chapter 8, DIVWAG represents the area occupied by a unit as a rectangle that typically covers several million square meters or more, especially in the case of maneuver units. The assessment logic in the Area Fire Model assumes that killable target elements in the unit are clustered together in several basic sub-groups within the total unit area (for example, tank platoons in an armored battalion), with gaps existing between the clusters. These clusters are called platoons (even though that term is not precise for such units as artillery battalions), and they represent the basic tactical element below which the parent unit would not normally be sub-divided. For example, an armored battalion might tactically assign his companys different missions, and they in turn might assign various missions to the platoons of which they are composed, but the platoons would not normally be broken into smaller entities for tactical reasons. Thus, the platoon would be considered the basic tactical element of the armored battalion. The basic tactical element of an artillery battalion might be an artillery battery, although it would be referred to as a "platoon" using this terminology.

b. It is one of these basic platoons that the Area Fire Model assumes has been acquired, and against which the resulting volley is assessed. Thus, required inputs to the model are the number of basic platoons in each target type, and the area covered by each platoon.

c. These values are entered on the 2807 data card, and are input for each UTD type (that is, for each type and size unit), and for each activity in which the type target might engage. This allows the number and size of the platoons of an armored battalion (or any other parent unit) to change, if appropriate, when the activity (mission) of the battalion changes.

3. COMPLETING THE 2807 DATA FORM.

a. Figure IV-8-A1-1 illustrates the required data to be entered on the 2807 card type. One card is needed for each target UTD that can be attacked by artillery. Cards for both Red and Blue units are required and they are distinguished by the R or B entered in column two. The UTD of each target type subject to artillery losses is entered in columns 3 to 6. The remainder of the card is divided into seven fields (separated

Card Column	Description of entry
1	Enter a "1" in column 1
2	Enter B for Blue units, R for Red units
3-6	Enter the UTD of the target
7	Leave blank
8-13	Area of one platoon when the parent UTD is in a STAY activity
14-15	Number of platoons when the parent UTD is in a STAY activity
16	Leave blank
17-22	Area of one platoon when the parent UTD is in a MOVE activity
23-24	Number of platoons when the parent UTD is in a MOVE activity
25	Leave blank
26-31	Area of one platoon when the parent UTD is in a FIRE activity
32-33	Number of platoons when the parent UTD is in a FIRE activity
34	Leave blank
35-40	Area of one platoon when the parent UTD is in an ATTACK activity
41-42	Number of platoons when the parent UTD is in an ATTACK activity
43	Leave blank
44-49	Area of one platoon when the parent UTD is in a DEFEND activity
50-51	Number of platoons when the parent UTD is in a DEFEND activity
52	Leave blank
53-58	Area of one platoon when the parent UTD is in an ENGINEER activity
59-60	Number of platoons when the parent UTD is in an ENGINEER activity

Figure IV-8-A1-1. Description of data to be entered on 2807 card type (continued next page).

by blank columns) corresponding to the seven target activities simulated in DIVWAG (stay, move, fire, attack, defend or prepare, engineer, withdraw). For each activity, the size of a basic platoon (in square meters) and the number of platoons are entered for the particular UTD type being considered. Both these values are right-justified on the card. A "1" must be entered in column one, and "2807" must be punched in columns 73-76.

b. In the event a particular UTD type cannot engage in a particular activity, no entry is made for that combination. For example, engineer units cannot "attack" in DIVWAG, and maneuver units cannot "fire"; thus, columns 35 through 42 would be left blank in the first case, and columns 26-33 would be blank in the second example.

c. The Area Fire Model provides default values to be used in the assessment equations if a combination arises during a DIVWAG simulation run for which no data have been provided on the 2807 card. These values are currently set at 19,999 square meters and 9 platoons. They can be readily changed if other values are desired.

d. There is no requirement to force the sum of the platoon areas to equal the total area of the rectangle representing the parent unit's dimension. In fact, this should be avoided, or else the platoon areas will take on such large size (when the parent unit is large) that they will be relatively invulnerable to artillery fire. The size of the basic tactical unit should be determined without regard to the size of the rectangle representing the parent unit, and should reflect the data preparer's best estimate of the area occupied on the ground by a platoon of a particular type performing a particular mission.

e. Once the Red and Blue cards have been punched and verified, they are assembled into a single deck. The Blue cards are placed ahead of the Red cards in the deck, but within the two groups, the cards can be in any order. This combined deck is then placed behind the cards of the dimension data load, and are loaded into the DIVWAG data files by the DIMLOAD load program.

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APPENDIX B

AREA FIRE MODEL PROGRAM DESCRIPTION

1. INTRODUCTION. The routines discussed in this appendix are required by the Area Fire Model to schedule DSL gamer-ordered artillery fire and to assess the damage and suppression effects of conventional area fires, either DSL-ordered or TACFIRE-generated. The suppression effects in the form of delayed events for firing and moving units assessed damage from area fire weapons as well as from other fire-power sources are discussed in Chapter 11, Suppression Model. Routines for the assessment of damage to individually located sensors are discussed in Chapter 6, Intelligence and Control Model, and the scheduling routines of the TACFIRE Model are discussed in Chapter 9. The macro flow of the Area Fire Model is shown in Figure IV-8-B-1.

2. ROUTINE FIREDT:

a. Purpose. FIREDT schedules the impact times of DSL gamer-ordered fire missions and sets up the subsequent assessment event. Both conventional and nuclear fires are scheduled within FIREDT.

b. Input Variables:

(1) Standard Common Block Variables. UMAIN, TCLOCK, BPOINT.

(2) Other Variables:

Name	Source	Contents
DGZX	ONE	X coordinate of impact point of volley.
DGZY	ONE	Y coordinate of impact point of volley.
DOST(27)	ONE	Number of volleys fired in the current fire mission; used in the routine as NVOLS.
NOR	ONE	Number of rounds in volley of the fire mission.
NORREC	ONE	Number of rounds requested to be fired in fire mission.
NUMMUN	ONE	Amount of munitions on hand at fire unit.

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Name	Source	Contents
NUMRND	ONE	Current number of tubes or missiles firing in the fire unit.
WMIDX	ONE	Weapon-munition combination index used to reference data in WMNPA array.
WMNPA(396)	DF25	Weapon-munitions parameters array.
IPWEOH(36)		WMNPA(1). Item codes of weapons array.
IPMEOH(36)		WMNPA(37). Item code of munitions array.
ITRONE(36)		WMNPA(73). Time to fire first volley array.
ITRN(36)		WMNPA(109). Time to fire second through Nth volley array.
ITRS(36)		WMNPA(145). Time to fire subsequent volleys array.
IRNCO(36)		WMNPA(181). Nth round cutoff array. Used to determine which firing time array to use.
IFL31(10, 201)	DF31	Supply Status File.
IFL31(1, N)		Equipment Item Code.
IFL31(4, N)		Quantity OH in trains.

c. Output Variables:

(1) Standard Common Block Variable. UMAIN

(2) Other Variables:

Name	Destination	Contents
DELT	ONE	Event time until round impact in effects area.
NOR	ONE	Number of rounds fired in this volley.

Name	Destination	Contents
NVOLS	ONE	Number of volleys fired in current fire mission.
NORREC	ONE	Number of rounds fired in current fire mission.

d. Logical Flow (Figure IV-8-B-1):

(1) Blocks 1, 2. If the fire mission request is for nuclear fire the routine NFIRDT is called; otherwise, the fire mission scheduling for conventional artillery fire continues.

(2) Block 3. The nuclear fire request is checked to determine if there are range limitations by a nuclear fire assessment scheduling routine.

(3) Block 4. The weapon-munitions data for the firing unit's force, are obtained from data file 25 and stored in WMNPA.

