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THE HUNTER-KILLER MODEL

VERSION 2.0

EXECUTIVE SUMMARY

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1 December 1986

Contract No. DAAK21-85-C-0058

Prepared for

The Center for Night Vision and Electro-Optics
DELNV-V
Fort Belvoir, Virginia 22060

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SAIC
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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)

The Hunter-Killer Model
Executive Summary

5. TYPE OF REPORT & PERIOD COVERED

Final

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

Ross Fairbrother
Robert T. Campbell

8. CONTRACT OR GRANT NUMBER(s)

DAAK21-85-C-0058

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Science Applications International Corporation
1710 Goodridge Drive
McLean, VA 22102

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS

The Center for Night Vision and Electro-Optics
Laboratory DELNV-V
Fort Belvoir, VA 22060

12. REPORT DATE

December 1, 1986

13. NUMBER OF PAGES

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)

Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Hunter-Killer Model

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

This manual provides an overview of the Hunter-Killer Model

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Unclassified

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1.0 INTRODUCTION

1.1 PURPOSE

The Hunter-Killer Model Version 2.0 Executive Summary is designed to provide managers with an overview of the features and capabilities of the Hunter-Killer Model. Data and computer requirements are described. In addition to this manual, documentation of the model includes:

The Hunter-Killer Model Version 2.0 User's Manual. This manual provides a detailed explanation of the concepts involved in the model's design. Additionally, it includes directions for preparing the data required by the model and for executing the model. This manual should contain all of the information required by most users of the model.

The Hunter-Killer Model Version 2.0 Programmer's Manual. This manual provides a detailed explanation of the internal structure of the model. It includes a dictionary of all global variables occurring in the model, a description of each program, the coding standards used, and instructions for modifying and compiling the model. This manual will be of interest primarily to the model's maintenance programmer.

A database system has been developed for the Hunter-Killer Model. This system is described in Section 4.3. The documentation for the database system consists of:

The Hunter-Killer Model Version 2.0 Database System User's Manual. This manual describes how to use the database system to store data and to prepare run streams for the model.

The Hunter-Killer Model Version 2.0 Database System Programmer's Manual. This manual describes the implementation of the database system. It is intended to be used by a maintenance programmer.

1.2 SECURITY AND CLASSIFICATION

The Hunter-Killer Model source code is UNCLASSIFIED, as are all of the manuals mentioned above. The data used by the model are also, as a rule, UNCLASSIFIED; however, inclusion in a run of the model of sensors or weapons whose performance characteristics are classified would cause the data and output for that particular run to become classified.

1.3 INQUIRIES

Inquiries concerning the Hunter-Killer Model or the Hunter-Killer Database System should be addressed to:

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2.0 MODELING AND SIMULATION

Most phenomena of the real world can, when taken individually, be described in the language of mathematics as a set of fixed relationships obeying the fundamental laws of nature or the more empirical approximations drawn from observation. For example, the distance traveled by a body moving at a fixed velocity can be expressed as "distance = velocity x time." Another statement of relationship might be "the radius of damage of a nuclear burst increases as the cube root of the yield." One can combine these two expressions to determine the amount of warning required by a person at a desired ground zero (DGZ) of a nuclear device of given yield if he is to escape the blast by moving away from it at a given velocity. It is not necessary to actually explode weapons of various yields while people are driving away from the DGZ at various speeds.

The development and use of a set of these abstract relationships to determine the outcome or the intermediate conditions of some collection of interacting real world phenomena are called "modeling" and the set itself is called a model. In the example above, if a number of weaons of various yields are exploded at various times and places over a large number of people in vehicles having different rates of speed, the computations become extremely tedious and complicated. The problem can best be resolved by transferring the computations to a large scale computer which does the arithmetic at lightning speed and can keep track in its memory of all the events as they occur.

If during the sequence of events in the above example the drivers have opportunities to make choices depending upon their observations of the situation, these choices can be added to the model by inserting a set of logical rules into the list of instructions that the computer follows. For example, at any fork in the road a vehicle takes that fork which leads most directly away from the most recent blast.

If there is a known probability that a particular weapon will not fire, then over a large number of weapons the performance of each individual weapon can be determined by the throw of a die. Suppose the chance of failure is one out of six. If the die comes up a six, for example, that weapon is said to fail. Such a procedure using random numbers in the computer instead of dice adds the capability of handling probabilistic processes in the model. Such a model is called a stochastic model.

A large and complex model containing logic and probability which runs on a computer from the initial conditions to completion without human intervention is usually called a simulation. This is a general term for the manipulation of the symbolic representation of a highly complex set of interacting events taking place over a period of time.

In order to simulate a particular real world activity, the mathematical expressions for the model must include all the factors significant to this activity and reflect faithfully their real life relationships. Moreover, in order that the model may be used more than once, these factors must be expressed so as to accept values of varying magnitudes for the many possible situations encountered in real world activity.

