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NAVAL POSTGRADUATE SCHOOL

Monterey, California



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Masters **THESIS**

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OPERATIONAL LANCHESTER-TYPE MODEL
OF SMALL UNIT LAND COMBAT

by

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Josef Smoler

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(11)

September 1979

Thesis Advisor:

J.G. Taylor

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Operational Lanchester-Type Model
of Small Unit Land Combat

by

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B.S., Technion-Israel Institute of Technology, 1973

Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

This thesis describes an operational Lanchester-type model of small-unit land combat. It is a time sequenced, deterministic, battalion-level, force-on-force model implemented on a digital computer. In comparison with other existing battalion level analytic models, this model contains some new modelling ideas about detection and fire allocation policies.

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I. INTRODUCTION

Although detailed combat models (such as high-resolution Monte Carlo simulations) are heavily used at the tactical level, some analysts and users still have doubts about the use of this kind of model. Detailed combat models (especially high-resolution Monte Carlo simulations) are costly to build, costly to run, require a staff of highly trained personnel to maintain, exercise and modify, are quite demanding in data-base requirements, not easily modified, essentially impossible to use to perform sensitivity and other parametric studies, and are not easily communicated to decision makers.

Though a detailed model is considered by many to be more realistic than an analytic model and to supply more information as output, one can definitely see that there is a price to pay for such detail. This is especially true if one considers some meaningful advantages of analytic models.

Analytic models in contrast are usually much simpler to use and both time and financial resources for their utilization are usually markedly reduced. They are very efficient for conducting sensitivity analysis and their results are readily interpretable, since the dynamics of the combat process are clearly and succinctly described by equations (i.e., they are an efficient tool for communication with decision makers). Analytic models are an

efficient tool for the user too, since they are usually more general thus facilitating their use under more diverse circumstances. Now that we have discussed the pros and cons of the two principal types of small-unit combat models, it remains for us to consider how to decide which one to develop and use under specific circumstances. What should one do to decide which type of model to use? Definitely there is no unique answer to this question. Furthermore, such an answer depends on considerations such as availability of time and money, level of accuracy desired, problem scenario, purposes of model use, etc. Since an analytic model is more abstract than a Monte Carlo simulation, one might ask himself: Do the two types of models describe the same combat process for the same given scenario?

Reference 5 describes a study that was conducted to compare the combat predictions generated by an analytical combat model to those predicted by a more detailed Monte Carlo simulation model. The analytical model was developed against an existing simulation model to determine whether both could generate comparable results. The analytic model was applied to replicate the processes as they were described in the simulation model and not as they might possibly occur in the real world. The conclusions of this study indicate good agreement and suggest that both models essentially describe the same process. In reference 4 it is suggested that the complex model should be used to educate

the analyst while a simple model should be used to communicate with the decision maker. In other words, complex models should be used as research tools to determine basic relations that can be presented to decision makers with simple easily-understood models. In this context the detailed model serves as the "back-up" for the simple model.

II. MOTIVATION

The BONDER/IUA and its derivatives BLDM and AMSWAG are analytical battalion-level combat models that have been and are currently widely used in the United States for defense planning purposes. After studying documentation for these models, the author decided to build his own small-scale version with certain important changes. For example, the detection and fire-allocation submodels in these models (at least to the extent that they are described in available documentary) have several features that appear to be at variance with both military experience and judgement. Reference 3 describes a sensitivity analysis of BLDM acquisition and firepower allocation models and shows that BLDM is relatively insensitive to changes in non-firing acquisition rates. The analysis explains that this insensitivity is a result of the firepower allocation logic and the fact that firing-cued probabilities in the model have been set to 0.99.

The study in reference 3 recommends that fire-cued acquisition probabilities considerably less than 0.99 should be used in the model and sections of search should be assigned weapon groups. It is also recommended that detection rates for targets lying within a group's primary search sector should be different from those for targets lying outside the sector. The author of this paper also could not strongly

agree with some of the basic assumptions of AMSWAG's detection and fire allocation models. AMSWAG conducts the battle in uniform time steps of 10 seconds each. AMSWAG's detection model keeps track of the cumulative acquisition probability that each firer has against each target at any time t and combines this with the new probability of acquisition during the interval $(t, t+\Delta t)$. This process is continued as long as line-of-sight is not interrupted. When line-of-sight is interrupted, however, the cumulative probability of acquisition is set to zero and the process will start again if intervisibility again exists at a later point in the battle. According to the author's experience, the cumulative acquisition probability should not be set to zero immediately since the observer still has some idea where to expect the target to appear. The computation of detection probability for each observer against every target must consequently depend on both the observer status (i.e., whether or not the observer fires during the current time interval) and the target status (i.e., whether or not the target fires during the current time interval), whether the target is inside or outside the observer search sector or the observer field of view). This is not done by AMSWAG's detection model.

The author of this paper also did not find the AMSWAG's fire allocation model to be a realistic representation of military reality, and consequently has developed a new one based on his previous military experience.

As a result of the discussion above, an analytic battalion level combat model was developed. Although the model was programmed for a specific scenario, it can still be applied to other battalion-level scenarios with relatively few modifications because of its generality.

III. THE MODEL

A. GENERAL DESCRIPTION

The model developed in this thesis is a time sequenced, deterministic, battalion-level, force-on-force computer model. The scenario portrays a blue TOW company (3 platoons with 3 TOWS in each) deployed in 3 fixed platoon-sized defensive positions (see B1, B2 and B3 in figure 1). The opponent, a red tank company (3 platoons with 3 tanks in each) conducts an attack along 3 predetermined routes of advance toward the defensive positions. Each route nominally contains a platoon-sized force (see R1, R2 and R3 in figure 1). The model conducts the battle in uniform time steps of 10 seconds each. Figure 2 provides the general scheme for the sequence and flow of events in the model. Basically the sequence of events for each time interval (i.e., 10 seconds) contains five main phases: movement, detection, fire-allocation, attrition and battle-termination (see figure 3). The movement phase is applied to the Red units only. Generally, every Red unit is advanced to the next interval along the associated route unless this unit is destroyed already or is in firing status. (In this case the unit will be advanced only every certain number of time intervals.) The detection phase is basically an accumulation process. Detection probabilities during $(t, t+\Delta t)$ between any two opponent units are computed and combined