(4) Block 5. Using the last two characters of the weapon-munitions code, (MUNTPY), the weapon-munitions combination index (WMIDX), is established for this round. This index is used to reference pertinent scheduling and indentification data in WMNPA.

(5) Blocks 6, 7. If the target is not within range of the firing unit, the DSL request is rejected. The range limits are obtained from WMNPA.

(6) Block 8. Using the munitions item code for this combination, IPMEOH(WMIDX) equals NMEOH, the number of artillery tubes or missiles, NUMRND, is obtained from EOH(NWEOH).

(7) Block 9. If this is the initial volley in the fire mission request, control goes to block L10 and initializes the fire mission data in subsequent blocks; otherwise, control goes to block L20.

(8) Blocks L10, 10. If the fire mission request is specified as the number of volleys to be fired by this firing unit, the number of volleys is determined as the absolute value of NOR. This quantity will have a negative value to indicate the request is in terms of firing unit volleys. If the number of rounds has been specified in the DSL order, NOR is positive and equal to the total number of rounds requested. The number of volleys is always converted to the number of rounds by multiplying the number of volleys requested by the number of artillery tubes or missiles, NUMRND.

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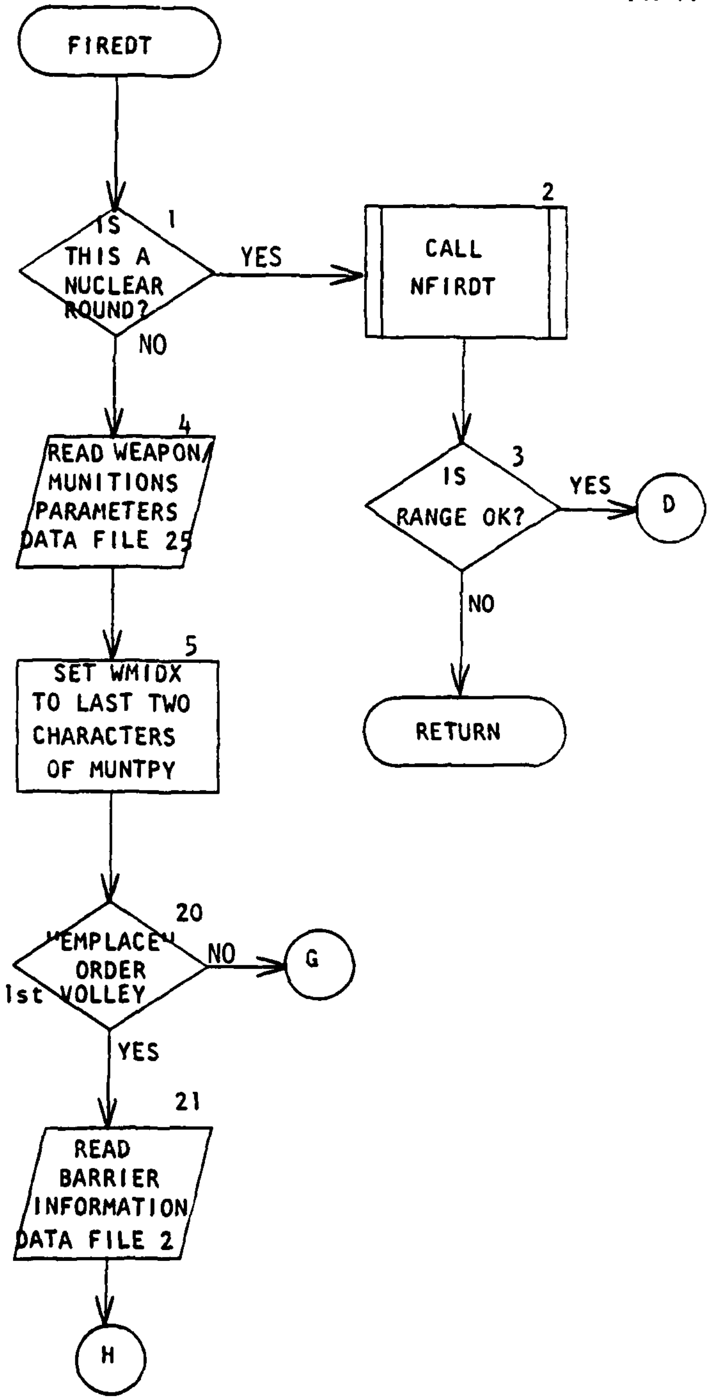

Figure IV-8-B-1. Routine FIREDT (Continued on next page)

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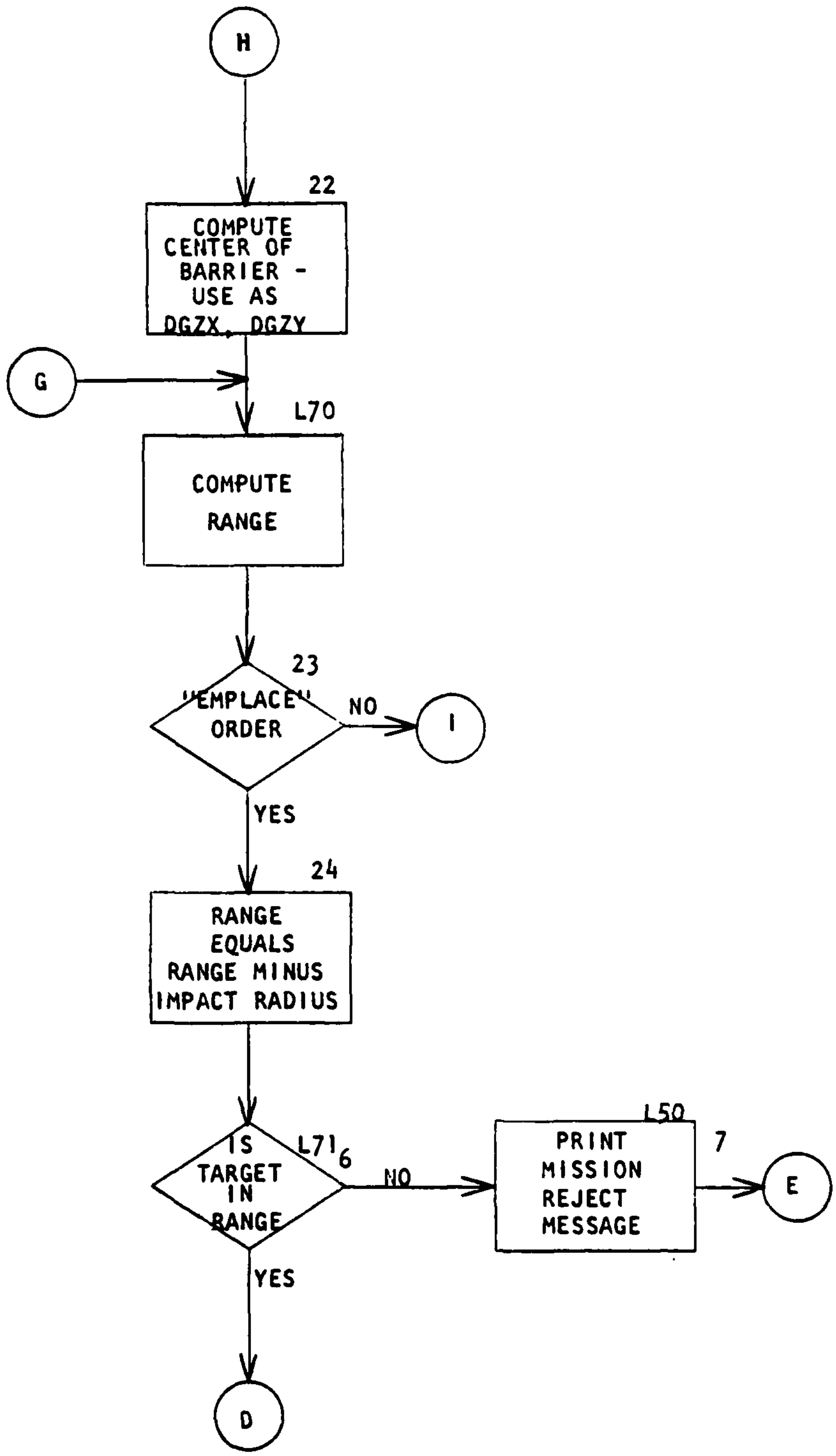
H
22
COMPUTE CENTER OF BARRIER - USE AS DGZX, DGZY
G
L70
COMPUTE RANGE
23
"EMPLACE" ORDER
NO
I
YES
24
RANGE EQUALS RANGE MINUS IMPACT RADIUS
IS TARGET IN RANGE
L71
6
NO
L50
PRINT MISSION REJECT MESSAGE
7
E
YES
D