3.0 THE HUNTER-KILLER MODEL

3.1 MODEL OVERVIEW

The Hunter-Killer Model is designed and constructed to study the performance of electro-optic sensor systems in a combat scenario. The model simulates a two-sided battle between individual platforms. Each platform may have one weapon and up to two sensors, a hunter and a killer. The killer sensor is used to acquire targets and to operate the weapon. In addition, there may be a second, independent sensor called the hunter that supports the killer by acquiring targets and passing them to the killer. This pair of sensors, the hunter and the killer, cooperatively search for targets with start-of-the-art and future sensor systems. Acquired targets are processed through a target selection scheme and are either discarded or engaged by the killer. The targets themselves are hunter-killer platforms, therefore making the model fully two-sided.

The Hunter-Killer Model is capable of simulating a wide variety of military scenarios. The model is open ended in terms of the number of platforms that can be included. The only absolute bound is the available computer memory and time. From a practical point of view, twenty to thirty platforms for twenty replications seens to be an upper bound.

The Hunter-Killer Model may be employed as a tool to perform many types of sensor performance analyses. Some analyses appropriate for the Hunter-Killer Model are:

Evaluate sensor effectiveness as measured by acquisition time.

Evaluate the sensor contribution to combat as measured by engagement times.

Evaluate the sensor/laser rangefinder contribution to combat as measured by shots fired per kill.

Evaluate sensor performance in terms of combat results such as equipment kills and force ratios.

Evaluate such concepts as Battlefield Identification Friend or Foe (BIFF).

Evaluate variations in search strategy.

The Hunter-Killer Model is basically a collection of discrete events and processes of different types supported by the relationships of modeled military activities. The data describe the equipment, weapons, sensors, and the parameters that depict their performance and relationships to each other. In this manner the combat process between two opponent forces is simulated.

3.2 THE BATTLEFIELD

The Hunter-Killer Model's battlefield is a rectangular coordinate system where coordinates are measured in meters. Only the first quadrant, with positive X and Y axes, is used. Movement vectors and search azimuths are given by compass directions, where the positive Y-axis direction is north (0 degrees), the positive X-axis direction is east (90 degrees), and so on. Superimposed on this battlefield is the terrain model which is used to determine whether line of sight exists between any two hunter-killers.

The platforms are arrayed on the battlefield by giving their X,Y coordinates. Movement for a platform is determined through a set of movement vectors, each of which gives a direction and a distance to be moved along with the platform's speed. After a platform has moved the distance given by a vector, it switches to the next vector in its movement set, if there is one.

The Hunter-Killer Model has available two terrain modeling techniques, which are referred to as low and high resolution terrain. Either technique may be used to determine whether line of sight exists between any two platforms. The low resolution terrain is modeled with a stochastic technique using input mean times that line of sight between platforms is established or broken. The high resolution terrain is modeled through elevations given at fixed intervals. The resolution used is determined through the data input to the model.

Both the low and high resolution techniques model macro-terrain -- the determination of LOS over large distances based on large terrain features. The Hunter-Killer Model additionally allows the modeling of micro-terrain, also called defilade: this is the use by a platform of terrain features to mask itself from others. This micro-terrain is modeled through a curve which gives the fraction of a target that is visible as a function of range. Use of this curve is controlled through an input switch which determines if targets are in defilade.

Figure 3-1 shows a typical battlefield with four blue platforms and thirteen red platforms. For one platform, HK2, the field of search (FOS) and the horizontal field of view (HFOV) is shown for both the hunter and killer sensors.

3.3 PLATFORMS

The basic element of the Hunter-Killer Model is the platform, which represents a piece of equipment. This equipment may be an armed platform, such as a tank or an APC, that can detect and fire upon targets and be fired upon itself. A platform may also represent a crew-served weapon such as a TOW. It can also be, in the context of this model, primarily a target. Trucks and other large items that may be fired upon but have limited or no capability to return fire fall into this category. Platforms may also be airborne, such as helicopters.