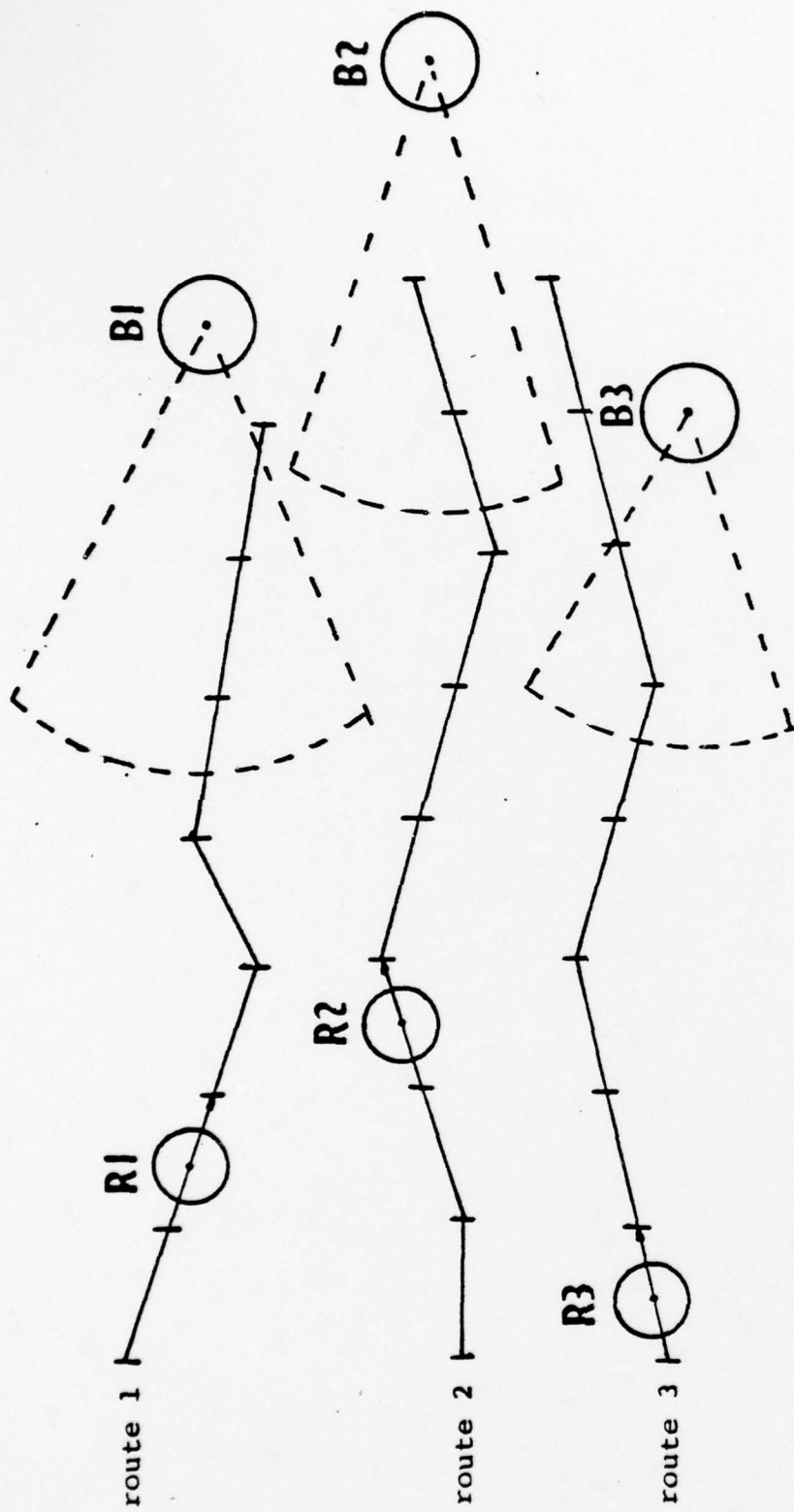


FIGURE 1. SCENARIO SCHEME

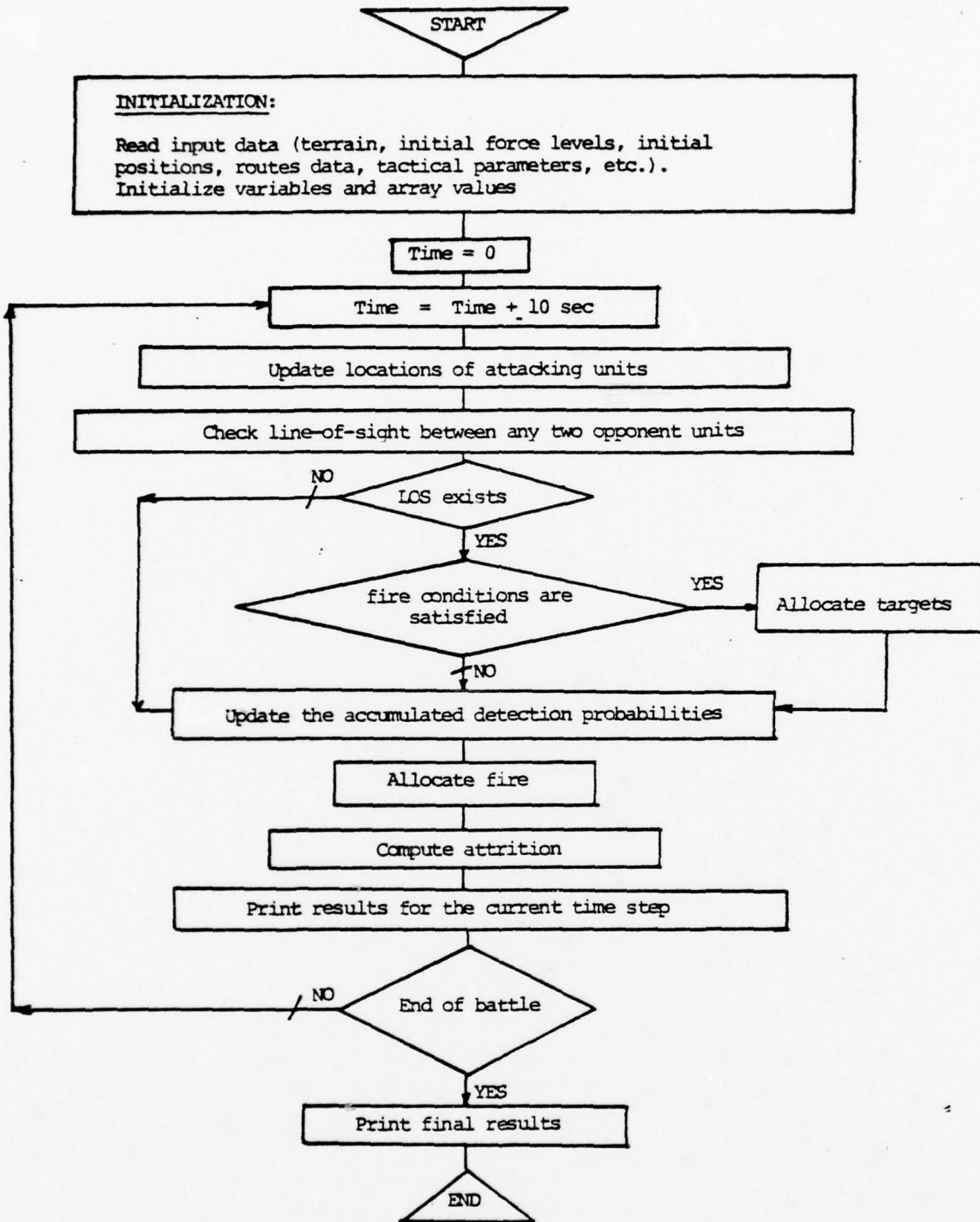


FIGURE 2. FLOW CHART

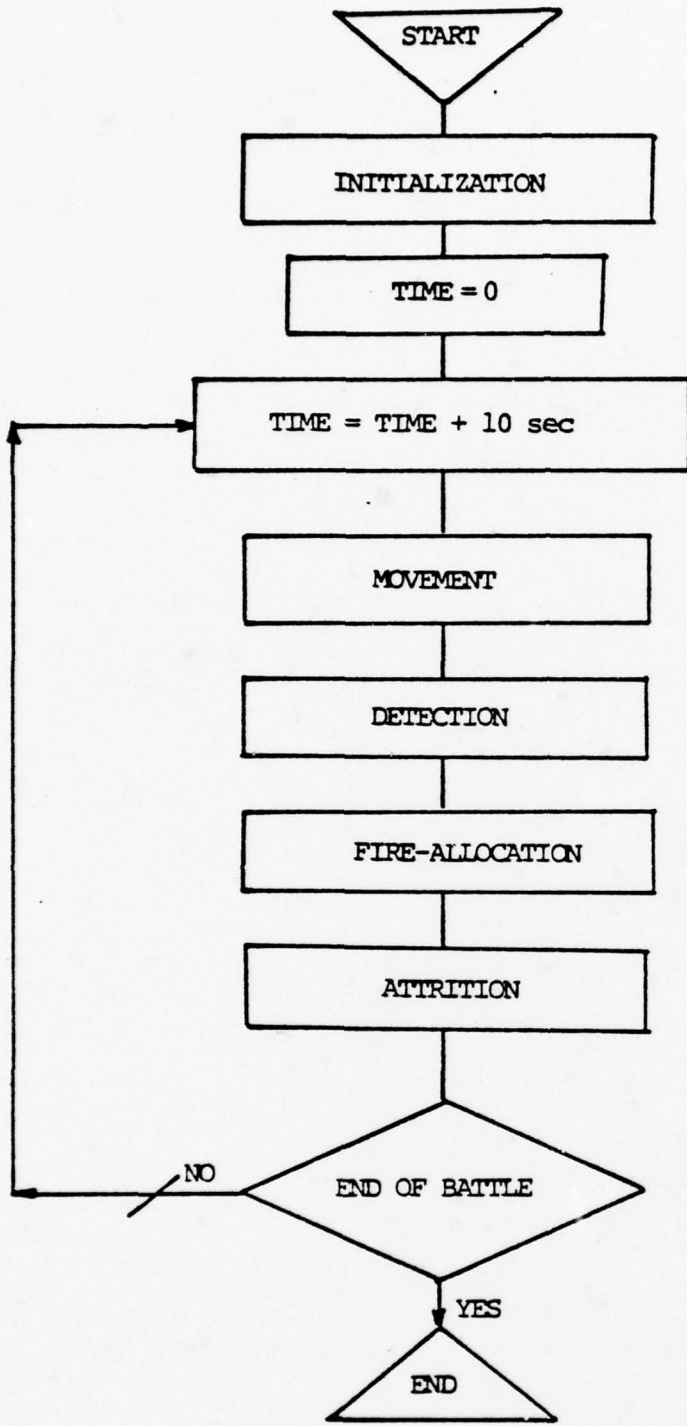


FIGURE 3. GENERAL SCHEME

with the appropriate accumulated probabilities at time t . Basically the accumulation process can be described by the following equation:

$$\begin{aligned} & \text{Pr}(\text{Unit } i \text{ does not detect unit } j \text{ at time } t+\Delta t) \\ &= \text{Pr}(\text{Unit } i \text{ does not detect unit } j \text{ at time } t) \\ & \quad \times \text{Pr}(\text{Unit } i \text{ does not detect unit } j \text{ during } t, t+\Delta t). \end{aligned}$$

The fire allocation phase selects possible targets for every surviving unit, assigns priorities to these targets and determines what fraction of each unit is allocated to fire at each target according to the fire-allocation policy. The attrition phase computes the attrition and the remaining force level for every surviving unit. Since the two forces are homogeneous and use only "aimed-fire", the attrition computation is based on simple Lanchester-type differential equations where the attrition coefficients are computed by the Bonder-Farrel formula. Every such sequence is ended by a battle-termination check process.

B. MOVEMENT PROCESS FOR ATTACKING UNITS

The 3 attacking tank platoons (see R1, R2 and R3 in figure 1) move along 3 predetermined routes. Each route is divided into intervals, 40 meters length each since a non-firing red platoon is assumed to move one such interval during a time step of 10 seconds (i.e., average speed of 9 mph).

Firing red platoon is delayed NOD times before moving to the next interval. Each interval in each route is represented by its center point coordinates and by its direction. If a red platoon enters to an interval along its associated route then it is considered to be positioned only in the center point of this interval (i.e., maximum location error of ± 40 since this is the distance between two consecutive intervals).

C. COMMAND AND CONTROL

Command and control are represented in a simple fashion by delaying units which move too fast. If the horizontal distance (along the x-axis) between any two red platoons is more than DISMAX, the leading unit is delayed in order to keep a straight front of the attacking force.

D. LINE-OF-SIGHT (LOS) DETERMINATION

The existence of line-of-sight between any two opposing units is determined in a subroutine called LOS which was written by Prof. James K. Hartman, Naval Postgraduate School. Each hill in the selected piece of terrain is described by a bivariate normal density function and is characterized by the following parameters:

1. Coordinate of the hill center point (x_c, y_c).
2. Peak height
3. Standard deviation corresponds to the x-axis (σ_x).
4. Standard deviation corresponds to the y-axis (σ_y).
5. Rotation factor (ρ).

The subroutine is applied by the following FORTRAN statement:

```
CALL LOS(XA, YA, TMACA, TMICA, SIZEA, XB, YB, TMACB,
         TMICB, SIZEB, LATOB, LBTOA, VISFRA,
         VISFRB)
```

where:

XA, YA - coordinate of unit A ($XA, YA \in 0 \div 10,000$ m)

TMACA - elevation of unit A (this is found by using the subroutine ELEV(XA, YA, TMACA))

TMICA - depth below ground surface [meters]

SIZEA - height of the vehicle [meters]

LATOB = $\begin{cases} 1 & \text{If want LOS with A as observer and B as target} \\ 0 & \text{Else} \end{cases}$

LBTOA = $\begin{cases} 1 & \text{If want LOS with B as observer and A as target} \\ 0 & \text{Else} \end{cases}$

VISFRA - fraction of A height as seen by B

VISFRB - fraction of B height as seen by A

$0 \leq \text{VISFRA}, \text{VISFRB} \leq 1$

E. DETECTION

1. Types of Detection

A target can be detected in either of two ways:

Random search within a designated section of responsibility

(non-firing detection) or by launch signature given the

target has fired at least one round (firing detection)

[Ref. 1].

2. Definitions

Let,

$P_{ij}(t+\Delta t)$ = the probability that unit j is detected by unit i at time $t+\Delta t$

We assume:

$$P_{ij}(0) = 0 \quad \forall i, j$$

$Q_{ij}(t+\Delta t) = 1 - P_{ij}(t+\Delta t)$ = Probability that unit j is not detected by unit i at time $t+\Delta t$

$QV_{ij}(t, \Delta t)$ = Probability that target j is not visually detected (i.e., non-firing detection) by unit i during $[t, t+\Delta t]$ provided that j does not fire during this time interval

$QP_{ij}(t, \Delta t)$ = Probability that target j is not detected by a launch signature during $[t, t+\Delta t]$ provided that j fires during this time interval

3. Computation of $QV_{ij}(t, \Delta t)$

Let

$t_{ij}^{(K)}$ = time for the K^{th} firer of unit i to detect one target of unit j . $K = 1, 2, \dots, S_i(t)$

where

$S_i(t)$ = number of survivors in unit i at time t .

We assume that $t_{ij}^{(1)}, t_{ij}^{(2)}, \dots, t_{ij}^{(S_i(t))}$ are independent and identically distributed by $\exp\{\lambda_{ij}\}$ (i.e., exponential distribution with parameter λ_{ij}), where

λ_{ij} = Non-firing detection rate of one target in unit j by one observer in unit i

T_{ij} = the time for unit i to detect one target of unit j

Assuming that all $S_i(t)$ survivors of unit i are searching for a target then

$$T_{ij} = \min\{t_{ij}^{(1)}, t_{ij}^{(2)}, \dots, t_{ij}^{(S_i(t))}\}$$

and T_{ij} is exponentially distributed with parameter $S_i(t)\lambda_{ij}$ (i.e., $T_{ij} \sim \exp\{S_i(t)\lambda_{ij}\}$)

$QV_{ij}(t, \Delta t)$ = Probability that no one of the $S_j(t)$ survivors of unit j is visually detected by unit i during $[t, t+\Delta t]$

$$\begin{aligned} &= [\Pr(T_{ij} > \Delta t)]^{S_j(t)} \\ &= [e^{-S_i(t)\lambda_{ij}\Delta t}]^{S_j(t)} \end{aligned}$$

or

$$QV_{ij}(t, \Delta t) = e^{-S_i(t)\lambda_{ij}\Delta t S_j(t)}$$

4. Computation of Non-Firing Detection Rate (λ_{ij})

Each firer is assigned to a search section (or section of responsibility) which is characterized by two parameters (see figure 3):

(a) Section width (ISECWD) where $0 \leq \text{ISECWD} \leq 2\pi$

(b) Primary direction (IPRDIR) where $-\pi \leq \text{IPRDIR} \leq \pi$

We assume that within the search section the search direction has the following probability density function:

$$f(\theta) = A + B \cos \theta \quad -D \leq \theta \leq D$$

where,

$$D = \text{ISECWD}/2$$

$$A = -B \cos D$$

$$B = \frac{1}{2(\sin D - D \cos D)}$$

$\theta = 0$ corresponds to the observer primary direction.

Note: A and B are chosen such that

$$\int_{-D}^D f(\theta) d\theta = 1$$

$f(\theta)$ is called the Limicon Function.

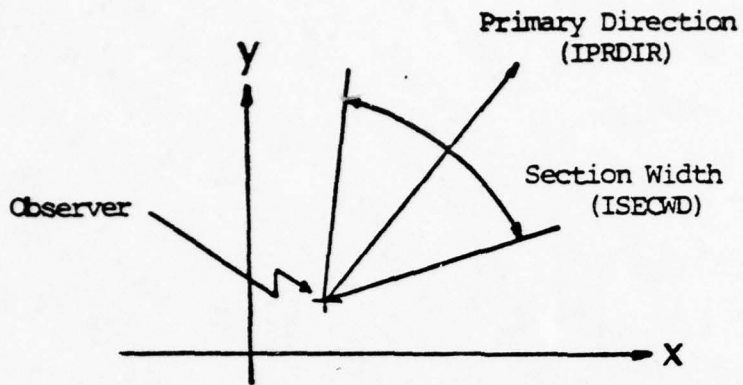


FIGURE 3. SEARCH SECTION

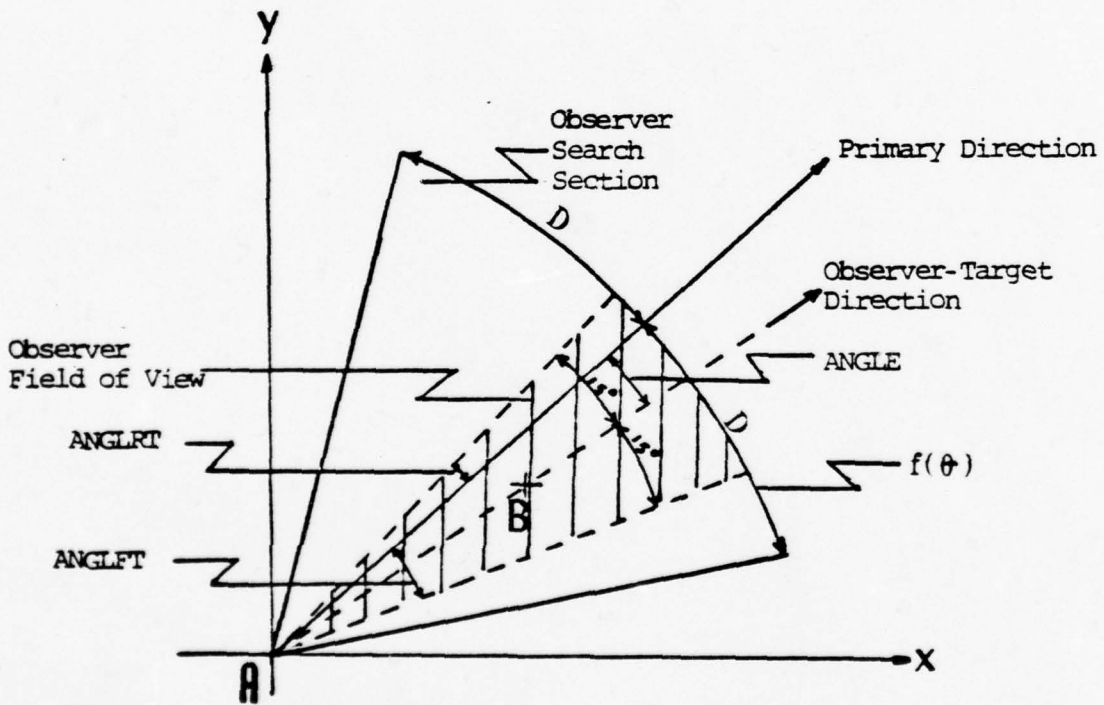


FIGURE 4. OBSERVER-TARGET SCHEME
A = Observer; B = Target

Figure 4 describes the observer-target scheme. Assuming 30° field of view for any observer A target B might be seen only if the observer A is looking at any direction such that $\text{ANGRT} \leq \alpha \leq \text{ANGLFT}$ where:

$$\text{ANGLFT} = \begin{cases} \text{ANGLE} + 15^\circ & \text{if } \text{ANGLE} + 15^\circ \leq D \\ D & \text{if } \text{ANGLE} + 15^\circ > D \end{cases}$$

ANGLE = the absolute value of the angle between the primary direction (IPRDIR) and the observer-target direction (OTANG)

$$\text{ANGRT} = \text{ANGLE} - 15^\circ$$

Thus,

$$\begin{aligned} P_k &= \Pr\{\text{ANGRT} \leq \alpha \leq \text{ANGLFT}\} = \int_{\text{ANGRT}}^{\text{ANGLFT}} f(\alpha) d\alpha \\ &= \text{shaded area in figure 4.} \end{aligned}$$

P_k is the probability that observer A is looking at direction which enables him to detect target B.

Given that observer A is looking at direction α such that $\text{ANGRT} \leq \alpha \leq \text{ANGLFT}$, the conditional detection rate $\{\lambda_{AB} | \text{ANGRT} \leq \alpha \leq \text{ANGLFT}\}$ is determined by the following regression curve [Ref. 6]:

$$\{\lambda_{AB} | \text{ANGRT} \leq \alpha \leq \text{ANGLFT}\} = 0.003 + [1.453 + \text{TCTFACT} \\ (0.5978 + 2.188 \times \text{RR}^2 - 0.5038 \times \text{HORVEL})^{-1}]$$

where,

TCTFACT = Terrain factor
 HORVEL = Target horizontal velocity [m/sec]
 RR = Equivalent range for a full height target [km]
 $= \frac{R}{\text{PCTVIS}} \times \frac{1}{1000}$

where,

R = The range between A and B
 PCTVIS = Height percentage of visibility of target B ($0 \leq \text{PCTVIS} \leq 1$).

The unconditional detection rate (of one observer detecting only one target) is:

$$\lambda_{AB} = \{\lambda_{AB} | \text{ANGRT} \leq \alpha \leq \text{ANGLFT}\} \times P_K$$

λ_{ij} is computed by the subroutine LAMDA using the following FORTRAN statement:

```
CALL LAMDA (I,J,PCTVIS,DETRAT)
```

where the variable DETRAT will contain the detection rate of one target in unit j by one observer in unit i.

5. Computation of $Q_{ij}(t+\Delta t)$

a. Observer Does Not Fire During $(t, t+\Delta t)$.

(1) Target j does not fire during $(t, t+\Delta t)$.

$$Q_{ij}(t+\Delta t) = Q_{ij}(t) \times QV_{ij}(t, \Delta t)$$

where,

$$\begin{aligned} QV_{ij}(t, \Delta t) &= [e^{-S_i(t)\lambda_{ij}^* \Delta t} S_j(t)] \\ &= [e^{-S_i(t)\lambda_{ij}^* \Delta t} S_j(t)] \end{aligned}$$

where,

$$\lambda_{ij}^* = \begin{cases} \lambda_{ij} & \text{if } j \text{ is a blue unit (stationary)} \\ PM \times \lambda_{ij} & \text{if } j \text{ is a red unit (moving)} \end{cases}$$

PM = Percent of time that unit i uses for searching targets. $0.0 \leq PM \leq 1.0$

λ_{ij} is computed by the subroutine LAMDA.

(2) Target j fires during $(t, t+\Delta t)$

Let,

$S_i(t)$ = number of survivors in unit i at time t

$S_j(t)$ = number of survivors in unit j at time t

FR_j = fire rate of each weapon system in unit j [rounds per second]

$FR_j \times \Delta t$ = number of rounds fired (at the average) by one firer of unit j during $(t, t+\Delta t)$.

$$N = FR_j \times \Delta t \times S_j(t) = \text{Total number of rounds fired by unit } j \text{ during } (t, t+\Delta t)$$

$$\text{Pr}\{\text{one survivor of unit } i \text{ to detect unit } j \text{ by one fire signature}\} = \text{Pr}\{\text{survivor looks at direction which enables him to see target } j\}$$

$$\times \text{Pr}\{\text{survivor detects unit } j \mid \text{survivor looks at direction which enables him to see unit } j\}$$

$$= P_K \times 1.0 = P_K$$

Assuming independence, one finds that

$$\text{Pr}\{\text{one survivor of unit } i \text{ does not detect unit } j \text{ by } N \text{ fire signatures}\} = (1 - P_K)^N$$

assuming independence between the survivors of unit i , we find that

$$\begin{aligned} \text{Pr}\{\text{all survivors of unit } i \text{ do not detect unit } j \text{ by a fire signature}\} &= [(1 - P_K)^N]^{S_i(t)} \\ &= (1 - P_K)^{N \times S_i(t)} \end{aligned}$$

$$\text{Pr}\{\text{at least one survivor of unit } i \text{ detects unit } j \text{ by a fire signature}\} = 1 - (1 - P_K)^{N \times S_i(t)}$$

$$QP_{ij}(t, \Delta t) = (1 - P_K)^{NS_i(t)} = (1 - P_K)^{FR_j \Delta t S_j(t) S_i(t)}$$

Now,

$$Q_{ij}(t+\Delta t) = Q_{ij}(t) [QV_{ij}(t, \Delta t) + QP_{ij}(t, \Delta t) - QV_{ij}(t, \Delta t) \times QP_{ij}(t, \Delta t)]$$

where $QV_{ij}(t, \Delta t)$ is computed as described in (1).

b. Observer Fires During $(t, t+\Delta t)$

We assume that if unit i is busy with firing during $(t, t+\Delta t)$ then no targets search is considered by unit i during this time interval. Only units within the field of view of unit i can be detected while unit i is firing. In other words, if unit i fires on unit K then OTANG is the direction of the line from the observer i to the target K and only units within $OTANG \pm 15^\circ$ can be detected by unit i (visually or by a fire signature).

(1) Target j fires during $(t, t+\Delta t)$

We define the following event:

A = unit j is within the field of view of unit i with at least one of unit i targets

We assume

$$\begin{aligned} \longrightarrow \Pr\{\text{unit } i \text{ detects unit } j \text{ by a fire signature during} \\ (t, t+\Delta t) | A\} &= 1.0 \end{aligned}$$

Thus,

$$\begin{aligned} \Pr\{\text{unit } i \text{ detects unit } j \text{ by a fire signature} \\ \text{during } (t, t+\Delta t) | \bar{A}\} \\ = 0 \end{aligned}$$

Thus,

$$Q_{ij}(t+\Delta t) = \begin{cases} 0 & \text{if event } A \text{ occurs} \\ g(n) & \text{if } j \text{ is a Red unit and event } \bar{A} \text{ occurs} \\ Q_{ij}(t) & \text{if } j \text{ is a Blue unit and event } \bar{A} \text{ occurs} \end{cases}$$

where $g(n)$ is an increasing function of n , where n is the number of time intervals elapsed since time t .

$$g(0) = Q_{ij}(t) ,$$

$$Q_{ij}(t) \leq g(n) \leq 1.0 \quad \forall n.$$

(2) Target j does not fire during $(t, t+\Delta t)$

If event A is the same as defined in (1), then

$$Q_{ij}(t+\Delta t) = \begin{cases} Q_{ij}(t) \times QV_{ij}^*(t, \Delta t) & \text{if event } A \text{ occurs} \\ g(n) & \text{if } j \text{ is a Red unit and} \\ & \text{event } \bar{A} \text{ occurs} \\ Q_{ij}(t) & \text{if } j \text{ is a Blue unit} \\ & \text{and event } \bar{A} \text{ occurs.} \end{cases}$$

where $g(n)$ is the same as defined in (1) and

$$QV_{ij}^*(t, \Delta t) = e^{-S_i^*(t) \lambda_{ij}^* \Delta t S_j(t)}$$

$$\lambda_{ij}^* = \lambda_{ij} \times RF$$

RF = Reduction factor (the detection rate of unit i has to be reduced since this unit fires during $(t, t + \Delta t)$ and the search for targets is not effective as for a non-firing unit)

$$S_i^*(t) = S_i(t) \times \left(\sum_{K \in K} PTT_{iK} \right)$$

PTT_{iK} = proportion of unit i allocated to unit K

K = $\{K | \text{Unit } K \text{ is engaged by unit } i \text{ and unit } j \text{ is within the field of view of unit } i \text{ while observing unit } K\}$

6. Intervisibility Effects on $P_{ij}(t)$

If line-of-sight does not exist between observer i and target j then no accumulation of detection probability takes place during the current time interval (i.e., $P_{ij}(t)$ remains the same). If line-of-sight does not exist during more than 3 consecutive time intervals then $P_{ij}(t)$ is set to zero (i.e., $P_{ij}(t) = 0$) and the accumulation process will start again from zero if line of sight again exists at a later point in the battle.

The motivation for this decision rule is seen by the observation that even if observer i loses line-of-sight

with target j for a short time, he still probably has some idea where to expect the target to appear again.

This decision rule was chosen somewhat arbitrarily, and some other time decreasing function may be employed if desired by the user.

7. Interpretation

$P_{ij}(t)$ can be interpreted as the average fraction of unit i that detects unit j . Any detection that occurs during the n^{th} time interval is used only in the next (i.e., $(n+1)^{\text{st}}$) time interval, since that detection represents new knowledge gained during the entire n^{th} interval under the conditions existing in that interval.

F. FIRE ALLOCATION

The first step in a firing event is to determine what fraction of each unit is allocated to fire at each target. Each firing unit does not have to select and fire at just one target. Rather, each firing unit might apportion a fraction of itself against several targets.

1. Selection of Targets

The following conditions are necessary for it to be possible for unit j to be a target of unit i :

(a) Line-of-sight must exist between unit i and unit j .

(b) The range between the two units should be within the interval $[RMIN_i, RMAX_i]$ where the two limits are determined by the weapon system type of unit i and by tactical considerations.

$$(c) P_{ij}(t - \Delta t) > 0.$$

2. Priority of Targets

Since the two forces are homogenous, the priority of a target is taken to be a function of range only (since homogeneous type of target is not considered).

3. Fire Allocation Procedure

It will be easier to explain this procedure by numerical example. First, for each unit i we find all the targets j which satisfy the three necessary conditions for being targets (see paragraph 1).

Second, we rank all the targets of unit i by the range.