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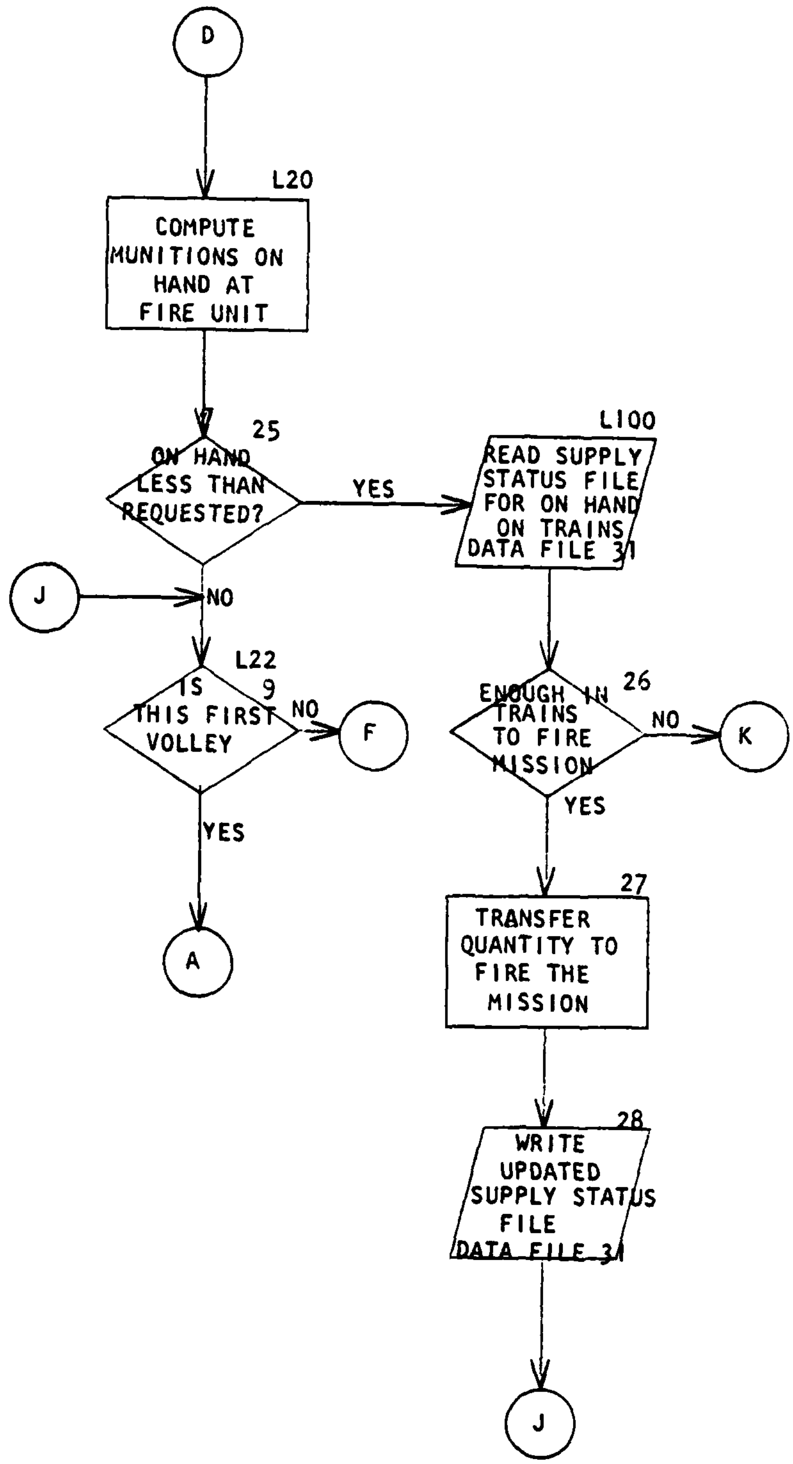
D
L20
COMPUTE MUNITIONS ON HAND AT FIRE UNIT
25
ON HAND LESS THAN REQUESTED?
YES
L100
READ SUPPLY STATUS FILE FOR ON HAND ON TRAINS DATA FILE 31
J
NO
L22
9
IS THIS FIRST VOLLEY
NO
F
YES
A
26
ENOUGH IN TRAINS TO FIRE MISSION
NO
K
YES
27
TRANSFER QUANTITY TO FIRE THE MISSION
28
WRITE UPDATED SUPPLY STATUS FILE DATA FILE 31
J

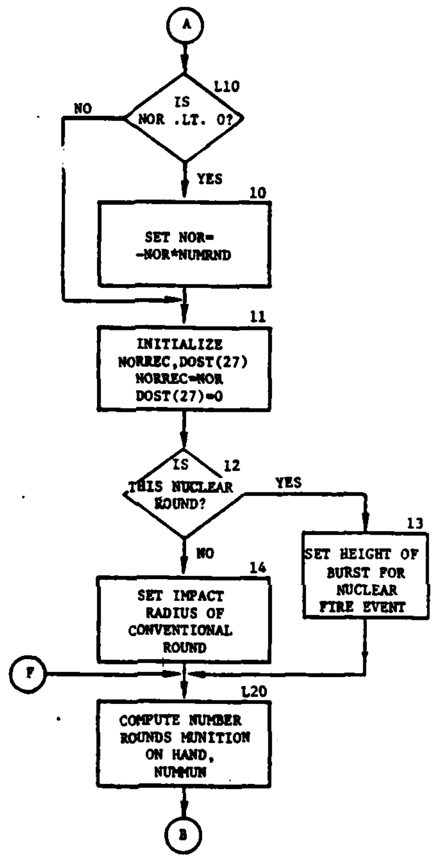

Figure IV-8-B-1. Routine FIREDT (Continued)

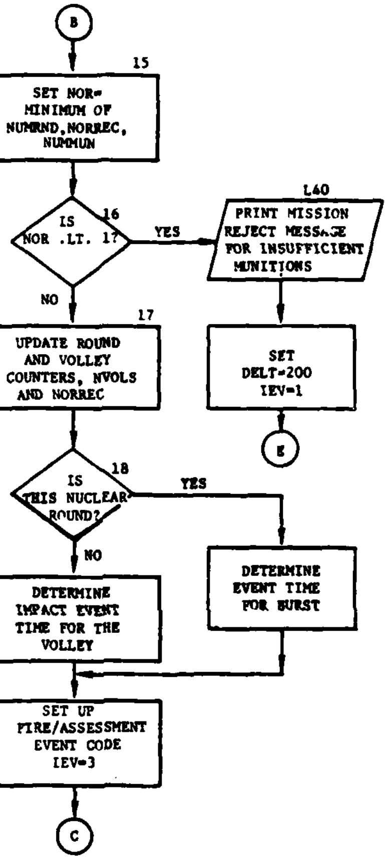

Figure IV-8-B-1. Routine FIREDT (Continued)

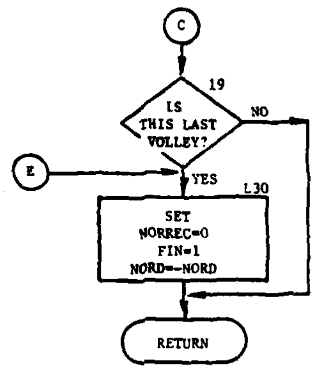

Figure IV-8-B-1. Routine FIREDT (Concluded)

(9) Block 11. The number of rounds to be fired in the fire mission request, NORREC, is initialized to the total number of rounds requested, NOR, and a value of zero stored in DOST(27) in UMAIN.