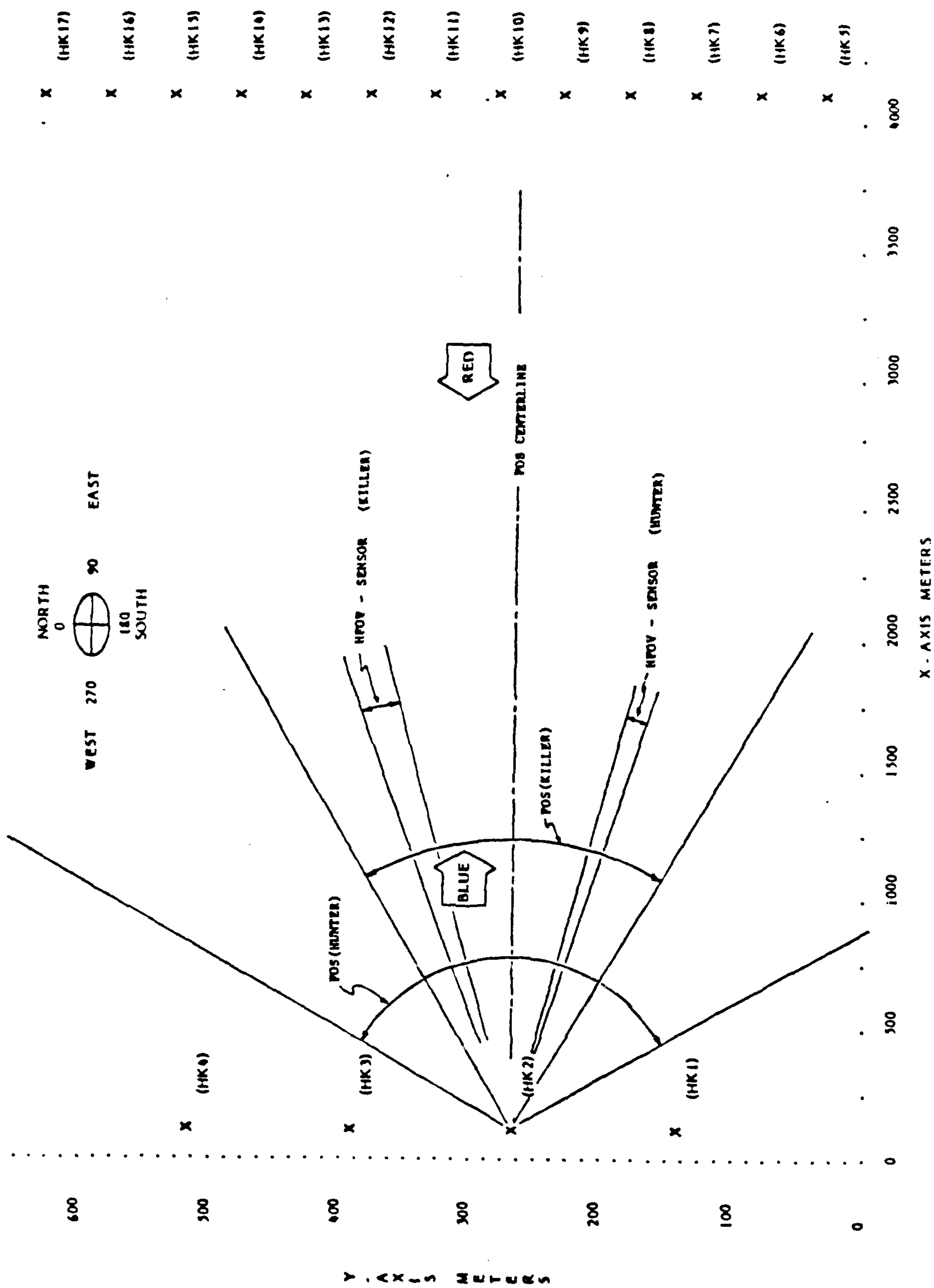

Figure 3-1, The Hunter-Killer Battlefield

Some equipment characteristics are the same for all pieces of that type of equipment. These characteristics include height, cross-sectional area, ground or airborne, side (blue or red), and the weapon to be used. A data structure called a type platform has been created to describe all common characteristics.

Whereas a type platform represents an equipment model, such as an M-1 tank, a platform represents a specific piece of equipment. The characteristics described by a type platform apply to all pieces of that model of equipment, and consequently are mostly target characteristics. The characteristics describing each individual platform control how that platform moves and acquires targets, and consequently are mostly offensive characteristics.

A platform is divided into two functional components: a hunter and a killer. Each component consists of a sensor and a set of rules governing how it attempts to acquire targets and what actions it takes once an acquisition is made. The hunter's function is to search for targets. Once the hunter has acquired a target it passes that target to the killer component to be engaged. The killer has two functions. When it is not engaging a target, it is searching in the same manner as the killer. When it acquires a target, or when the hunter acquires a target and passes it to the killer, the killer stops searching and starts engaging the target. The killer continues to fire on the target until it is dead, out of range, or line of sight is lost. While the killer is firing on the target the hunter continues to acquire targets for the killer to engage.

Ground platforms do not communicate with each other, so a target found by one platform on a side cannot be passed to another platform. This means that a platform may have a killer only, which acquires and engages targets. If the platform has a hunter only, however, the platform will acquire targets but will be unable to do anything with them.

3.4 MOVEMENT

Movement of platforms is controlled through a movement interval and through movement vectors. The movement interval is an input value, typically set to 100 meters, that is used for all ground platforms. It is the size of the step used to update the coordinates of a platform. The movement vectors are a set of straight line segments along which a platform moves. Each vector is specified by an azimuth, length, and speed. Each platform may be given its own set of vectors. If a platform does not have a set of vectors, it does not move.