Let

$$S_i(t) = 100$$

$$RMAX_i = 3000 \text{ m}$$

$$RMIN_i = 500 \text{ m}$$

and assume we have the following situation:

| <u>Target (j)</u> | <u>Range</u> | <u>Priority</u> | <u>$P_{ij}(t)$</u> |
|-------------------|--------------|-----------------|-------------------------------|
| 3 | 750 | 1 | 0.2 |
| 1 | 820 | 2 | 0.9 |
| 2 | 900 | 3 | 0.7 |

If we allocate fire to each target j as if this target is the only one we have:

| <u>Target (j)</u> | <u>Max Allocation = $P_{ij}(t) \times S_i(t)$</u> |
|-------------------|--|
| 3 | $P_{i3}(t) \times S_i(t) = .2 \times 100 = 20$ |
| 1 | $P_{i1}(t) \times S_i(t) = .9 \times 100 = 90$ |
| 2 | $P_{i2}(t) \times S_i(t) = .7 \times 100 = \underline{70}$ |

Total: 180

For example, since $P_{i3}(t) = 0.2$ means that 20% of unit i have detected unit j at time t , then not more than 20% of unit i can fire on unit j . Thus, at the maximum not more than $P_{i3}(t) \times S_i(t) = 0.2 \times 100 = 20$ firers out of 100 survivors of unit i can be allocated to fire at unit j . We can obviously see that we need 180 survivors in unit i if we want to allocate fire to each target as if this target is the only one. Since $180 > S_i(t) = 100$ we can't do that. Let us define the following events:

D_j = Target j has been detected by unit i ,
 $j = 1,2,3$

\bar{D}_j = Target j has not been detected by unit i ,
 $j = 1,2,3$

If the fire policy is to allocate 100% of the firepower of unit i to the most prior target then we have:

| <u>Situation</u> | <u>Probability</u> | <u>Engaged Target</u> |
|---|-------------------------------------|-----------------------|
| $\bar{D}_1 \cap \bar{D}_2 \cap \bar{D}_3$ | $0.1 \times 0.3 \times 0.8 = 0.024$ | - |
| $D_1 \cap \bar{D}_2 \cap \bar{D}_3$ | $0.9 \times 0.3 \times 0.8 = 0.216$ | 1 |
| $\bar{D}_1 \cap D_2 \cap \bar{D}_3$ | $0.1 \times 0.3 \times 0.8 = 0.056$ | 2 |
| $\bar{D}_1 \cap \bar{D}_2 \cap D_3$ | $0.1 \times 0.3 \times 0.2 = 0.006$ | 3 |
| $D_1 \cap \bar{D}_2 \cap D_3$ | $0.9 \times 0.7 \times 0.8 = 0.504$ | 1 |
| $D_1 \cap \bar{D}_2 \cap D_3$ | $0.9 \times 0.3 \times 0.2 = 0.054$ | 3 |
| $\bar{D}_1 \cap D_2 \cap D_3$ | $0.1 \times 0.7 \times 0.2 = 0.014$ | 3 |
| $D_1 \cap D_2 \cap D_3$ | $0.9 \times 0.7 \times 0.2 = 0.126$ | 3 |

The fire distribution is:

$$\Pr\{\text{Target 1 will be engaged}\} = 0.216 + 0.504 = 0.72$$

$$\Pr\{\text{Target 2 will be engaged}\} = 0.056$$

$$\Pr\{\text{Target 3 will be engaged}\} = 0.20$$

Thus, if the same battle is repeated many times then in 72% of the times all the $S_i(t) = 100$ survivors of unit i are allocated to target 1, in 5.6% of the times to target 2 and in 20% of the times to target 3.

If the fire policy is as follows:

| # of targets | % of unit i allocated to each target | | |
|--------------|--------------------------------------|-----------------|-----------------|
| | 1 st | 2 nd | 3 rd |
| 1 | 100% | | |
| 2 | 80% | 20% | |
| 3 | 80% | 15% | 5% |

then we have,

| <u>Situation</u> | <u>Probability</u> | <u>Allocation</u> | | |
|---|--------------------|-------------------|--------------|--------------|
| | | <u>tgt 1</u> | <u>tgt 2</u> | <u>tgt 3</u> |
| $\bar{D}_1 \cap \bar{D}_2 \cap \bar{D}_3$ | 0.024 | - | - | - |
| $D_1 \cap \bar{D}_2 \cap \bar{D}_3$ | 0.216 | 100% | - | - |
| $\bar{D}_1 \cap D_2 \cap \bar{D}_3$ | 0.056 | - | 100% | - |
| $\bar{D}_1 \cap \bar{D}_2 \cap D_3$ | 0.006 | - | - | 100% |
| $D_1 \cap D_2 \cap \bar{D}_3$ | 0.504 | 80% | 20% | - |
| $D_1 \cap \bar{D}_2 \cap D_3$ | 0.054 | 20% | - | 80% |
| $\bar{D}_1 \cap D_2 \cap D_3$ | 0.014 | - | 20% | 80% |
| $D_1 \cap D_2 \cap D_3$ | 0.126 | 15% | 5% | 80% |

$$E[\text{percent of fire of unit } i \text{ allocated to target 1}] = 100 \times 0.216 + 80 \times 0.504 + 20 \times 0.054 + 15 \times 0.126 = \underline{64.89}$$

$$\begin{aligned}
 E[\text{percent of fire of unit } i \text{ allocated to target 2}] &= 100 \times 0.056 + 20 \times 0.504 \\
 &\quad + 20 \times 0.014 + 5 \times 0.126 \\
 &= \underline{16.59}
 \end{aligned}$$

$$\begin{aligned}
 E[\text{percent of fire of unit } i \text{ allocated to target 3}] &= 100 \times 0.006 + 80 \times 0.054 \\
 &\quad + 80 \times 0.014 + 80 \times 0.126 \\
 &= \underline{16.12}
 \end{aligned}$$

If we compare the two fire policies we have,

| | Tgt 1 | Tgt 2 | Tgt 3 | Total |
|-----------|--------|--------|--------|-------|
| Policy I | 72% | 5.6% | 20% | 97.6% |
| Policy II | 64.89% | 16.59% | 16.12% | 97.6% |

Comments:

(1) The big change of fire allocation to target 2 is explained by the fact that situation 5 (i.e., $\bar{D}_1 \cap D_2 \cap \bar{D}_3$) has high probability of occurrence (0.504) and 20 firers of unit i are allocated to target 2 in this case.

(2) In both cases only 97.6 firers of unit i are allocated since there is a positive probability of not detecting all the three targets (i.e., positive probability for $\bar{D}_1 \cap \bar{D}_2 \cap \bar{D}_3$) and in this case no fire is allocated at all.

(3) This method gets more complicated as the number of targets becomes larger.

G. ATTRITION

Since the two forces (i.e., attacker and defender) are taken to use only "aimed" fire, variable coefficient Lanchester-type equations of modern warfare [see Ref. 2] are used to assess force-on-force attrition. For each time interval $[t, t+\Delta t]$ let,

- $S_i(t)$ = number of survivors in unit i at time t
- B_i = the group of Blue units who fire against unit i
- R_j = the group of Red units who fire against unit j
- A_{ij} = the rate at which one firer of unit i kills unit j targets. (Attrition rate of unit j by one firer of unit i)
- $PROP_{ij}$ = proportion of unit i allocated to fire against unit j .

These parameters are computed for each time interval. The attrition-rate coefficient A_{ij} is computed according to

$$A_{ij} = \frac{1}{E(T_{ij})},$$

where T_{ij} is the time for one firer of unit i to kill one target of unit j under the conditions existing in this time interval. $E(T_{ij})$ is computed by the Bonder-Farrell formula (see Ref. 7):

$$E(T_{ij}) = t_a + t_1 - t_h + \frac{t_h + t_f}{P(K|H)} + \frac{t_m + t_f}{P(h|m)} \\ \times \left\{ \frac{1 - P(h|h)}{P(K|H)} + P(h|h) - p \right\} \quad (1)$$

where,

t_a = time to acquire a target,

t_1 = time to fire first round after target acquired,

t_h = time to fire a round following a hit,

t_m = time to fire a round following a miss,

t_f = projectile time of flight,

P = Probability of hit on first round,

$P(h|h)$ = Probability of a hit on a round following a hit,

$P(h|m)$ = Probability of a hit on a round following a miss,

$P(K|H)$ = Probability of destroying a target given it is hit.

This formula (1) holds for the following conditions:

- (1) Markov-dependent fire with parameters P , $P(h|h)$ and $P(h|m)$. (I.e., Hit probability of any round depends only on the result of the previous round.)
- (2) Geometric distribution for the number of hits required for a kill with parameter $P(K|H)$ (i.e., accumulated damage is not considered!).

If the firing weapon system is TOW then we assume $P(K|H) = 1.0$ and $p(h|m) = p(h|h) = p$. In this case we have

$$E(T_{ij}) = t_a + t_l + t_f + \frac{(t_m + t_f)(1-p)}{p}$$

If the firing weapon system is a tank then we assume $P(K|H) = 1.0$ (because of lack of information) and $t_f \approx 0$. In this case we have:

$$E(T_{ij}) = t_a + t_l + \frac{t_m}{p(h|m)}(1-p),$$

The attrition of each Blue unit j is described by the following differential equation:

$$\frac{dS_j(t)}{dt} = - \sum_{i \in R_j} A_{ij}(S_i(t) \times \text{PROP}_{ij})$$

and similarly the attrition of each Red unit i is described by:

$$\frac{dS_i(t)}{dt} = - \sum_{j \in B_i} A_{ji}(S_j(t) \times \text{PROP}_{ji})$$

where the attrition coefficients A_{ij} and A_{ji} are computed by Bonder-Farrell's model.

The basic differential equations of force-on-force attrition are approximated by the following Euler-Cauchy difference equations:

$$S_i(t+\Delta t) = \text{Max}\{0, S_i(t) - \sum_{j \in B_i} A_{ji}(S_j(t) \times \text{PROP}_{ji}) \Delta t\}$$

For each Blue unit i

$$S_j(t+\Delta t) = \text{Max}\{0, S_j(t) - \sum_{i \in B_j} A_{ij}(S_i(t) \times \text{PROP}_{ij}) \Delta t\}$$

For each Red unit j

COMMENTS:

- (1) While computing attrition in a given scenario we can consider all the targets as stationary since the defender is in fixed positions and since the hit probability of a TOW against moving target is almost the same as for stationary (given that the target is not too close). Thus also the Red units can be considered as stationary for attrition computation purposes.
- (2) This attrition model does not consider the problem of intervisibility "windows" for the TOW.
- (3) Hit probabilities as $P(h|h)$ and $P(h|m)$ are functions of: size of the target (full target or turret target), type of ammunition (HGAT or APFSDS), Range, angle between the firer and the target etc. Since most of this information is classified only full size targets,

APFSDS ammunition (for tanks) and the range were considered while running the program in the computer.

- (4) Artillery is not considered in this model. One should remember that artillery reduces very drastically the TOW hit probability (but not too much the tank's hit probability).

H. BATTLE-TERMINATION PROCESS

The breakpoint for each unit is 100% lost of its initial force level. The battle is terminated when either:

1. One of the two opponent forces (i.e., Red or Blue) is annihilated (i.e., its 3 platoons have reached the breakpoint).
2. The average distance between the surviving Red force and the surviving Blue force is "too close."

IV. SENSITIVITY ANALYSIS

Sensitivity study was done without considering the line-of-sight factor (i.e., it was assumed that line-of-sight exists all the time) in order to make the battle more active (i.e., fights are more frequent and more units are involved in every one of them) and thus more sensitive to most of the parameters.

A. FIRE ALLOCATION POLICY

Three fire allocation policies were tested:

| Policy | 1 | 2 targets | | 1 st | 3 targets | |
|--------|--------|-----------------|-----------------|-----------------|-----------------|-----------------|
| | Target | 1 st | 2 nd | 1 st | 2 nd | 3 rd |
| 1 | 100% | 100% | - | 100% | - | - |
| 2 | 100% | 80% | 20% | 80% | 15% | 5% |
| 3 | 100% | 50% | 50% | 33.3% | 33.3% | 33.3% |

Table 1. Fire Allocation Policies

Appendix C describes the output for three battles corresponding to the three different fire allocation policies. Table 2 summarizes the main events in each battle for comparison purposes.

| E V E N T | Policy 3 | | | | Policy 2 | | | | Policy 1 | | | |
|-----------------------|----------|-----|-------|-------|----------|-----|-------|-------|----------|-----|-------|-------|
| | UD | T | RTL | BTL | UD | T | RTL | BTL | UD | T | RTL | BTL |
| 1 | 6 | 40 | 0.131 | 0.333 | 6 | 40 | 0.131 | 0.333 | 6 | 40 | 0.128 | 0.333 |
| 2 | 1 | 140 | 0.472 | 0.444 | 1 | 150 | 0.484 | 0.503 | 1 | 150 | 0.464 | 0.517 |
| 3 | 2 | 210 | 0.710 | 0.508 | 4 | 240 | 0.623 | 0.667 | 4 | 210 | 0.557 | 0.667 |
| 4 | 4 | 300 | 0.837 | 0.667 | 3 | 410 | 0.864 | 0.712 | 3 | 390 | 0.760 | 0.714 |
| 5 | 3 | 440 | 1.00 | 0.68 | 2 | 440 | 1.00 | 0.723 | 2 | 440 | 1.00 | 0.759 |

Table 2. Fire Allocation Sensitivity

where,

EVENT occurs when a unit is destroyed

UD = The number of the destroyed unit

T = time (sec)

RTL = Red total lost (percentage)

BTL = Blue total lost (percentage)

The conclusions drawn from these results are:

- a. Policy 3 should be preferred to the Blue force since its total lost is consistently smaller when it uses this policy.
- b. Policy 1 should be preferred by the Red force for the same reasons.
- c. These conclusions are appropriate only for the given scenario and they might be different for other scenarios.