(10) Blocks 12, 13, 14. If this is a nuclear round, the height of burst (HOB) is determined. If it is a conventional round, the effects radius, IR, is obtained from WMNPA in the array MWIR.

(11) Block L20. The number of rounds on hand in the firing unit, NUMMUN, is obtained from the equipment on hand list of the unit, EOH(NMEOH).

(12) Block 15. The number of rounds to be fired in the current volley is determined as the minimum of NUMRND, NUMMUN, and NORREC. NORREC is the number of remaining rounds to be fired in the mission. For the first volley, therefore, NORREC, is the number of rounds requested.

(13) Blocks 16, L40. If munitions are not available in the firing unit or the unit trains rejection message is printed to indicate insufficient available munitions to accept fire mission. A 2-minute stay event is given to the unit.

(14) Block 17. If adequate munitions exist in the firing unit, the number of rounds remaining in the mission, NORREC, is updated to account for the current volley; (i.e., NORREC = NORREC - NORA) and the number of volleys fired, NVOLS, is incremented by one.

(15) Block 18. If this is a nuclear round, the event time for the burst is determined; otherwise, the impact time of the volley is obtained from WMNPA and the event code is set to 3 for a fire/ assessment event to be performed after this elapsed time.

(16) Blocks 19, L30. If this is the last volley in the fire mission, the mission counter, NORRED, is set to 0, FIN is set to 1, and NORD is set to -NORD.

(17) Blocks 20, 21. If this is the first volley of an "EMPLACE" minefield order information about the barrier to be fired must be retrieved from Data File 2. The correct File 2 record is determined by a call to BUIDRC. This record can then be used from File 2 by a call to GETRCD.

(18) Block 22. The end points of the barrier trace (X and Y) are determined from the File 2 record and the center point is determined by (X2 + X1)/2, (Y2 + Y1)/2. The impact point of the rounds is this calculated DGZX, DGZY.

(19) Block 23. For an "EMPLACE" minefield order, the range is computed to be the range to DGZX, DGZY less the impact radius of the munition.

(20) Blocks L100, 26, 27. If three is not enough munitions on hand or the combat vehicles to fire the mission, the unit's Supply Status File is read to determine if there are munitions on hand in trains sufficient to fire the mission. If there is, the quantity is transfered, and the mission continues. If there is not, a mission rejection message is printed out.

(21) Block 28. After reducing the on hand in trains quantity the updated Supply Status File record is written.

3. ROUTINE AREAFR:

a. Purpose. AREAFR computes the damage effects to personnel and equipment items as a result of conventional artillery and mortar fire volleys. The routine computes unit losses, updates unit status files for losses sustained, updates supression factors for assessed units, and updates the firing artillery unit for munition expenditures.

b. Input Variables:

(1) Standard Common Block Variables: UMAIN, UCOOP, TCLOCK, BPOINT, IFORCE, DAY, HOUR, MINUTE.

(2) Other Variables:

Name	Source	Contents
AUTEOH(201)	DF50	Authorized equipment item levels for unit.
TRECRD(10)	DF3	Terrain record. Used to set LXBIAS to 5 for unforested and to 2 for forested conditions.
EOHPRO(3,100)	DF30	Unit equipment providing protection to personnel. EOHPRO(1,J) is the item code of the equipment, EOHPRO(2,J) is the number of personnel protected by this item, and EOHPRO(3,J) is the number of personnel lost when this item is lost. The index J is the order in priority in which the equipment items afford personnel protection.
FILE12(35)	TWO	Assessment information data passed from Ground Combat Model for mortar fire assessment.
EEQPT(100)	EQUIPT	Identification codes of equipment items as stored in integer array.
LSEOH2(10,200)	DF6	Secondary equipment item loss table.
MXRNGE	DF29	Maximum range of weapon-munition combination.

Name	Source	Contents
MNRNGE	DF29	Minimum range of weapon-munition combination.
MNDATH(216)	DF29	Weapons-munition delivery and assessment data array.
SIGTAB(6)	DF29	Round dispersion error at minimum, maximum, and four intermediate range points.
LAEOH(200)	DF29	Lethal area of round against enemy equipment array.
UDDTBL(189)	DF28	Unit dimension and distribution array.
NEOH	DF28	Number of items not uniformly distributed in bands.
EOHD(7,20)	DF28	Packed distributions of equipment for seven activities.
EOHLST(20)	DF28	Item code list of equipment distributed in bands.
PERSD(7)	DF28	Packed distribution of personnel for seven activities.
PCWORD	DF28	Packed word used to retrieve data from PERSD, EOHD.
UNPRO(7)	DF30	Unit personnel protection array. Contains the distribution of personnel in foxhole, prone, and standing postures, in warned and unwarned states.

c. Output Variables:

(1) Standard Common Block Variables. UMAIN, UCOOP, IOUT.

(2) Other Variables:

Name	Destination	Contents
FSUP	ONE	Updated suppression factor.
NOR	ONE	Number of rounds fired [OUTEQP(I), where I = MNDATA(2)].
OUTEQP(200)	ONE	Equipment items lost by assessed unit.

d. Logical Flow (Figure IV-8-B-2):

(1) Blocks 1, 2. If the assessment event is for organic mortar fire within the Ground Combat Model, partial assessment information is obtained from the FILE12 array passed from the Ground Combat Model.

(2) Block L3000. The weapon-munitions combination index, IWMUNX, is used to reference the lethal area and delivery tables stored on data file 29.

(3) Block 3. To ensure that the fire unit will not fire more rounds than it has on hand, the number of rounds on hand MNDATA(2) is compared to the number of rounds requested, NOR, and NOR is decreased if it is the larger. Otherwise, the fire and assessment event is not performed. Also, if the impact point of the round (DGZX, DGZY), is within a range from the firing unit that is greater than the range of the weapon, RMAX, the impact point is changed to the maximum range along the firing azimuth.

(4) Block 5. An output record of the fire event is generated and written on the history tapes by calling routine PUTOUT.

(5) Block 6. Increment event activity counter of firing unit.

(6) Block 7. To obtain a list of units to be screened for area fire assessment resulting from this fire event, routine SEARCH is called with a search radius of 3500 meters plus the effects radius, IR. If the number of units in the search radius, NUNITS, is zero, control branches to block L3510.

(7) Block 8. The dispersion error, SIGMA, for the munition type at the firing range is computed using the routine INTPOL and the SIGMA values, SIGTAB(6), at the six range values.

(8) Block 9. The target unit's secondary equipment item table is obtained from data file 6 using the force index of the target. The information is stored in array LSEOH2.

(9) Block 10. Read equipment type codes from COMMON EQUIPT.

(10) Block 11. For all secondary equipment items and nonassessment items, the lethal area LAEOH(J) is set to zero. For item codes 1 through 6 this is always done, but for item codes 7 through 200, the secondary equipment loss table is searched to identify secondary equipment items. This procedure ensures that the model's assessment logic is compatible with the data input requirements (i.e., no secondary items are allowed nonzero lethal areas).

(11) Block L3200. The list of units returned by the SEARCH routine is examined beginning with this block. The IUID index list identifying each unit is ULIST(N), where N is the nth unit in the list.