3.5 AIR TACTICS

The Hunter-Killer Model is capable of simulating airborne platforms in addition to ground platforms. An airborne platform, in terms of the Hunter-Killer Model, is simply another platform that is in the air at a given altitude instead of being on the ground. It may have one or two sensors, may have a weapon, may acquire targets, and may engage acquired targets. Also, it may become a target and be engaged or killed just like any other platform. The principal effect of the altitude is on line of sight. A masked platform cannot see targets and cannot be seen. When low resolution terrain is used, an unmasked platform can see 100% of the targets it detects (unless microterrain is used) and is 100% exposed to sensors able to see it. When high resolution terrain is used, line of sight and percentage visible to and from the platform are computed in the same way as for other platforms, except the altitude is added to the elevation of the ground at the platform's location. This has the effect of making targets more exposed than they are to a ground observer, but less exposed than with the constant 100% fraction visible of low resolution terrain. This is also a more accurate reflection of the difficulty of finding targets among the terrain features.

Unlike ground platforms, which operate independently of all other platforms, airborne platforms are grouped into flight teams (though a team may consist of a single platform). A team usually consists of two to four platforms. One platform has as its primary function the acquisition and designation of targets. RPVs and scout helicopters fall into this category. Whether this platform may also engage targets is determined through the data, which indicate which platforms have weapons. The additional team members are attack platforms. These may be airborne, such as helicopters, or ground, such as artillery. Based on current U.S. Army doctrine, it is assumed in this that the teams have one scout and multiple attack platforms; however, the actual composition of a flight team is determined by the user through the input data. The primary acquisition platform is referred to as the scout, whether it is capable of engaging or not. The other platforms are referred to as attack platforms.

Flight teams may fly at fixed altitudes -- essentially acting like a ground platform in the air. They may also use popup tactics in which the team flies masked to a location, the scout unmasks to locate targets and request fire from an attack platform, then remasks. The team then flies to a new position for another popup. Airborne platforms may also be given automatic target recognition systems (ATR) that allow them to minimize the time they are unmasked. An ATR rapidly scans a field of search and stores the imagery. The platform can then mask and review the stored imagery and select targets. The ATR system is also capable of cuing the operator to possible targets.

3.6 WEAPONS

Each type of platform in the Hunter-Killer Model may have one weapon. Weapon performance is expressed through probability of kill curves which depend on the weapon being fired, the target's platform type, and the range to the target.

Weapons are modeled through probability of kill (PK) curves given in the input data. A curve may be defined for each weapon and type platform (target) combination. The input curve consists of a set of points, each of which gives a range and the probability of the weapon killing the type platform at that range. When a platform fires a round, the appropriate curve is selected. The range from the firing platform to the target is computed and the PK for that range is interpolated. A sample value between 0 and 1 is obtained using the SIMSCRIPT II.5 pseudo-random number generator. If the sample value is less than the PK, the target has been killed. If the sample value is greater than the PK, the round did not kill the target.

The above algorithm may be modified if the firing platform has a laser rangefinder. Range errors are one of the major factors in not successfully making a kill. By including a laser rangefinder on the firing platform, the probability of killing the target can be significantly increased. To allow for rangefinders, each weapon and type platform combination actually has two PK curves, one used when rangefinding is available and the other used when it is not. When a round is fired the firing platform uses its rangefinder. The success of the range finding as determined by the strength of the signal returned from the target controls the selection of the PK curve.

3.7 SENSORS

The Hunter-Killer Model is capable of simulating a large variety of sensors, both contrast and infrared. Target resolution by a contrast sensor is by minimum resolvable contrast (MRC). Target resolution by an infrared sensor is by minimum resolvable temperature (MRT). In addition, infrared sensors may perform minimum detectable temperature (MDT) acquisitions. These occur when the sensor can perceive, but not necessarily resolve, a target. In such a situation, the observer may perceive a hot spot, but be unable to resolve the source.

Helicopters are highly vulnerable when unmasked. As a consequence, sensor systems are being developed which will minimize the amount of time helicopters are exposed. These automatic target recognition (ATR) systems allow a helicopter to unmask for a brief amount of time, typically for ten seconds, while the system scans the field of search and stores the imagery. The helicopter then remasks and hovers while the system postprocesses the stored imagery.

The helicopter cannot remain masked for too long while the operator reviews the stored imagery or the targets will have moved sufficiently to make reacquisition difficult. An ATR system is capable of cuing the operator to likely targets so that the operator does not need to review the entire stored FOS. As the operator reviews the targets a priority is assigned to each. The helicopter then unmasks and fires. The ATR system uses the stored target priorities and locations for rapid reacquisition of the targets. The information can also be passed off to other members of a flight team for action.

These systems can also be used in a manual mode like other sensors.

The Hunter-Killer Model simulates the use of ATR systems by flight teams. It is assumed that these systems will all be FLIRs.

Resolution curves are used to determine the spatial frequency of a target. Each curve is defined by exactly twenty points, with linear interpolation used to compute values between the input points. The values given by a resolution curve depend on the sensor's resolution technique. For a contrast sensor, each resolution curve gives the spatial frequency of the target, in cycles per milliradian, as a function of the target's apparent contrast. For a thermal sensor, each curve gives the spatial frequency of the target as a function of the detected temperature difference between the target and the background, in degrees Celsius.