- d. The differences are relatively small but they might be larger for different scenarios (i.e., different force structure, weapon characteristics, etc.).
- e. In this sensitivity study the same fire allocation policies were tested for both sides. Future work might be done to test different policies for the two forces.

B. MOVEMENT DELAY OF A FIRING UNIT

A firing Red unit is delayed NOD time intervals before moving to the next route interval.

A sensitivity study of this parameter was done for NOD = 2, 3, 4, 5, 6, 8. Table 3 describes the results of this study. Table 4 shows the sensitivity of battle termination time to the parameter NOD. One can see that a change from NOD = 2 to NOD = 6 extends the battle time by more than 25%. No change is caused by changing NOD from 6 to 8. Table 5 shows the sensitivity of Blue total lost (fraction of initial strength) to changes in NOD. No significant change is caused to this variable by changing the value of NOD from 2 to 4. A change of 6% is caused by changing NOD from 4 to 5 and 8% by changing NOD from 4 to 6. We can also see that from NOD = 5 and further on the event's sequence is changed although the final results are not significantly changed.

| NOD = 2 | | | NOD = 3 | | | NOD = 4 | | | NOD = 5 | | | NOD = 6 | | | NOD = 8 | | |
|---------|-----|-----|---------|-----|-----|---------|-----|-----|---------|-----|-----|---------|-----|-----|---------|-----|-----|
| TD | T | LOC | TD | T | LOC | TD | T | LOC | TD | T | LOC | TD | T | LOC | TD | T | LOC |
| 6 | 40 | F | 6 | 40 | F | 6 | 40 | F | 6 | 40 | F | 6 | 40 | F | 6 | 40 | F |
| 1 | 150 | 11 | 1 | 150 | 10 | 1 | 150 | 9 | 1 | 150 | 9 | 1 | 150 | 8 | 1 | 150 | 8 |
| 4 | 220 | F | 4 | 240 | F | 4 | 250 | F | 2 | 260 | 14 | 2 | 240 | 13 | 2 | 240 | 13 |
| 3 | 380 | 33 | 3 | 410 | 33 | 3 | 440 | 33 | 4 | 330 | F | 4 | 430 | F | 4 | 430 | F |
| 2 | 410 | 33 | 2 | 440 | 33 | 2 | 460 | 32 | 3 | 480 | 32 | 3 | 550 | 32 | 3 | 550 | 32 |

RTL = 1.0 RTL = 1.0 RTL = 1.0 RTL = 1.0 RTL = 1.0 RTL = 1.0
 BTL = 0.726 BTL = 0.723 BTL = 0.724 BTL = 0.682 BTL = 0.667 BTL = 0.667

TD = TARGET DESTROYEE T = TIME LOC = LOCATION

RTL = RED TOTAL LOST (fraction of original strength)
 BTL = BLUE TOTAL LOST (fraction of original strength)

F = FIXED POSITION

TABLE 3. NOD SENSITIVITY ANALYSIS

| NOD | Battle Termination Time (sec) |
|-----|-------------------------------|
| 2 | 410 |
| 3 | 440 |
| 4 | 460 |
| 5 | 480 |
| 6 | 550 |
| 8 | 550 |

Table 4. NOD VS BATTLE TERMINATION TIME

| NOD | Blue Total Lost |
|-----|-----------------|
| 2 | 0.726 |
| 3 | 0.723 |
| 4 | 0.724 |
| 5 | 0.682 |
| 6 | 0.667 |
| 8 | 0.667 |

Table 5. NOD VS BLUE TOTAL LOST

C. DETECTION RATE REDUCTION OF A FIRING UNIT

The detection rate of a firing unit is reduced by a multiplicative factor RF ($0.0 \leq RF \leq 1.0$) in comparison to that of a non-firing unit. This is done, since it is hypothesized that the search effectiveness is not the same in both cases. The sensitivity of results to changes in this parameter (RF) was done for RF = 0.2, 0.3, 0.4, 0.5, 0.6, 0.8. It was found that the battle outcomes are not significantly sensitive to changes in the RF parameter.

D. OBSERVATION TIME PROPORTION OF A MOVING UNIT

The parameter PM is defined as the proportion of time a moving unit spends for targets search. Sensitivity study of this parameter (PM) was done for PM = 0.15, 0.25, 0.35, 0.45, 0.55.

It was found that the battle outcomes are not significantly sensitive to changes in the PM parameter.

V. FUTURE MODEL ENHANCEMENT AND UTILIZATION

A. FUTURE ENHANCEMENT AREAS

The following additions or improvements in the model are recommended:

1. Addition of artillery to both sides. Artillery has significant suppression effects on the TOWs.
2. Addition of information (target acquisition) handoff from one unit to another.
3. Addition of ability to play minefield and barriers.
4. Addition of the effects of close air support.
5. Modification to the interactive mode.

In such a mode tactical decisions (e.g., route selection) could be input by players as the battle evolves. Additionally, some more predetermined alternative routes and alternative fire allocation policies can be programmed. In this case, the players of both sides (company or platoon commanders) can decide after each time interval which tactic of fire allocation to use, which route to choose and to ask for artillery or close air support (with appropriate amount of delay).

B. UTILIZATION

The model with the additional recommended improvements might be used as a tool for tactical training (battalion, company and platoon leaders) or tactical planning (effect

of different structure of forces or units, types of weapon systems, fire allocation policies, minimum or maximum ranges of fire, etc.) at the battalion level.

APPENDIX A
PROGRAM LISTING

THE00010
THE00020
THE00030
THE00040
THE00050
THE00060
THE00070
THE00080
THE00090
THE00100
THE00110
THE00120
THE00130
THE00140
THE00150
THE00160
THE00170
THE00180
THE00190
THE00200
THE00210
THE00220
THE00230
THE00240
THE00250
THE00260
THE00270
THE00280
THE00290
THE00300
THE00310
THE00320
THE00330
THE00340
THE00350
THE00360
THE00370
THE00380
THE00390
THE00400
THE00410
THE00420
THE00430
THE00440
THE00450
THE00460
THE00470
THE00480

```

COMMON /GRPL/ IPRDIR(6), ISECWD(6), MVTDIR(6), X(6), Y(6), SPD(6)
COMMON /GRP2/ TA(2), T1(2), TH(2), TM(2), TF1(2), TF2(2), TF3(2),
1P(2,6), PHH(2,6), PHM(2,6), PKH(2,6), FL(6), NLI(3), XIC(3,100), YIC(3,100),
COMMON /GRP3/ NBU, NRU, F6(6), Q(6,6)
1DIR(3,100), AVSP
1JUSTA(6), I1(6), LOST(6,6), VISFRA, VISFRB, SIZETK,
1SIZETW, NT(6), NF(6), DLSMAX, RMINTK, RMXTK, RMINTW, RMXTW, OP, TCWFR, TNKFR,
1NLOSC(6,6), VISFP(6,6), APNA(5,6), LOA(6,6), NA(6), OFL(6), POL(6)
1PTT(3,3), RF, POA(6,6), OLDQ(6,6), ROT(6,6)
COMMON /GRP4/ LNT(6,6), PEAK(100), SX(100), SY(100), RHD(100)
COMMON /GRP5/ LNT(6,6), TWRHQ(100), TWSCL(100), BASE
COMMON /HILLS/ XC(100), YC(100), SCALE(100), CPXX(150), CPYY(150)
COMMON /HILLS/ NHILLS
COMMON /COVER/ CX(150), CY(150), NCVELS
COMMON /COUNTRY/ KH, KHW, KV, KN, KGRS, KELL, KINT
COMMON /GRID/ LST(10,10), NHL(10,10), LISTH(450), KHREP(100), KTREP
COMMON /GRID/ LSTC(10,10), VC(10,10), LISTC(400), KCREP(150)

```

CCCCC

INITIALIZATION.

```

MP=0
PAI=22.0/7.0
ZL=0.00001
CALL SETUP
A SUBROUTINE TO READ THE TERRAIN DATA FOR THE LINE-OF-SIGHT
SUBROUTINE
READ(5,100)NBU, NRU, AVSP, SIZETK, SIZETW, RMINTK, RMXTK, RMINTW,
1RMXTW
100 FORMAT(I2, I1, I2, I1, F4.1, I1, F4.2, I1, F6.1, I1, F6.1, I1, F6.1, I1,
1, F6.1)
WRITE(6,164)NBU, NRU, AVSP, SIZETK, SIZETW, RMINTK, RMXTK, RMINTW,
1RMXTW
164 FORMAT(I1, 'NBU=' I1, I1, 'NRU=' I1, I1, 'AVSP=' F4.1, I1, 'SIZETK=' I1,
1, 'RMINTW=' F6.1, I1, 'RMXTW=' F6.1, I1, 'RMXTK=' F6.1, I1,
1, 'RMINTK=' F6.1, I1, 'TOWER=' I1, F5.3, I1, F5.3, I1, F5.3, I1, I1)
READ(5,120)PM, RF, TOWFR, TNKFR, NOD
120 FORMAT(F5.3, I1, F5.3, I1, F5.3, I1, F5.3, I1, I1)
WRITE(6,165)PM, RF, TOWFR, TNKFR, NOD
165 FORMAT(I1, 'PM=' I1, 'RF=' I1, 'TOWFR=' I1, F5.3, I1, F5.3, I1,
1, 'TNKFR=' I1, F5.3, I1, 'NOD=' I1, I1)
K=NRU+1

```

CC

THE 00490
 THE 00500
 THE 00510
 THE 00520
 THE 00530
 THE 00540
 THE 00550
 THE 00560
 THE 00570
 THE 00580
 THE 00590
 THE 00600
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```

L=NRU+NB1
101 READ(5,101)(NJI(I),I=1,3)
    FORMAT(3(I3,IX))
    DN 2 I=1,3
    K20=NOI(I)
    XX=5000.0
    YY=YY-500.0
    DC 2 J=1,K20
    XIC(I,J)=XX+(J-1)*40.0
    YIC(I,J)=YY
    IDIR(I,J)=0
2 CONTINUE
    SUMRO=0.0
    DC 3 I=1,NRU
    READ(5,103)FL(I)
    FORMAT(1F6.3)
    FC(I)=FL(I)
    SUMRO=SUMRO+FO(I)
    X(I)=XIC(I,1)
    Y(I)=YIC(I,1)
    MVTDIR(I)=IDIR(I,1)
    SPD(I)=AVSP
    IUSTAT(I)=0
    IPRCIR(I)=IDIR(I,1)
    ISECWD(I)=I20
    NF(I)=0
    II(I)=1
3 CONTINUE
    SUMB0=0.0
    DC 4 I=K,L
    READ(5,104)X(I),Y(I),FL(I),IPRDIR(I),ISECWD(I)
    FORMAT(7F9.3,IX,F9.3,IX,F6.3,IX,I3,IX,I3)
    FO(I)=FL(I)
    SUMB0=SUMB0+FO(I)
    MVTDIR(I)=0
    SPD(I)=0.0
    IUSTAT(I)=0
4 CONTINUE
    DO 85 I=1,L
    WRITE(6,169)I,FL(I),X(I),Y(I),IPRDIR(I),ISECWD(I),MVTDIR(I),
    1 SPD(I),IUSTAT(I)
    169 FORMAT(IX,I=,I1,IX,FL(I)=,F6.3,IX,X(I)=,F9.3,IX,Y(I)=,
    1 F9.3,IX,IPRDIR(I)=,I3,
    1 IX,ISECWD(I)=,I3,IX,MVTDIR(I)=,I3,IX,SPD(I)=,
    1 F4.1,IX,IUSTAT(I)=,I1)
    85 CONTINUE
    DELT=10.0
  
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DO 5 I=1,2
  READ(5,105) TA(I), TL(I), TH(I), TM(I), TF1(I), TF2(I), TF3(I)
  FORMAT(7(F4.1,1X))
DO 514 J=1,6
  READ(5,515) P(I,J), PHH(I,J), PHM(I,J), PKH(I,J)
  FORMAT(4(F5.3,1X))
CONTINUE
CONTINUE
PTT(1,1)=1.0
PTT(1,2)=0.8
PTT(2,2)=0.2
PTT(1,3)=0.8
PTT(2,3)=0.15
PTT(3,3)=0.05
WRITE(6,518) PTT(1,1), PTT(1,2), PTT(1,3), PTT(2,2), PTT(2,3), PTT(3,3)
518 FORMAT(1X, PTT(1,1)=, F5.3, 1X, PTT(1,2)=, F5.3, 1X, PTT(2,2)=,
1 F5.3, 1X, PTT(1,3)=, F5.3, 1X, PTT(2,3)=, F5.3, 1X, PTT(3,3)=,
1 F5.3)
DO 31 I=1,NRU
  DO 31 J=K,L
  NLOSC(I,J)=0
  NLOSC(J,I)=C
  Q(I,J)=1.0
  Q(J,I)=1.0
  VISFR(I,J)=C.0
  VISFR(J,I)=0.0
31 CONTINUE
  IC=1

```

UPDATE LOCATION OF RED UNITS.