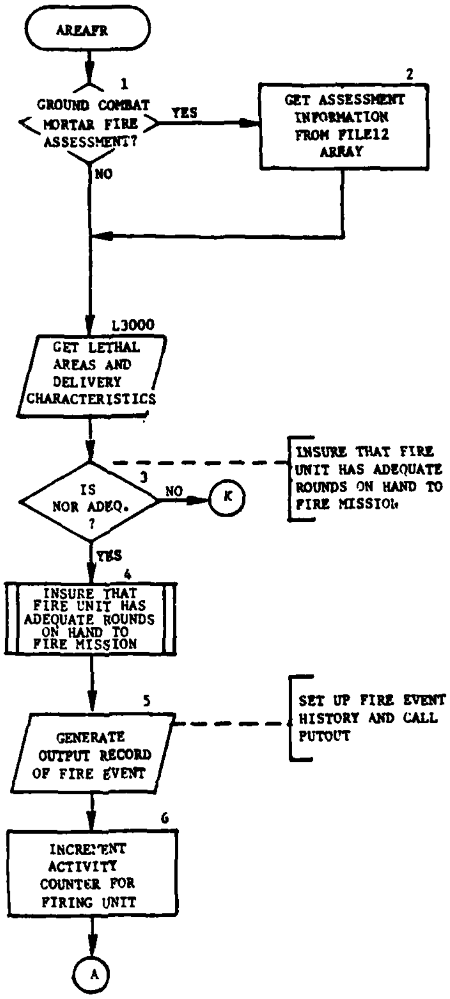

Figure IV-8-B-2. Routine AREAFR (Continued on Next Page)

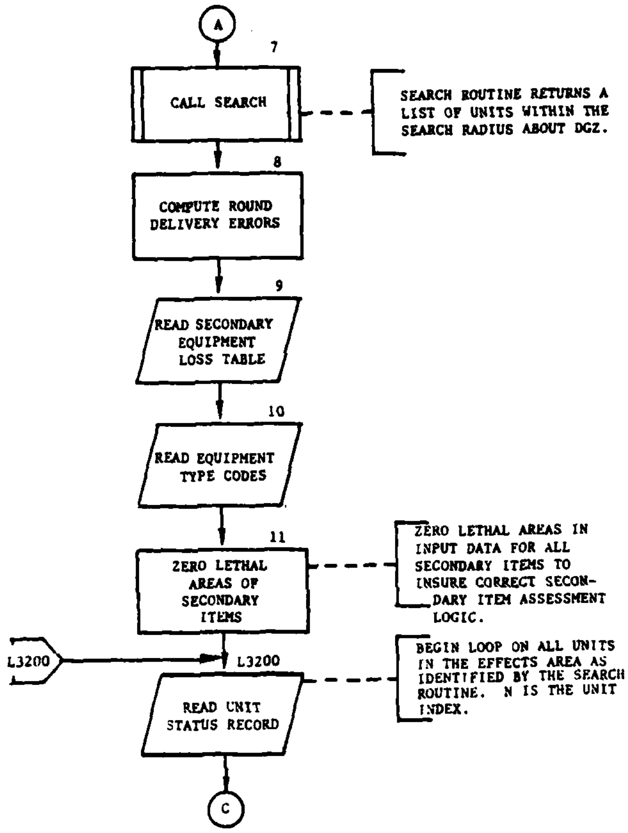

Figure IV-8-B-2. Routine AREAFR (Continued)

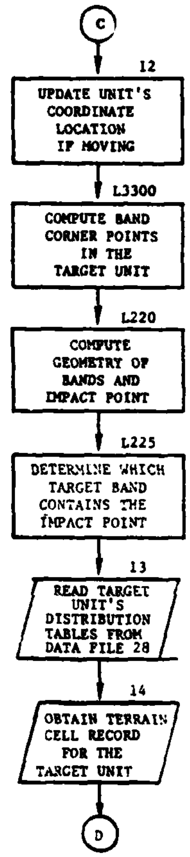

Figure IV-8-B-2. Routine AREAFR (Continued)

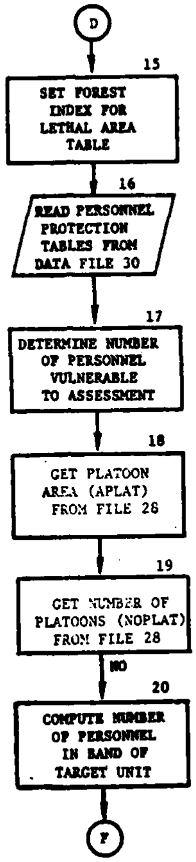

Figure IV-8-B-2. Routine AREAFR (Continued)

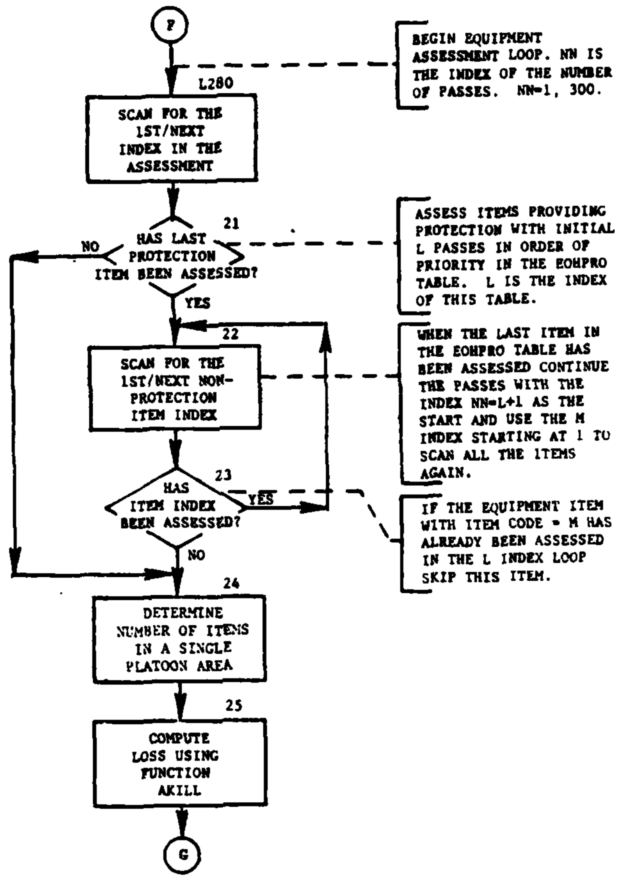

Figure IV-8-B-2. Routine AREAFR (Continued)

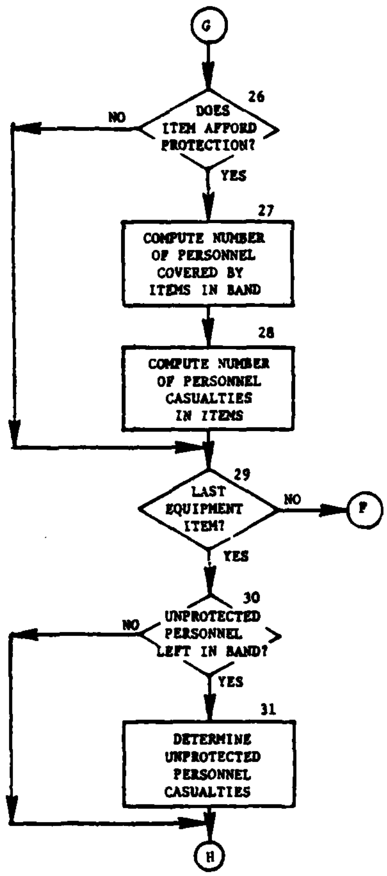

Figure IV-8-B-2. Routine AREAFR (Continued)