3.8 JOHNSON CRITERIA

The Johnson Criteria are a set of four values used to define levels of target discrimination. The levels, in order of increasingly precise discrimination, are: detection, classification, recognition, and identification. These level may be defined as follows:

> Detection (level 1) is the ability to distinguish that an object is of military interest.
>
> Classification (level 2) is the ability to distinguish a target by general type; e.g., as a tracked vehicle instead of a wheeled vehicle.
>
> Recognition (level 3) is the ability to distinguish between two targets of similar type; e.g. between two type of tracked vehicles such as APCs and tanks.
>
> Identification (level 4) is the ability to discriminate the exact model of a target; e.g., T72 or M1 tank.

Each level is defined by the minimum number of cycles from a standard bar type target pattern that must be distinguished for a target to be acquired at that level. Figure 3-2 presents the discrimination levels as a function of a number of cycles.

The Johnson levels are used to construct a target hierarchy in the Type Platform section of the data set. The type platforms are all level 4 targets. The hierarchy relates these level 4 targets to level 1, 2, and 3 targets. A typical hierarchy is shown in Figure 3-3.

As shown in Figure 3-3, a component may acquire a T72 tank at a Johnson level of 3. This means that the component can distinguish the target as a tank of some kind but not the specific type of tank. If the target is acquired at a level of 2, the component can only determine that the target is some kind of tracked vehicle. If the target is acquired at a level of 1, the component can only determine that a target is present.

The Hunter-Killer Model uses these criteria for several purposes. When an acquisition occurs, the level to which the target can be discriminated is determined. The next action taken by the acquirer is based on that level. Each component of a platform has an input minimum action level to which a target must be acquired before the component takes action against the target. For a hunter component, this action is to pass the target to the killer component. For a killer component, this action is to fire on the target. If the target is acquired at a level lower than the action level it will be ignored.