```

DISMAX=150.0
DO 9 I=1,NRU
  IF(IUSTAT(I).EQ.2) GOTO 9
  IF(IUSTAT(I).EQ.0) GOTO 76
  NF(I)=NF(I)+1
  IF(NF(I).LT.NOD) GOTO 9
  NF(I)=0
  II(I)=I(I)+1
  K7=II(I)
  X(I)=XIC(I,K7)
  Y(I)=YIC(I,K7)
  MVDIR(I)=IDIR(I,K7)
  IPRDIR(I)=IDIR(I,K7)

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9 CONTINUE
  K9=NRU-1
  DO 10 I=1,K9
    IF(IUSTAT(I).EQ.2) GOTO 10
    K8=I+1
    DO 11 J=K8,NRU
      IF(IUSTAT(J).EQ.2) GOTO 11
      DIST=X(I)-X(J)
      IF(ABS(DIST).LE.DISMAY) GOTO 11
      IF(DIST.GT.ZL) GOTO 50
      I3=J
      I1(I3)=I1(I3)-1
      K7=I1(I3)
      X(I3)=XIC(I3,K7)
      Y(I3)=YIC(I3,K7)
      MVDIR(I3)=IDIR(I3,K7)
      IPRDIR(I3)=IDIR(I3,K7)
      GOTO 11
    50 I3=I
      GOTO 51
  11 CONTINUE
  10 CONTINUE
  
```

LINE--OF-SIGHT CHECK BETWEEN UNITS AND TARGETS SELECTION

CCCCCCCC

```

DO 17 J=K,L
  NT(J)=0
17 CONTINUE
  DC 12 I=1,NRU
  NT(I)=0
  IF(IUSTAT(I).EQ.2) GOTO 12
  DO 16 J=K,L
    IF(IUSTAT(J).EQ.2) GOTO 16
    XX1=X(I)
    YY1=Y(I)
    133 CALL ELEV(XX1,YY1,TMACI)
    XX2=X(J)
    YY2=Y(J)
    CALL ELEV(XX2,YY2,TMACJ)
    LATOB=1
    LBTOA=1
    CALL LOS(XX1,YY1,TMACI,0.0,SIZEJK,XX2,YY2,TMACJ,0.0,SIZEJTW,
  
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```

LLATOB, LBTOA, VISFRA, VISFRB)
VISFRA=1.0
VISFRB=1.0
VISFR(I, J)=VISFRA
VISFR(J, I)=VISFRB
IF(VISFRA.GT.ZL) GOTO 18
LOST(I, J)=0
LOST(J, I)=0
NLOSC(I, J)=NLOSC(I, J)+1
NLOSC(J, I)=NLOSC(I, J)
GOTO 16
18 LOST(I, J)=1
LOST(J, I)=1
NLOSC(I, J)=0
NLOSC(J, I)=0
RANGE=SQRT((X(I)-X(J))**2+(Y(I)-Y(J))**2)
IF(RANGE.LT.RMIN) K=OR.RANGE.GT.RMXTW) GOTO 20
IF(Q(I, J).EQ.1.0) GOTO 20
IUSTAT(I)=1
IUSTAT(J)=1
NT(I)=NT(I)+1
M=NT(I)
LCT(I, M)=J
ROT(I, M)=RANGE
IF(M.EQ.1) GOTO 20
CALL SORT(I, M)
IF(RANGE.LT.RMIN) K=OR.RANGE.GT.RMXTW) GOTO 16
IF(Q(J, I).EQ.1.0) GOTO 16
IUSTAT(J)=1
NT(J)=NT(J)+1
M=NT(J)
LOT(J, M)=I
ROT(J, M)=RANGE
IF(M.EQ.1) GOTO 16
CALL SORT(J, M)
CONTINUE
16 CONTINUE
DO 25 I=1, NRU
IF(IUSTAT(I).EQ.2) GOTO 25
IF(NT(I).NE.0) GOTO 25
IUSTAT(I)=0
NF(I)=0
25 CONTINUE
DO 79 J=K, L
IF(IUSTAT(J).EQ.2) GOTO 79
IF(NT(J).EQ.0) IUSTAT(J)=0
79 CONTINUE

```

CCCCCCCC

UPDATE OF THE ACCUMULATED DETECTION PROBABILITIES.

```

IAA=1
IBB=NRU
ICC=K
IDD=L
I=I+IAA, IBB
FR=TO MFR
OP=PM
37 DO 14 I=IAA, IBB
   IF(IUSTAT(I), EQ, 2) GOTO 14
   CC 19 J=ICC, IDD
   PROP=0.0
   IF(IUSTAT(J), EQ, 2) GOTO 19
   OLDQ(I, J)=Q(I, J)
   IF(LOST(I, J), EQ, 0) GOTO 15
   IF(NT(I), GT, 0) GOTO 22
   PCTVIS=VISF(I, J, I)
   CALL LAMDA(I, J, PCTVIS, DETRAT, PSUBK)
   QV=EXP(-(FL(I, J)*DETRAT*OP#DELT*FL(J, I)))
   IF(NT(J), GT, 0) GOTO 23
   Q(I, J)=Q(I, J)*QV
   GOTO 19
23 QP=(1.0-PSUBK)*(FR*DELT*FL(I, J)*FL(J, I))
   Q(I, J)=Q(I, J)*(QV+QP-QV*QP)
   GOTO 19
22 N5=NT(I)
   DO 24 I1=1, N5
   K1=LOTT(I, I1)
   ANG1=ATAN2(Y(K1)-Y(I), X(K1)-X(I))
   ANG2=ATAN2(Y(J)-Y(I), X(J)-X(I))
   IF(ANG1*ANG2, GE, 0.0) GOTO 77
   IF(ANG2.LT, 0.0) GOTO 32
   ANG=2*PAI+ANG1-ANG2
   GOTO 35
32 ANG=2*PAI+ANG2-ANG1
35 IF(ANG, GT, PAI) ANG=2*PAI-ANG
   GOTO 33
77 ANG=ABS(ANG2-ANG1)
33 AA=15.0*PAI/180.0
   IF(ANG, GT, AA) GOTO 24
   FRCP=PRCP+PTT(I1, N5)
24 CONTINUE

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IF (PROP.EQ.0.0) GOTO 34
IF (NT(J).GT.0) GOTO 36
CALL LAMDA(I,J,PCTVIS,DETRAT,PSUBK)
DETRAT=DETRAT*RF
QV=EXP(-(FL(I)*PROP*DETRAT*DELT*FL(J)))
Q(I,J)=Q(I,J)*QV
GOTO 19
36 Q(I,J)=0.0
GOTO 19
34 IF (IAA.EQ.1) GOTO 19
Q(I,J)=1.0
GOTO 19
15 IF (NLOSC(I,J).LE.3) GOTO 19
15 Q(I,J)=1.0
15 CONTINUE
14 CONTINUE
IF (IAA.EQ.K) GOTO 38
FR=TNKFR
IAA=K
IBB=L
ICC=1
ICD=NRJ
OP=1.0
GOTO 37
  
```

CCCCCCCCCCCC

FIRE ALLOCATION.

```

38 DO 28 I=1,L
28 NA(I)=0
DO 26 J=1,L
IF (JUST AT (I).EQ.2) GOTO 26
IF (NT(I).EQ.0) GOTO 26
DO 27 J=1,3
APPA(I,J)=0.0
27 CONTINUE
IF (NT(I).EQ.1) GOTO 78
IF (NT(I).EQ.2) GOTO 29
NQT=3
MM1=LOT(I,1)
MM2=LOT(I,2)
  
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MM3=LOT(I,3)
PROB=(1.0-Q(I,MM1))*Q(I,MM2)*Q(I,MM3)
APOA(I,1)=APOA(I,1)+PTT(1,1)*PROB
PRCB=Q(I,MM1)*(1.0-Q(I,MM2))*Q(I,MM3)
APOA(I,2)=APOA(I,2)+PTT(1,1)*PROB
PROB=Q(I,MM1)*Q(I,MM2)*(1.0-Q(I,MM3))
APOA(I,3)=APOA(I,3)+PTT(1,1)*PROB
PROB=(1.0-Q(I,MM1))*Q(I,MM2)*Q(I,MM3)
APOA(I,1)=APOA(I,1)+PTT(1,2)*PROB
APOA(I,2)=APOA(I,2)+PTT(2,2)*PROB
PROB=(1.0-Q(I,MM1))*Q(I,MM2)*(1.0-Q(I,MM3))
APOA(I,3)=APOA(I,3)+PTT(1,2)*PROB
APOA(I,1)=APOA(I,1)+PTT(1,2)*PROB
APOA(I,2)=APOA(I,2)+PTT(2,2)*PROB
APOA(I,3)=APOA(I,3)+PTT(1,2)*PROB
APOA(I,1)=APOA(I,1)+PTT(1,3)*PROB
APOA(I,2)=APOA(I,2)+PTT(2,3)*PROB
APOA(I,3)=APOA(I,3)+PTT(3,3)*PROB
DO 44 J=1,NCT
KK=LOT(I,J)
NA(KK)=NA(KK)+1
IN=NA(KK)
LCA(KK,IN)=1
PCA(KK,IN)=APOA(I,J)
44 CONTINUE
25 NOT=2
MM1=LOT(I,1)
MM2=LOT(I,2)
PROB=(1.0-Q(I,MM1))*Q(I,MM2)*PROB
APOA(I,1)=APOA(I,1)+PTT(1,1)*PROB
APOA(I,2)=APOA(I,2)+PTT(1,1)*PROB
PROB=(1.0-Q(I,MM1))*Q(I,MM2)*PROB
APOA(I,1)=APOA(I,1)+PTT(1,2)*PROB
APOA(I,2)=APOA(I,2)+PTT(2,2)*PROB
GOTO 30
7E NOT=1
MM1=LOT(I,1)
PRCB=1.0-Q(I,MM1)
APOA(I,1)=APOA(I,1)+PTT(1,1)*PROB
GOTO 30
26 CCNTINJE

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ATTRITION.

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SUMR=0.0
SUMB=0.0
DO 40 I=1,L
  IF(IUSTAT(I).EQ.2) GOTO 40
  M6=NA(I)
  SUM=0.0
  IF(M6.EQ.0) GOTO 47
  DC 41 J=1,M6
  M7=LOA(I,J)
  IF(M7.LT.K) GOTO 42
  ITYPE=2
  GOTO 43
42 ITYPE=1
43 RANGE=SQRT((X(I)-X(M7))**2+(Y(I)-Y(M7))**2)
  CALL ETK(ITYPE,RANGE,T)
  AJI=I.0/T
  SUM=SUM+AJI*FL(M7)*POA(I,J)*DELT
  CONTINUE
44 OFL(I)=FL(I)
47 FL(I)=FL(I)-SUM
  IF(FL(I).GT.ZL) GOTO 46
  FL(I)=0.0
  IUSTAT(I)=2
  IF(I.LT.K) GOTO 60
  SUMB=SUMB+FL(I)
  GOTO 75
60 SUMR=SUMR+FL(I)
75 TPOL(I)=(F0(I)-FL(I))/F0(I)
  POL(I)=(OFL(I)-FL(I))/OFL(I)
  RTPOL=(SUMR0-SUMR)/SUMR0
  BTPOL=(SUMB0-SUMB)/SUMB0
  CCNTINJE
40 CCNTINJE

```

PRINT AND CHECK FOR BATTLE DETERMINATION.

CCCCCCCC

CCCCCCCC

CC

```

I TIME=IC*10
RAX=0.0
RAY=0.0
MONE=0
DO 57 I=1, NRU
IF (IUSTAT(I).EQ.2) GOTO 57
RAX=RAX+X(I)
RAY=RAY+Y(I)
MONE=MONE+1
CONTINUE
57 IF (MONE.EQ.0) GOTO 125
RAX=RAX/MONE
RAY=RAY/MONE
BAX=0.0
BAY=0.0
MONE=0
DO 58 I=K, L
IF (IUSTAT(I).EQ.2) GOTO 58
BAX=BAX+X(I)
BAY=BAY+Y(I)
MONE=MONE+1
CCNT=I
58 IF (MONE.EQ.0) GOTO 125
BAX=BAX/MONE
BAY=BAY/MONE
AVD=SQRT((RAX-BAX)**2+(RAY-BAY)**2)
MP=MP+1
IF (MP.LE.4) GOTO 99
WRITE(6,127)
FORMAT(11)
127 MP=1
99 WRITE(6,112) I TIME, AVD
112 FCRMAT(//IX, I TIME=, I4, IX, SEC. //IX, AVERAGE RANGE BETWEEN RED AND
1 1 BLUE=, F6.1, IX, //)
WRITE(6,113)
113 FCRMAT(IX, UNIT LOCATION FORCE LEVEL STATUS LOST-PCT TARGETS',
DO 59 I=1, L
N6=NT(I)
IF (N6.NE.0) GOTO 48
WRITE(6,264) I, I(I), FL(I), IUSTAT(I), TPOL(I)
FORMAT(2X, I1, 6X, I3, 7X, F5.3, 7X, I1, 6X, F5.3)
264 GOTO 59
48 WRITE(6,114) I, I(I), FL(I), IUSTAT(I), TPOL(I), (LOT(I, J), J=1, N6)
114 FCRMAT(2X, I1, 6X, I3, 7X, F5.3, 7X, I1, 6X, F5.3, 5X, 3(I1, IX) //)
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59 CCNTINUE
  WRITE(6,115)RTPOL
115 FORMAT(IX,'RED TOTAL PERCENTAGE OF LOST=',F5.3)
  WRITE(6,116)BTPOL
116 FORMAT(IX,'BLUE TOTAL PERCENTAGE CF LOST=',F5.3///)
  
```

CCCCCCCCCCCC

CHECK FOR BATTLE DETERMINATION.