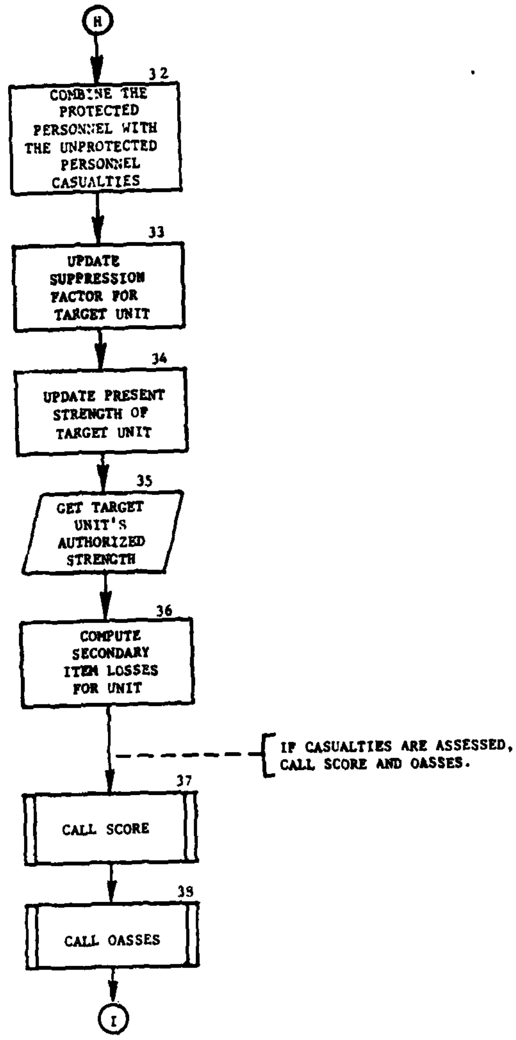

Figure IV-8-B-2. Routine AREAFR (Continued)

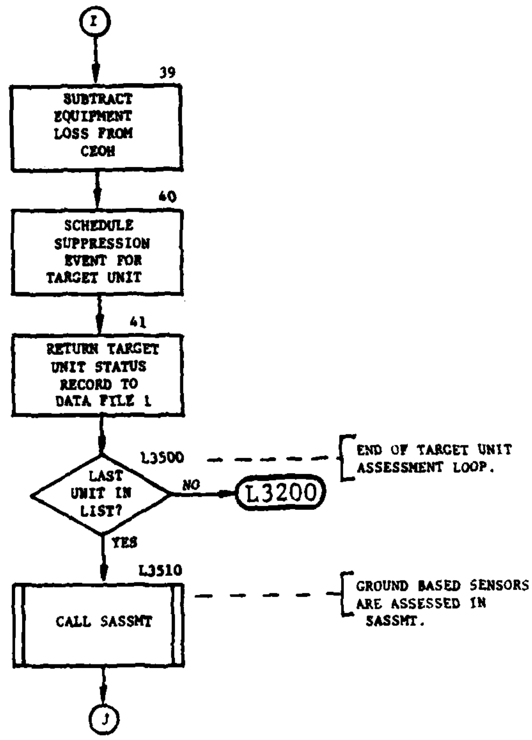

Figure IV-8-B-2. Routine AREAFR (Continued)

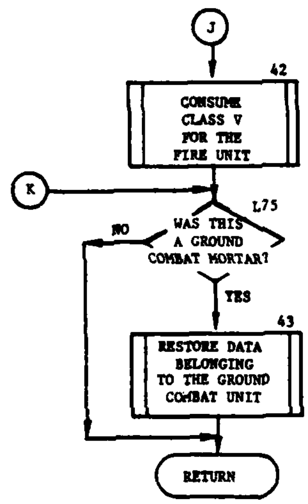

Figure IV-8-B-2. Routine AREAFR (Concluded)

(12) Block 12. The locations of moving ground units are updated to correspond to actual locations at the time of impact of the rounds. ITIME minus TCLOCK is the remaining time before the scheduled end of the move event, and CDELT is the total move segment's event time.

(13) Block L3300. Target geometry calculations begin with the computation of the corner points of the target unit. These X and Y coordinates are stored in the arrays PX and PY respectively.

(14) Block L220. Corner points of each band in the target unit are computed and stored in BX1, BY1, BX2, and BY2 arrays.

(15) Block L225. Once the corner points of each band have been established, they are used to determine which band of the target contains the center of impact of the volley. If the impact point lies precisely on a band boundary separating two adjacent bands, the front-most band is assumed to contain the point.

(16) Block 13. To continue the assessment, the target unit's distribution tables are obtained from data file 28, stored in array UDDTBL.

(17) Block 14. The target unit's location is used to obtain the terrain cell record by calling routine IOTERN.

(18) Block 15. Using the terrain cell forestation index, the second character of TRECRD(1), the lethal area bias, LXBIAS, is set to 2 for forest conditions (index equals 0), and is set to 5 for unforested conditions (index equals 1). This is used later to obtain the correct lethal areas against unprotected personnel from the appropriate lethal area table.

(19) Block 16. Using the force index and the activity index, CIACTX, of the target unit, the personnel protection tables are obtained from data file 30. These tables are used to determine the protection afforded to personnel by the unit's equipment items and to assess casualties if equipment items are lost.

(20) Block 17. The number of personnel in the unit vulnerable to assessment, TPERS, is determined by adding the present strength, CPREST, and suppressed strength, CSUPST, and adding the fractional value stored in CICFRA. The fraction of personnel suppressed, BETA, is computed and used after the target unit is assessed damage to distribute assessment to personnel in suppressed and unsurpressed states.

(21) Block 18. The area (in square meters) of a single platoon (APLAT) of this type target engaged in the current activity is obtained from data file 28.

(22) Block 19. The number of platoons (NOPLAT) contained in a target of this type and activity is also obtained from data file 28. Both APLAT and NOPLAT are input data loaded via the 2807 card.

(23) Block 20. To find the number of personnel in the impact band, the personnel distribution table value, PERSD(CIACTX), is examined. If it equals zero the personnel are distributed uniformly in the unit and the number of personnel in the band, PERS, is obtained by dividing the total personnel, TPERS, by the number of bands, CNBND. If, however, PERSD(CIACTX) does not equal zero, the personnel are not uniformly distributed. The fraction in the impact band is found using the value in PCWORD.

(24) Block L280. This block is the beginning of the assessment loop for each item in the impact band of the Nth unit. The loop index, NN, is set to make up to 300 passes through the subsequent assessment logic. The index, NN, is a pass counter index.

(25) Block 21. The assessment loop is such that the equipment items providing protection to personnel are assessed first and in order of priority as they appear in the equipment item personnel protection table. This table is scanned with an index, L, where EOHPRO(I,L) is the equipment item code of the Lth item in the protection table. When the last item in this table has been assessed, a new index counter, M, is used to identify the equipment item code to be examined for assessment. Thus, a second pass is made through the equipment item list, this time in ascending order of the equipment item codes.

(26) Block 22. This block is the beginning of the scan index, M, and represents the assessment of all primary equipment items that do not afford personnel protection. The first pass through this block is made when the NN index is equal to the number of equipment items providing protection plus one; i.e., NN = L + 1.

(27) Block 23. If the Mth equipment item code has already been assessed as providing personnel protection, this item is skipped and the M and NN indexing are incremented to continue the assessment of all items.

(28) Block 24. The number of equipment items in a single platoon area is determined by using the minimum of three estimates of allocating equipment types to platoon areas.

(29) Block 25. The number of items lost is computed by using the function AKILL. It requires the number of items in the platoon area, the fraction of the rounds that are expected to fall within the platoon area, PHIT; lethal area of the round against the equipment item, LAEOH (J); the number of rounds in the volley, NOR; and the platoon area, APLAT.

(30) Block 26. If the item assessed affords personnel protection, the personnel casualties associated with the equipment loss are determined in blocks 27 and 28; otherwise, these calculations are omitted.