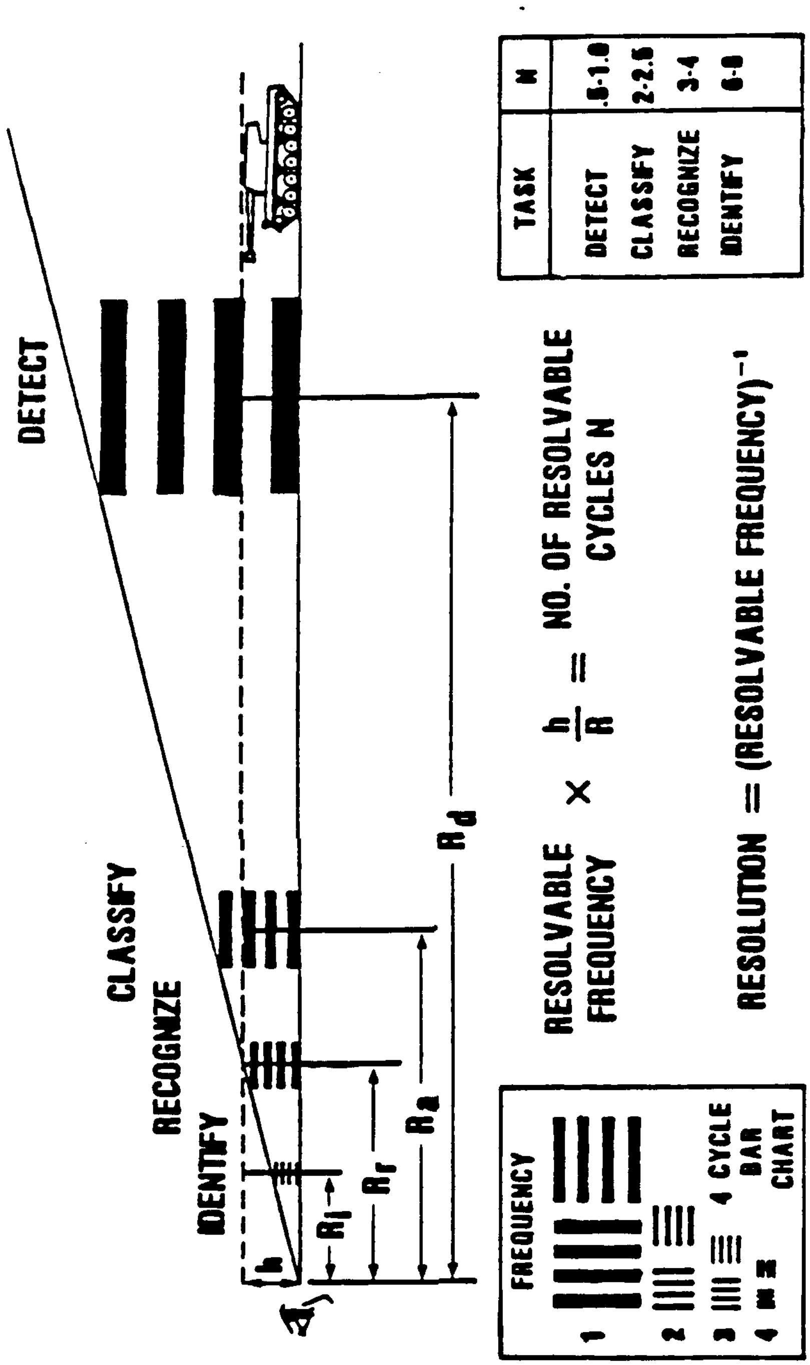

Figure 3-2, Johnson Resolution Criteria

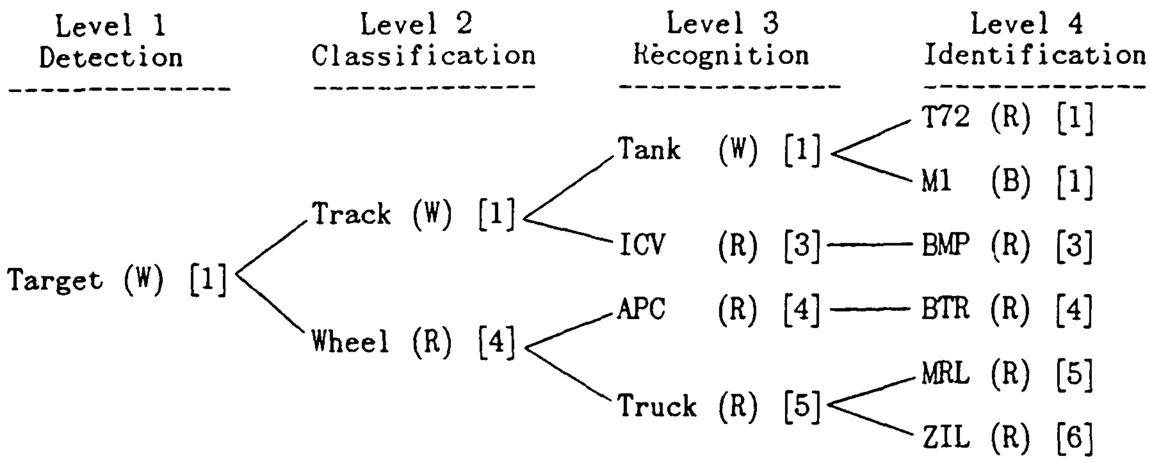

Figure 3-3, Johnson Hierarchy of Targets

Also, the time required to acquire a target is dependent on the action level. A component can quickly determine that some type of target is on the battlefield. Acquisition takes much longer if the component is required to interrogate the target long enough to determine the specific type of target.

In Figure 3-3, the letter in parentheses after the target name is the side to which it belongs: B means blue, R means red, W means white (neither blue or red). The level 3 target called tank is white because there are two types of tank on the battlefield, the T72 and the M1. At level 3, recognition, an observer cannot distinguish between them. A killer component with an action level of 1, 2, or 3 which acquired the target at level 3 would fire on it even though the target may be friendly.

The level 3 target ICV (infantry combat vehicle) is red because the only level 4 ICV on the battlefield is the red BMP. Similarly, the level 3 targets APC (armored personnel carrier) and truck are red because all targets lower in the hierarchy are all red.

The data set assigns priorities to targets in a similar manner. Priorities are defined for level 4 targets, shown in square brackets in Figure 3-3. A lower number indicates a higher priority, with 1 being the highest priority. These priorities are used by the killer to decide which target to engage first if the platform has detected multiple targets at the same time.

A level 1, 2, or 3 target is assigned the highest priority of the targets under it in the hierarchy. The level 3 tank has a priority of 1 because both of the level 4 targets below it are level 1. The level 2 track target also has a priority of 1, the highest of the priorities of the level 3 targets beneath it -- tank and ICV.

3.9 ACQUISITION TIMES AND LEVELS

The procedure to compute acquisition times and Johnson levels is based on the NV&EOC Search Model. The Search Model is a single target, single observer model consisting of display and physical search submodels. The display submodel predicts probability of acquisition versus time for a fixed viewing device. Observers acquire a target by visually searching the device display with eye movements. The physical search submodel extends the display model to predict the probability of acquisition when the observer must scan the device over a known search field in order to acquire the target.

The major assumptions and limitations contained in the Search Model are listed below.

The target is within the sensor's field of search and line of sight exists.

The observer acquires a target only by its primary signature, IR or contrast. The target's location, motion, and weapon firing have no effect on acquisition.

The target is static and does not make or break LOS nor does the range vary during the attempted acquisition.

The FOS search tactics are an unspecified, uniform scan.

Ground targets have average and unspecified background clutter.

The atmosphere is homogeneous.

All observers are equally good (or bad) at the skills of target acquisition. The performance of observers does not vary over time; i.e., they do not experience learning or fatigue.