```

  IOT=0
  DO 53 I=1,NRU
  IF(FL(I).EQ.0.0) GOTO 53
  IOT=I
  CCNTINUE
53 IF(IOT.EQ.1) GOTO 54
  WRITE(6,117)
117 FORMAT(IX,'*** RED FORCE IS ELIMINATED. END OF BATTLE.')


```

 IOT=0
 DO 55 I=1,K1L
 IF(FL(I).EQ.0.0) GOTO 55
 IOT=I
 CCNTINUE
55 IF(IOT.EQ.1) GOTO 56
 WRITE(6,118)
118 FORMAT(IX,'*** BLUE FORCE IS ELIMINATED. END OF BATTLE.')


```

56 IF(AVD.GT.500.0) GOTO 65
  WRITE(6,119)
119 FORMAT(IX,'*** DISTANCE BETWEEN FORCES IS TOO CLOSE. END OF BATTLE
  1.')


```

 GOTO 66
65 IC=IC+1
 GOTO 67
66 STOP
 DEBUG SUBCHK
 END

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SUBROUTINE LAMDA(I,J,PCTVIS,DET RAT,PK)
SURROUTINE TO COMPUTE DETECTION RATE (DETRAT) OF
BY OBSERVER I GIVEN THE VISIBLE FRACTION (PCTVIS).
COMMON /GRP1/ IPRDIR(6),ISECWD(6),MVTDIR(6),X(6),Y(6),SPC(6)
TCFACT=1.0
ZEROL=0.00001
PAI=22.0/7.0
D=(ISECWD(I)*PAI/180.0)/2.0
BBB=(1.0/(2.0*(SIN(D)-D*COS(D))))
IF(ABS(BBB).LT.ZEROL) BBB=0.0
A/A=(-BBB)*COS(D)
IF(ABS(AAA).LT.ZEROL) AAA=0.0
OTANG=ATAN2((Y(J)-Y(I)),(X(J)-X(I)))
PC=IPRDIR(I)*PAI/180.0
IF((PD*OTANG).GE.0.0) GOTO 1
IF(PD.LT.0.0) GOTO 9
ANGLE=2*PAI+OTANG-PD
GOTO 10
9 ANGLE=2*PAI+PD-OTANG
10 IF(ANGLE.GT.PAI) ANGLE=2*PAI-ANGLE
1 ANGLE=ABS(PC-OTANG)
2 IF(ANGLE.GT.0) GOTO 3
ANGLFT=ANGLE+(15.0*PAI/180.0)
IF(ANGLFT.GT.D) ANGLFT=D
ANGRT=ANGLE-(15.0*PAI/180.0)
PK=BBB*(SIN(ANGLFT)-SIN(ANGRT))+AAA*(ANGLFT-ANGRT)
IF(PK.LT.0.0) GOTO 3
IF(PK.GT.1.0) GOTO 5
GOTO 8
3 PK=0.0
DETRAT=0.0
GOTO 6
5 PK=1.0
8 RANGE= SORT((X(J)-X(I))**2+(Y(J)-Y(I))**2)
RR=0.001*RANGE/PCTVIS
TOANG=ATAN2((Y(I)-Y(J)),(X(I)-X(J)))
AD=MVTDIR(J)*PAI/180.0
HORVEL=ABS(SPD(J)*SIN(TOANG-AD))
DENOM=1.453+TCFACT*(0.5978+2.188*(RR**2))-0.5038*HORVEL
IF(DENOM.LE.ZEROL) DENOM=ZEROL
DETRAT=0.003+1.088/DENOM
DETRAT=DETRAT*PK

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6 RETURN
  DEBUG SUBCHK
  END

SUBROUTINE ETK(I, RANGE, T)
  SUROUTINE TO COMPUTE EXPECTED TIME TO KILL A TARGET.
  COMMON /GRP2/ TA(2), TH(2), TM(2), TF1(2), TF2(2), TF3(2),
  JP(2,6), PHH(2,6), PHM(2,6), PKH(2,6), TF(2)
  IF(I.EQ.2) GOTO 5
  TF(I)=TF1(I)
  GOTO 6
5 IF(RANGE.GT.1000.0) GOTO 7
  TF(I)=TF1(I)-(TF1(I)*(1000.0-RANGE)/1000.0)
  GOTO 6
7 IF(RANGE.GT.2000.0) GOTO 8
  TF(I)=TF2(I)-((TF2(I)-TF1(I))*(2000.0-RANGE)/1000.0)
  GOTO 6
8 TF(I)=TF3(I)-((TF3(I)-TF2(I))*(3000.0-RANGE)/1000.0)
  GOTO 6
9 J=(RANGE+250.0)/500.0
  IF(J.GT.6) J=6
  T=TA(I)+T1(I)-TH(I)+(TH(I)+TF(I))/PKH(I,J)+(TM(I)+TF(I))/
  PHM(I,J)+((1.0-PHH(I,J))/PKH(I,J)+PHH(I,J))-P(I,J)
  RETURN
  DEBUG SUBCHK
  END

SUBROUTINE SORT(I,M)
  COMMON /GRP 5/ LOT(6,6), ROT(6,6)
  DO 19 J=1,M
  IF(ROT(I,J).GE.ROT(I,J)) GOTO 19
  NN=LOT(I,J)
  RCT(I,J)=ROT(I,M)
  LOT(I,J)=LOT(I,M)
  RCT(I,M)=R
  LOT(I,M)=NN
  CONTINUE
  RETURN
  DEBUG SUBCHK
  END

SUBROUTINE SETUP
  COMMON /HILLS/ XC(100), YC(100), PEAK(100), SX(100), SY(100), RHO(100)
  COMMON /HILLS/ SCALE(100), TWORHO(100), TWO SCL(100), BASE
  COMMON /HILLS/ NHILLS

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COMMON /COVER/ CXC(150), CYC(150), CPEAK(150), CPXX(150), CPYY(150)
 COMMON /COVER/ CPXY(150), NCVELS
 COMMON /COUNTR/KH,KHW,KV,KN,KGRS,KELL,KINT
 COMMON /GRID/ LST(10,10), NHL(10,10), LISTH(450), KHRP(100), KTREP
 COMMON /GRID/ LSTC(10,10), NC(10,10), LISTC(400), KCREP(150)
 READ(1,7) NFILLS
 READ(1,47) BASE
 FORMAT(F10.4)
 FORMAT(5F8.3,F6.4)
 DO 50 I=1,NFILLS
 READ(1,17) XC(I),YC(I),PEAK(I),SX(I),SY(I),PHO(I)
 CONTINUE
 READ(1,37) LST
 READ(1,37) NHL
 READ(1,7) NHTOT
 READ(1,37) (LISTH(I), I=1,NHTOT)
 FORMAT(16I5)
 READ(1,7) NCVELS
 IF (NCVELS.EC.O) GO TO 65
 DO 60 I=1,NCVELS
 READ(1,27) CXC(I),CYC(I),CPEAK(I),CPXX(I),CPYY(I),CPXY(I)
 FORMAT(3F10.4,3E13.7)
 KCREP(I)=-2147483600
 CONTINUE
 READ(1,37) LSTC
 READ(1,37) NC
 READ(1,7) NCTOT
 READ(1,37) (LSTC(I), I=1,NCTOT)
 DO 100 I=1,NHILLS
 SX(I)=SX(I)*1.625
 SY(I)=SY(I)*1.625
 XC(I)=(XC(I)-500.)*100.
 YC(I)=(YC(I)-930.)*100.
 TWRHO(I)=2.*RHO(I)
 SCALE(I)=-1./ (2.*(1.-RHO(I)**2))
 TWSCL(I)=2.*SCALE(I)
 KHRP(I)=-2147483600
 ALL VALUES NOW IN METERS ON 0 -- 10,000 GRID
 CONTINUE
 KTREP=-2147483600
 KH=0
 KHW=0
 KV=0
 KN=0
 KGRS=0
 KELL=0
 KINT=0

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RETURN SUBCHK
DEBUG SUBCHK
SUBROUTINE LOS(XA,YA, TMACA, TMICA, SIZEA, XB, YB, TMACB, TMICB, SIZEB,
-L ATOB, LBTOA, VISFRA, VISFRB)
COMMON /HILLS/ XC(100), YC(100), PEAK(100), SX(100), SY(100), RHO(100)
COMMON /HILLS/ SCALE(100), TWORHC(100), TWSCL(100), BASE
COMMON /HILLS/ NHILLS
COMMON /COVER/ CX(150), CYC(150), CPEAK(150), CPXX(150), CPYY(150)
COMMON /COUNTR/ KH, KHW, KV, KN, KGRS, KELL, KINT
COMMON /GRID/ LST(10,10), NHL(10,10), LISTH(450), KHREP(100), KTREP
COMMON /GRID/ LSTC(10,10), NCL(10,10), LISTC(400), KCREP(150)
DIMENSION IGX(20), IGY(20), IEL(100), CS1(100), CS2(100)
DATA NGRID/10, GSIZE/1000./
C SUBROUTINE TO COMPUTE FRACTION VISIBLE FOR OBSERVER TARGET PAIRS
VISFRA=1.
VISFRB=1.
XBA=XB-XA
YBA=YB-YA
IF((XBA.EQ.0.).AND.(YBA.EQ.0.)) RETURN
IF(SIZEA+TMICB.LE.0.) GO TO 510
IF(SIZEB+TMICB.LE.0.) GO TO 510
IF(TMICA.LT.0.) VISFRA=1.0+TMICA/SIZEA
IF(TMICB.LT.0.) VISFRB=1.0+TMICB/SIZEB
ZA=TMACB + TMICA + SIZEA
ZB=TMACB + TMICB + SIZEB
KTREP=KTREP+1
ZBA=ZB-ZA*XBA
YBASQ=YBA*YBA
XYBA=XBA*YBA
TWOXBA=2.*XBA
TWOYBA=2.*YBA
NGRSQ=0
IF(XBA) 110,95,100
XBA=0.1
ISGX=-1
XINC=GSIZE/XBA
GO TO 120
ISGX=1
XINC=-GSIZE/XBA
IF(YBA) 140,125,130
YBA=0.1
ISGY=-1
YINC=GSIZE/YBA
GO TO 150
C COMPUTE GRID SQUARES CROSSED BY A TO B LINE
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100
110
120
125
130

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140 ISGY=1
150 VINC=-G SIZE /YBA
    IF(IX.GT.NGRID) IX=NGRID
    IY=1+IF(IY.GT.NGRID) IY=NGRID
    XNEXT=G SIZE*(FLOAT(IX)+0.5*(ISGX-1.))
    YNEXT=G SIZE*(FLOAT(IY)+0.5*(ISGY-1.))
    XSTEP=(XB-XNEXT)/XBA
    YSTEP=(YB-YNEXT)/YBA
    NGRSQ=N GR SQ +1
    IGX(NGRSQ)=IX
    IF(NGRSQ)=IY
    IF(XSTEP.GT.1.) AND.(YSTEP.GT.1.) GO TO 200
    IF(XSTEP-YSTEP) 170,180,190
    IX=IX +ISGX
    XSTEP=XSTEP+XINC
    GO TO 160
    IX=IX+ISGX
    XSTEP=XSTEP+XINC
    IY=IY+ISGY
    YSTEP=YSTEP+YINC
    GO TO 160
200 KGRS=KGRS+NGRSQ
C GRID SQUARE LIST NOW COMPLETE IN IGX, IGY WITH NGRSQ ENTRIES
C
C NOW FIND WHICH COVER ELLIPSES TOUCH THE A TO B LINE,
C CHECK ELEVATIONS AT S1 AND S2 FOR EACH SJCH ELLIPSE
NELS=0
CFTMAX=0
IF(NCVELS.EC.0) GCTO 270
DO 260 K=1,NGRSQ
  IX=IGX(K)
  IY=IGY(K)
  N=NC(IX,IY)
  IF(N.EQ.0) GO TO 260
  LS=LSTC(IX,IY)
  LEND=LS+N-1
  DO 250 L=LS,LEND
    KELL=KELL+1
    IC=LSTC(L)
    IF(KCREP(IC).EQ.KTREP) GO TO 250
    KCREP(IC)=KTREP
    RX=XA-CXC(IC)
    RY=YA-CYC(IC)
    PXX=CPXX(IC)
    PXY=CPXY(IC)

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AA=PXX*XBAS*PYY*YBASQ+PXY*XYBA
BB=PXX*TWXBA*RX+PYY*TWYBA*RY+PXY*(RX*YBA+FY*XBA)
CC=PXX*RX*Y+PYY*RY*Y+PXY*RX*RY-1.0
ARG=BB*BB-4.0*AA*CC
IF(ARG.LE.0.) GO TO 250
SC=SQR(ARG)
S1=(BB+SQ)/(2.0*AA)
S2=(SQ-RB)/(2.0*AA)
IF(S1.GE.1.) GO TO 250
IF(S2.LE.0.) GO TO 250
IF(S1.LE.0.) GO TO 510
IF(S2.GE.1.) GO TO 510
CHECK LOS AT S1 AND S2
C NOW KINT=KINT+1
CPK=CPEAK(IC)
XS=XAS+S2*XBA
YS=YAS+S2*YBA
CALL ELLEV(XS,YS,HTS)
HTS=HTS+CPK
ZS=ZAS+S2*ZBA
IF(LA)B.EQ.0) GO TO 210
CALL KOVER(ZA,TMACR,SIZEB,ZB,S2,HTS,ZS,VISFRB)
IF(VISFRB.LE.0.) GO TO 510
IF(LB)DA.EQ.0) GO TO 220
S=1.-S2
CALL KOVER(ZB,TMACA,SIZEA,ZA,S,HTS,ZS,VISFRA)
IF(VISFRA.LE.0.) GO TO 510
XS=XAS+S1*XBA
YS=YAS+S1*YBA
CALL ELLEV(XS,YS,HTS)
HTS=HTS+CPK
ZS=ZAS+S1*ZBA
IF(LA)DB.EQ.0) GO TO 230
CALL KOVER(ZA,TMACB,SIZEB,ZB,S1,HTS,ZS,VISFRB)
IF(VISFRB.LE.0.) GO TO 510
IF(LB)DA.EQ.0) GO TO 240
S=1.-S1
CALL KOVER(ZB,TMACA,SIZEA,ZA,S,HTS,ZS,VISFRA)
IF(VISFRA.LE.0.) GO TO 510
NELS=NELS+1
TEL(NELS)=IC
CS1(NELS)=S1
CS2(NELS)=S2
IF(CPK.GT.CFTMAX) CHTMAX=CPK
CONTINUE
CONTINUE
CALL ELLIPSES CHECKED
  
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C NGW START ON THE HILLS
270 ON 600 K=1,NGRSQ
IX=IGX(K)
IY=IGY(K)
IF(NHL(IX,IY).EQ.0) GO TO 600
LS=LS+(IX,IY)
LEND=LS+NHL(IX,IY) -1
DO 500 L=LS,LEND
I=LISTH(L)
IF(KHREP(I).EQ.KTREP) GO TO 500
KHREP(I)=KTREP
C PROCESSING FOR HILL I STARTS HERE
KF=KH+1
C COMPUTE W = TOP OF THIS HILL ALONG O-T LINE
CX=XBA/SX(I)
CY=YBA/SY(I)
DX=(XA-XC(I))/SX(I)
DY=(YA-YC(I))/SY(I)
FQ=TWOCL(I)*(CX*DX+CY*DY+RHO(I))*(CX*DY+CY*DX))
GC=SCALE(I)*(CX*CX+CY*CY+TWRHO(I)*CX*CY)
IF(GO.EQ.0) GO TO 500
W=-FQ/(2.*GO)
IF(ABS(W).GT.5.) GO TO 500
FSQ=FQ*FQ
EQ=SCALE(I)*(DX*DX+DY*DY+TWRHO(I)*DX*DY)
POWER=EQ-FSQ/(4.*GO)
IF(POWER.LT.-3.) GO TO 500
HHW=PEAK(I)*EXP(POWER)
KHW=KHW+1
IF(HW.LE.BASE) GO TO 500
ZW=ZA+W*ZBA
IF(W.LT.0.)OR.(1.GT.1.) GO TC 300
IF(HHW.GE.ZW) GO TO 510
CVHTW=0.
IF(NELS.EQ.0) GO TO 300
DC 280 M=1,NELS
IF((CS1(M).GE.W).CR.(CS2(M).LE.W)) GO TO 280
IC=IEL(M)
IF(CVHTW.LT.CPEAK(IC)) CVHTW=CPEAK(IC)
CONTINUE
280 IF((HHW+CVHTW).GE.ZW) GO TO 510
300 IF((HHW+CHTMAX.LT.AMINI(ZA-SIZEA,ZE-SIZEB)) GO TO 500
C IF WE GET TO HERE THEN NEED TO FIND LCWEST SIGHT LINE OVER HILL
C NEWTON ITERATION A TO B GIVING VISFRB
KV=KV+1
V=W
HHV=HHW

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330 NCT=0
    FV=FQ*V
    TWOGV=2.*GQ*V
    FCNV=ZA+HHV*(TWOGV*V+V-1.)
    KN=KN+1
    FACTOR=(TWOGV*TWOGV+2.*(GQ+TWOGV*FQ)+FSQ)
    DFCNV=HHV*V*FACTOR
    IF(ABS(DFCNV).LT.1.E-10) GO TO 350
    V=V-FCNV/DFCNV
    IF(ABS(V).GT.5.) GO TO 400
    FV=FQ*V
    TWOGV=2.*GQ*V
    POWER=EQ+FV+GQ*V*V
    IF(POWER.LT.-3.) GO TO 400
    HHV=PEAK(I)*EXP(POWER)
    DHV=HHV*(FQ+TWOGV)
    ELV=ZA+DHV*V
    IF(ABS(HHV-ELV).LT.1.) GO TO 350
    NCT=NCT+1
    IF(NCT.LT.10) GO TO 330
    IF((V.LT.0.).OR.(V.GT.1.)) GO TO 400
    CVHTV=0
    IF(NELS.EQ.0) GO TO 390
    DO 380 M=1,NELS
    IF((CS1(M).GE.V).OR.(CS2(M).LE.V)) GO TO 380
    IC=IEL(M)
    IF(CVHTV.LT.CPEAK(IC)) CVHTV=CPEAK(IC)
    CGNT=IC
    HTV=HHV+CVHTV
    ZV=ZA+V*ZBA
    CALL KOVER(ZA,TMACB,SIZEB,ZB,V,HTV,ZV,VISFRB)
    IF(VISFRB.LE.0.) GO TO 510
    C NEWTON ITERATION B TO A GIVING VISFRA
    400 IF(LBTOA.EQ.0) GO TO 500
    KV=KV+1
    V=W
    VM1=V-1.
    HFV=HHV
    NCT=0
    FV=FQ*V
    TWOGV=2.*GQ*V
    FCNV=ZB+HHV*(FQ+TWOGV)*VM1-1.)
    KN=KN+1
    FACTOR=(TWOGV*TWOGV+2.*(GQ+TWOGV*FQ)+FSQ)
    DFCNV=HHV*VM1*FACTOR
    IF(ABS(DFCNV).LT.1.E-10) GO TO 450
    V=V-FCNV/DFCNV
    IF(ABS(V).GT.5.) GO TO 500
  
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VMI=V-1.
FV=FQ*V
TMQGV=2.*GO*V
PCWER = EQ+V+GQ*V*V
IF(PWR.LT.-3.) GO TO 500
IF(POWER(I)*EXP(POWER)
DHV=HHV*(FC+TMQGV)
ELV=ZB+DHV*VMI
IF (ABS(HHV-ELV) .LT.1.) GO TO 450
NCT=NCT+1
IF (NCT.LT.10) GO TO 430
IF (V.LT.0.)OR.(V.GT.1.) GO TO 500
CVHTV=0.
IF(NELS.EQ.0) GO TO 490
DC 480 N=1,NELS
IF((CSI(M).GE.V).CR.(CS2(M).LE.V))GO TO 480
IC=IEL(M)
IF(CVHTV.LT.CPEAK(IC)) CVHTV=CPEAK(IC)
CONTINUE
HTV=HHV+CVHTV
ZV=ZA+V*ZBA
S=-VMI
CALL KOVER(ZB,TMACA,S,IZEA,ZA,S,HTV,ZV,VISFRA)
IF (VISFRA.LE.0.) GO TO 510
CONTINUE
CONTINUE
RETURN
VISFRA=0.
VISFRB=0.
RETURN
DEBUG SUBCHK
END
SUBROUTINE KOVER(ZO,TMACT,SIZEZ,ZT,S,HTS,ZS,VISFRT)
IF(S.EQ.0.) GO TO 2000
IF(HTS.GE.ZS) GO TO 2050
HEXT=ZJ+(HTS-ZO)/S
EVIST=AMAX1(HEXT,TMACT)
IF(EVIST.GE.ZT) GO TO 2050
IF(EVIST.LE.ZT-SIZEZ) RETURN
VIS=(ZT-EVIST)/SIZEZ
IF(VIS.LT.VISFRT) VISFRT=VIS
RETURN
IF(HTS.LT.ZC) RETURN
VISFRT=0.0
RETURN
END
SUBROUTINE ELEV(X,Y,TMAC)
COMMON /HILLS/ XC(100),YC(100),PEAK(100),SX(100),SY(100),RHO(100)
  