(31) Block 27. The number of personnel protected in the band by the equipment items being assessed is determined using data in the equipment item personnel protection table, EOHPRO, where EOHPRO(1,L) is the Lth priority equipment item code, EOHPRO(2,L) is the number of personnel afforded protection by a single equipment item, and EOHPRO(3,L)

is the number of personnel lost when this equipment item is lost. The total number of personnel covered in this band by this equipment type is computed from the product of EOHPRO(2,L) and CEOH(J). If there are fewer personnel in the target unit not yet given cover than could be afforded protection by this equipment item, they are uniformly distributed among the available equipment of this type. The remaining personnel, PERS, not afforded protection is updated to account for those covered by this equipment type.

(32) Block 28. Personnel losses due to equipment lost are found by the product of EOHLSS, EOHPRO(3,L) and [AVGNP/EOHPRO(2,L)], where the ratio accounts for the possibility of too few personnel to fill all vehicles.

(33) Block 29. This block is the end of the equipment item assessment loop. If the last item has been assessed, proceed with assessment of unprotected personnel. Otherwise, return to block L280.

(34) Block 30. If all personnel are protected by equipment, no calculations of unprotected personnel casualties are made.

(35) Block 31. Personnel that are not afforded protection by equipment items are assessed in this block. Assessment is made for three categories to account for distribution of personnel as standing, prone, or foxhole, and for either warned or unwarned postures.

(36) Block 32. Those unprotected personnel casualties are combined with the personnel casualties resulting from equipment items lost to determine the total number of personnel casualties.

(37) Block 33. Update suppression factor, FSUP, to indicate that unit was assessed.

(38) Block 34. The personnel losses in the impact band previously assessed are removed from the present strength, CPREST, and fractional losses are stored in CICFRA.

(39) Block 35. The unit's authorized strength is obtained from data file 50 before beginning secondary equipment loss calculation. The quantities authorized are stored in AUTEOH.

(40) Block 36. Secondary item losses are the product of the primary item loss quantity, L, and the expected fraction of the secondary item on hand in each primary item, [CEOH(I)/AUTEOH(I)].

(41) Block 37. Call SCORE to perform assessment event bookkeeping on data file 48.

(42) Block 38. Call OASSES to create assessment output record of assessment event.

(43) Block 39. The equipment item loss is recorded by substracting the losses, OUTEQP(J), from the equipment on hand, CEOH(J).

(44) Block 40. Units moving or firing suffer an interruption of that activity when they are hit by area fire. The suppression event scheduled activates the routine SUPRES which models the suppression of the unit's activity.

(45) Block 41. The updated target unit's status record is returned to its location in data file 1.

(46) Block L3500. If this was the last target unit to be assessed, control goes to L3510; otherwise, the loop on the target units continues and control returns to block L3200.

(47) Block L3510. Routine SASSMT is called to assess damage to ground based sensors within the effects area of the rounds.

(48) Block 42. The munitions expended in the mission are recorded by subtracting them from the equipment on hand list of the firing unit.

(49) Block L75. If the assessment was for a ground combat mortar firing event, control transfers to block 43. Otherwise, control returns to the calling routine.

(50) Block 43. Data used in the Ground Combat Model are restored to the status record of the unit being assessed.

4. ROUTINE AKILL:

a. Purpose. The function AKILL is used to compute the number of items or personnel of a given type or in a certain posture that are damaged or killed by artillery rounds.

b. Input Variables:

Name	Source	Contents
ALIVE	Call	Number of personnel or equipment items of a given type in the target.
DFRAC	Call	Fraction of the personnel or items to be assessed in the target area.
AREA	Call	Lethal area of a single round against the designated equipment item type or against personnel in the designated posture.
NRNDS	Call	Number of rounds in the volley.
RFRAC	Call	Fraction of rounds expected to impact within the target area.

Name	Source	Contents
TAREA	Call	Magnitude of target area being assessed.

c. Output Variables:

Name	Destination	Contents
AKILL	Call	Number of personnel killed or equipment items destroyed.

d. Logical Flow (Figure IV-8-B-3):

(1) Block 1. If the lethal area of the round is greater than the target area, the effective lethal area of the round is set equal to the target area.

(2) Block 2. The value of the function AKILL is computed by using the arguments described in the list of input variables and the equation:

$$AKILL = (ALIVE)(DFRAC) * \left[1 - \exp \frac{-(RFRAC)(LAREA)(NRNDS)}{TAREA} \right] \quad \text{IV-8-B-1}$$

5. ROUTINE OASSES:

a. Purpose. OASSES contracts an output record of the assessment event and categorizes the equipment items lost into five categories for a dondensed assessment record.

b. Input Variables:

(1) Standard Common Block Variable. UMAIN.

(2) Other Variables:

Name	Source	Contents
CAS	Call	Personnel casualties from assessment event.
CCODE (50)	Call	Equipment type codes.
OUTEQP (200)	Call	Equipment item losses from assessment event.

c. Output Variables:

Name	Destination	Contents
IOUT (256)	ONE	Standard output record of assessment event.
JOUT (128)	ONE	Condensed assessment event output record.

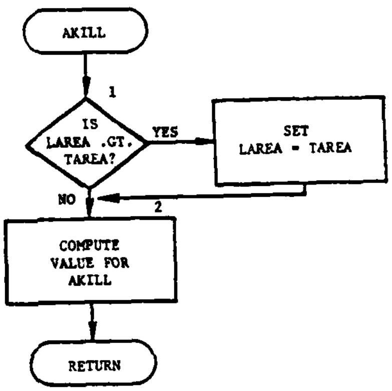

Figure IV-8-B-3. Routine AKILL

d. Logical Flow (Figure IV-8-B-4):

(1) Block 1. Standard output data of the assessment event including event time (IOTIM), event type (IOIEV), fire unit (IUID), and assessed unit (CIUID) are set in output array IOUT.

(2) Block 2. Begin scanning equipment item list in assessed unit to identify five categories of equipment types. These categories are groupings of similar equipment items and are specified in input data by an assigned code.

(3) Blocks 3, 4. To sum the total amounts of each equipment category the equipment item code, I, is used to identify the equipment type code, and this code character is converted to an index (INDEX) value of 1, 2, 3, 4, or 5. The amount on hand, CEOH(I), and the amount lost, OUTEQP(I), are accumulated in the summing matrix, HOLD(1,INDEX) and HOLD(2,INDEX) respectively.

(4) Block 5. This block is the end of the loop on equipment items in the target unit.

(5) Block 6. The categorized equipment type data stored in HOLD are put into an output array, JOUT, with the casualties, CAS; and routine PUTOUT is called to write a record on the history tapes from IOUT and JOUT.

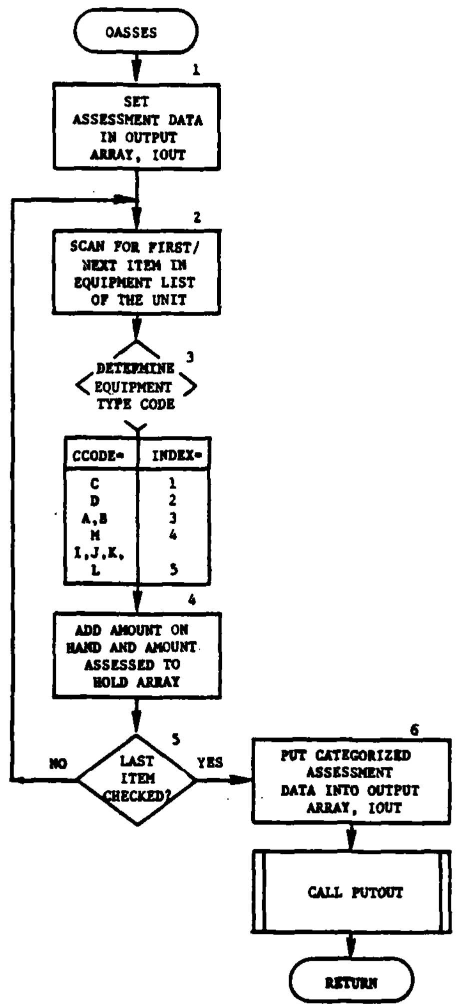

Figure IV-8-B-4. Routine OASSES

NOTES

APPENDIX C

AREA FIRE MODEL OUTPUT DESCRIPTIONS

1. INTRODUCTION. This appendix contains samples and detailed descriptions of printed output from routines within the Area Fire Model of the Period Processor.