The observers do not have memory. If a target is acquired at too low a level to take action the observers do not file the target into their memory for later interrogation.

The sensors make Class I errors in that they fail to acquire legitimate targets. The sensors do not make Class II errors in that they never acquire an object that is not a target. Even if false targets are correctly rejected, the interrogation process would consume time that could be spent searching.

Each target is in a separate FOV and is acquired independent of all other targets. The sensor does not acquire the second and subsequent targets in a unit based upon acquiring the first.

The scan rate is independent of the environment or number of acquisitions occurring. The sensor does not interrogate regions that have previously produced acquisitions. The scan rate continues without regard to the visibility.

All targets are the same except for critical dimension and temperature;

for example, tanks are not assigned unique and observable properties to distinguish them from motor-generator sets.

Sensors perform at full capability and do not experience failure (partial or complete) from either normal failure or battle damage. Sensors can perform until their platform is killed.

Sensors do not communicate and cooperate in search with the exception of hunter/killer pairs and flight teams.

There is no distinction between night and day except through data such as the resolution curves or the background light level used by contrast sensors. During daytime the sun position has no effect.

Masking by vegetation is not considered, except as micro-terrain is used to reduce the fraction of the target's critical dimension that is visible to the observer.

3.10 THE SIMULATION

A single replication of the model causes a set of blue and red platforms to move, acquire targets, and engage targets. During the replication a number of statistics are collected to measure the performance of the platforms in acquiring and engaging targets. Some of the data collected are the minimum, maximum, and average sensor acquisition times, the number of shots fired, the number of targets killed, the average number of targets in the field of search, and the average engagement duration.

A stochastic model should always be run for more than one replication. The model makes decisions such as whether line of sight exists or whether a shot causes a kill by comparing input probabilities with samples generated by the SIMSCRIPT II.5 pseudorandom generator. It is possible for the results of any one replication to be skewed by the particular samples generated in that replication. To avoid this problem, the Hunter-Killer Model is always run for multiple replications, typically ten to twenty. The model collects statistics for each replication and prints them at the end of the replication. The model also averages the statistics over all replications and prints summary reports.

There is no hard and fast rule for the number of replications that must be run. Past observations have shown that because the model uses only a few platforms, typically fewer than twenty, the results can vary significantly from replication to replication depending on which side makes the first acquisition and which side makes the first kill. The averaged results over all replications do not, however, change significantly for most data sets after ten replications have been made. The averaged results from runs of twenty or more replications are essentially identical.

The simulation is driven by the movement of the platforms. Each time a platform moves, a list of targets in the field of search of its hunter and killer components is updated. For each of these targets an acquisition time is computed and a target acquisition is scheduled.

When an acquisition occurs, the component of the observing platform determines the Johnson level at which the target was acquired. If acquisition level is less than the component's action level, the component switches its sensor to narrow FOV. The acquisition level is again determined. If the level is still less than the action level the target is ignored and the component resumes searching for targets. Otherwise, action is taken against the target. If the acquiring sensor is the hunter, the action is to pass the target to the killer to be fired upon. If the acquiring sensor is the killer, the action is to fire on the target.

When the killer engages a target, it fires a single round. The effects of the round are assessed using the input probability of kill curves. If the first round did not kill the target, the killer reloads and fires again. The killer continues this procedure until the target is killed. At that time, the killer determines if the hunter has found more targets and, if so, fires on them. When the killer has no more targets it resumes searching.

Engagements can be interrupted by several events. Platforms continue to move while engaging. After a move the firing platform may no longer have line of sight to the target. Additionally, while a platform is engaging a target the enemy platforms may acquire it and engage and kill it.

A replication continues for a fixed amount of time determined through the data set.

4.0 DATA REQUIREMENTS

4.1 DATA OVERVIEW

The Hunter-Killer Model is driven by data supplied by the user which describe the performance characteristics of equipment and the overall conditions under which they operate. Very few values are coded into the model itself: to the greatest extent possible the model contains only the logic which determines how input values are used. By having the data external to the model a large variety of scenarios may be examined without requiring any changes to the model's source code.

4.2 DATA ORGANIZATION

The data are organized into blocks, each block giving the data for a specific capability of the model. There is a Controls data block which is concerned with the overall conditions under which a run is to be made. There are several blocks giving the performance characteristics of the equipment being modeled. These blocks include Lasers, Sensors, Type Weapons, and Type Targets. Other blocks describe the hunter-killer platforms and their tactics by giving the platform types, initial locations, search tactics, and movement vectors. There is also a block describing the terrain on which the platforms will move.

The data are structured for minimal repetition. For example, each platform must have data describing its signature to the sensors. Since a scenario is likely to include many identical platforms -- such as several occurrences of a single type of tank -- giving the target signature for each platform would cause duplication of data. Instead of describing each platform's target characteristics along with its location and other platform specific data, the platform describes its type, such as type 101 which may have the name M1-TANK. The target signature for all platforms of type M1-TANK is then given only once, in the Type Target data block. The various blocks are interrelated through the use of identification numbers assigned by the user.

4.3 THE HUNTER-KILLER DATABASE SYSTEM

The Hunter-Killer Model is intended to run on a variety of mainframe computers. To avoid the necessity of maintaining nearly identical sets of data on each mainframe, a single database system was developed. This system has been implemented on an IBM AT computer using the dBASE III (a trademark of Ashton-Tate) database management software. The database system is not required in order to use the Hunter-Killer Model; instead, it provides a tool to simplify the maintenance of the data. The data may be kept directly on the mainframe on which the model is stored and executed.

The Hunter-Killer Database System is menu driven, displaying to the user a series of screens showing options from creating a new database to printing a report on a database. These screens lead the user through the system with a minimal need to refer to other documentation. The data within the database system are structured into the same blocks which appear in the run stream as discussed in Section 4.2.

After the data have been entered into the database system, a run stream may be generated. To do so, the user selects the menu screen for run stream generation and responds to the screen's prompts. The prompts ask which mainframe is being used and which of the multiple copies of the Controls and Hunter-Killers data are to be used. The system then builds the run stream in the format required by the Hunter-Killer Model. The IBM AT is then connected with the mainframe on which the model is to be run and the run stream is uploaded to that mainframe. Depending on the type of mainframe and the boards and software installed on the IBM AT, the connection to the mainframe may either be through a telephone using a modem and a communications software package or through a direct wire connection.

5.0 MODEL OUTPUT

5.1 REPORT CLASSES

The Hunter-Killer Model produces four classes of reports which provide a user with detailed information to support analysis. The generation of all reports except the final summaries, which are always printed, is at the option of the user. The reports classes are: Data Echo, Replication, Final Summaries, and Debugging.

5.2 DATA ECHO REPORTS

The user may select to have printed at the start of each run a report which reflects the data that were input. This allows the user to determine if the data file had been set up correctly and was read correctly. Additionally, printing this report prevents any confusion at a later date about which data were used to generate the remaining reports. All values shown are labeled with their names and, if appropriate, their units of measure.

5.3 REPLICATION REPORTS

The user may select to have a variety of reports produced by each replication of the model. These reports are:

The Initial Line of Sight Report, describing at the start of the replication which sensors have which targets in their fields of search and what percentages of the targets are visible.

Status Reports, printed at a user selected interval, giving each platform's position along with other status data.

The Scoreboard, giving for each platform its status at the end of the replication and a list of targets it killed.

The Acquisition and Engagements Times Report giving sensor performance statistics for the replication.

The Engagement Results Report, giving the number of shots and kills made by each platform along with other statistics that were gathered during the replication.

5.4 FINAL SUMMARIES

The model produces final summaries which average the results over all of the replications. These reports include an Acquisition and Engagement Times Report and an Engagement Results Report. Additionally, histograms are produced giving the number of shots and losses on each side in each replication as a function of range. The histograms are also produced as a function of time.

5.5 DEBUGGING REPORTS

Every run generates a small file containing progress messages printed at the start of the run, before and after each replication, and at the end of the run. Additionally, there are three controls allowing the user to select to have a message printed after each significant action. These messages give detailed information on the computations being made. These messages are intended primarily for the maintenance programmer who is studying the model's computations in detail.

6.0 RESOURCE REQUIREMENTS

6.1 COMPUTER SYSTEMS

The Hunter-Killer Model has been implemented using the SIMSCRIPT II.5 simulation language. This language has few system dependent features, allowing a model written in it to be transported easily to any computer which has a current SIMSCRIPT II.5 compiler. The compilers are available on most common mainframe computers, including IBM, CDC, VAX, PRIME, Sperry, and Honeywell. The compiler is also available for personal computers running under MS-DOS.

Currently, the model is operated on two mainframe computers. The model was developed on a CDC Cyber 835 running under the NOS/BE operating system. The model was also successfully transferred to an IBM 4341 running under CMS.

6.2 TIME AND MEMORY REQUIREMENTS

The time and computer memory requirements of the Hunter-Killer Model are highly dependent on the size of the simulation to be executed. For example, statistics are collected for each replication then printed after all replications have been completed. This requires the use of arrays, one dimension of which is the number of replications. Increasing the number of replications, consequently, increases the size of the arrays. Naturally, the amount of CPU time required also increases with the number of replications. CPU time also increases with the length of each replication. Most simulations using this model are expected to consist of twenty replications of thirty to sixty simulated minutes each.

The other major factor affecting the size of the simulation is the number of hunter-killers being modeled. A maximum of twenty hunter-killers are expected, though more may be included. The most common runs to date have consisted of seventeen hunter-killers, four blue versus thirteen red.

On the CDC Cyber 835 these runs have required 70,000 to 120,000 octal words of memory and 100 to 600 decimal seconds of CPU time.

On the IBM 4341 these runs have been executed in a partition of 760K to 1024k and have required 100 to 600 seconds of CPU time.