2. AREA FIRE MODEL OUTPUT. The output of this model identifies all units within the effects area of the munition. Personnel casualties and equipment losses, both primary and secondary, are determined and listed in the output. Figure IV-8-C-1 shows a sample of the printed output. In the figure, an alphabetical character (descriptor) designates an appropriate line, or group of lines that is explained as follows:

Output Descriptor	Explanation	
A	FIRING, IUID:	unit identification number of the firing unit.
	UID:	unit identification of the firing unit.
	NOR:	number of rounds.
	MUNTPY:	munition type index.
	DGZX:	X coordinate of ground zero.
	DGZY:	Y coordinate of ground zero.
	NORD:	pending order code of the firing unit.
	ASSESSING, COIUID:	unit identification number of the unit being assessed.
	COUID:	unit identification of unit being assessed.
	COXACT:	X coordinate of the target.
	COYACT:	Y coordinate of the target.
	COIEV:	event code of the target.
	CONORD:	pending order code of the target.
	COPRESTR:	present personnel strength of the target.
B	This message specifies assessment of the Jth equipment item in the impact band of the unit.	
	J:	item code of the primary equipment type being assessed.
	CEOH:	number of equipment type J in entire target.
	DFRAC:	fraction of equipment type J in impact band.
	ALPHA:	number of equipment type J in impact band (equals CEOH multiplied by DFRAC).
	CCEOH:	number of equipment type J in platoon area.
	LAEOH:	lethal area (square meters) of this munition type against equipment type J.

(A)
```
FIRING, IUID= 186 UID=B155DS3B NOR=     6 HUNTFY=A026 DGZX= 141798.00 DGZY= 120565.00 NORD= 10
ASSESSING, COIUID= 632 COUID=B2210ZTK COXACT= 142475.76 COYACT= 120988.60 COIEV=   4 CONORD=   6 COPRESTR=   228
```

(B)

J	CEOH	DFRAC	ALPHA	CCEOH	LAEOH	EOHLOSS	COVERD	AVGNP	EOHPRO2	EOHPRO3	X	FERS	BCAS
35	21.9916	1.000	21.9916	1.8326	119	.06647	87.966	4.00	4	3	18.2664	122.0973	.199402
188	7.9968	.900	7.1971	.6664	149	.03012	71.971	10.00	10	8	6.2696	56.1258	.240985
32	.8151	1.000	.8151	.0680	149	.00307	3.264	4.00	4	3	0.0000	46.8614	.009223
21	81.3954	.333	27.1318	6.7829	3129	4.21519	0.000	0.00	0	0	0.0000	45.8614	0.000000
23	.1760	1.000	.1760	.0147	6239	.01009	0.000	0.00	0	0	0.0000	46.8614	0.000000
25	2.0016	1.000	2.0016	.1668	3129	.10365	0.000	0.00	0	0	0.0000	45.8614	0.000000
27	.2221	1.000	.2221	.0185	3129	.01150	0.000	0.00	0	0	0.0000	46.8614	0.000000
154	3.7045	.333	1.2348	.3087	119	.01129	0.000	0.00	0	0	0.0000	46.8614	0.000000

(C)
```
I= 1 PEOPLE=   3.9051 FRAC= .510 LAREA=   3591 UCAS=    1.312159, UNPROTECTED PERSONNEL CASUALTIES
I= 1 PEOPLE=   3.9051 FRAC= .310 LAREA=   1873 UCAS=     .516552, UNPROTECTED PERSONNEL CASUALTIES,
I= 1 PEOPLE=   3.9051 FRAC= .210 LAREA=     57 UCAS=     .013699, UNPROTECTED PERSONNEL CASUALTIES
```

(D)

IMPACT BAND	NO.OF BANDS	RANGE (METERS)	SIGMA (METERS)	PROB. OF HIT	TGT UTD	TGT.ACT. INDEX	AREA OF PLATOON	NO.OF PLTS.	TOT. PERS. CASUALTIES	TARGET WIDTH	TARGET DEPTH	TARGET ORIENT	FOREST INDEX
1	3	8041.47	52.6011	.1940	GEMT	4	3750.	12.	2.292020	2000	2100	181.05	5

Figure IV-8-C-1. Area Fire Model Sample Printed Output.

Output Descriptor	Explanation
	EOHLOSS: number of equipment type J killed by this volley.
	COVERD: number of personnel in the impact band protected by equipment type J (equals ALPHA multiplied by AVGNP).
	AVGNP: average number of personnel protected by each equipment type J (will equal EOHPRO2 unless there are insufficient personnel in target to fill all equipment type J vehicles).
	EOHPRO2: number of personnel protected by each equipment type J (specified in input data).
	EOHPRO3: number of protected personnel killed when an equipment type J is killed (specified in input data).
	X: a variable used to keep a running total of the number of unprotected people in the other bands (outside the impact band) of the target.
	PERS: a variable used to keep a running total of the number of unprotected people in the impact band. Both X and PERS are reduced when an equipment item code capable of protecting personnel is assessed, by an amount equal to the total number of personnel protected by that item code.
	BCAS: number of protected personnel killed because of the losses to equipment type J (equals EOHLOSS multiplied by EOHPRO3 multiplied by the ratio of AVGNP to EOHPRO2).
C	These three lines of output list losses of unprotected personnel who are standing, prone, or in foxholes, respectively.
	I: identifies the number of the band containing the center of impact of the volley.
	PEOPLE: number of unprotected personnel assumed to be in one platoon area.
	FRAC: fraction of unprotected personnel that are standing (line 1), prone (line 2) or in foxholes (line 3).

Output Descriptor	Explanation
	LAREA: lethal area of the round against unprotected personnel assumed to be in each of the three postures.
	UCAS: number of unprotected personnel casualties in each of the three postures.
D	This line lists general information concerning the results of the assessment.
	IMPACT BAND: identifies the number of the band containing the center of impact of the volley (same as I above).
	NO. OF BANDS: total number of bands in the target.
	RANGE (METERS): distance from center of fire unit to the coordinates DGZX, DGZY.
	SIGMA (METERS): the weapon error (standard deviation) at the range defined above.
	PROB. OF HIT: the fraction of rounds expected to impact within the platoon area [equals 1. - exp $(-APLAT/2\pi\sigma^2)$].
	TGT. UTD: the UTD of the target unit.
	TGT. ACT. INDEX: the activity index of the target unit.
	AREA OF PLATOON: area (in square meters) of a single platoon in the target unit (input on 2807 card type). Same as APLAT.
	NO. OF PLTS.: the number of platoons in the target unit (input on 2807 card).
	TOT. PERS. CASUALTIES: total personnel losses (protected and unprotected) to the target unit. Equals ΣBCAS + ΣUCAS.
	TARGET WIDTH: width of target (in meters).
	TARGET DEPTH: depth of target (in meters).
	TARGET ORIENT: direction target is facing (degrees). Measured counter-clockwise from east.
	FOREST INDEX: degree of forestation of target unit (2 = forested; 5 = no forest).

APPENDIX D

SOURCE LISTINGS FOR PERIOD PROCESSOR AREA FIRE MODEL

(AVAILABLE UNDER SEPARATE COVER)

NOTES

APPENDIX E

REFERENCES

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