```

450

480
490

500
600
510

2000
2050

THE09610
 THE09620
 THE09630
 THE09640
 THE09650
 THE09660
 THE09670
 THE09680
 THE09690
 THE09700
 THE09710
 THE09720
 THE09730
 THE09740
 THE09750
 THE09760
 THE09770
 THE09780
 THE09790
 THE09800
 THE09810
 THE09820
 THE09830
 THE09840
 THE09850
 THE09860
 THE09870
 THE09880
 THE09890
 THE09900
 THE09910
 THE09920
 THE09930

```

COMMON /HILLS/ SCALE(100),TWRHO(100),TWOSCL(100),BASE
COMMON /HILLS/ NHILLS
COMMON /GRID/ LST(10,10),NHL(10,10),LISTH(450),KHREP(100),KTREP
COMMON /GRID/ LSTC(10,10),NC(10,10),LISTC(400),KCREP(150)
DATA NGRID/10/,GSIZE/1000./
C FUNCTION TO COMPUTE TERRAIN ELEVATION FOR GIVEN X, Y COORDINATES.
ZMAX=BASE
IX=1+IFIX(X/GSIZE)
IF(IX.GT.NGRID) IX=NGRID
IY=1+IFIX(Y/GSIZE)
IF(IY.GT.NGRID) IY=NGRID
IF(NHL(IX,IY).EQ.0) GO TO 150
LC=LST(IX,IY)
LEND=LS+NHL(IX,IY)-1
DO 100 L=LS,LEND
I=LISTH(L)
QX=(X-XC(I))/SX(I)
QXSQ=QX*QX
IF (QXSQ .GE.9.) GO TO 100
QY=(Y-YC(I))/SY(I)
QYSQ=QY*QY
IF (QYSQ .GE. 9.) GO TO 100
QXY=TWORHO(I)*QX*QY
FACTOR=SCALE(I)*(QXSQ+QYSQ+QXY)
IF(FACTOR.LT.-3.) GO TO 100
HT=PEAK(I)*EXP(FACTOR)
IF(HT.LE.ZMAX) GO TO 100
ZMAX = HT
CONT INJE
TMAC=ZMAX
RETURN
DEBEG SUBCHK
END
100
150

```

APPENDIX B

Definition of Variables in Computer Program

| | | |
|-----------|---|---|
| IPRDIR(I) | = | Primary direction of unit i |
| ISECWD(I) | = | Width of search section of unit i |
| MVTDIR(I) | = | Movement direction of unit i |
| X(I),Y(I) | = | Coordinates of unit i |
| SPD(I) | = | Speed of unit i |
| TA(K) | = | Time to acquire a target for the K th weapon system type (K = 1, 2) |
| TI(K) | = | Time to fire first round after target acquired for the K th weapon system type (K = 1, 2) |
| TH(K) | = | Time to fire a round following a hit for the K th weapon system type (K = 1, 2) |
| TM(K) | = | Time to fire a round following a miss for the K th weapon system type (K = 1, 2) |
| TF1(K) | = | Projectile time of flight to 1000 m for the K th weapon system type (K = 1, 2) |
| TF2(K) | = | Projectile time of flight to 2000 m for the K th weapon system type (K = 1, 2) |
| TF3(K) | = | Projectile time of flight to 3000 m for the K th weapon system type (K = 1, 2) |
| P(I,J) | = | Probability of hit on first round. I = unit index. J = range index (J = 1, 2, 3, 4, 5, 6 corresponds to range = 500, 1000, 1500, 2000, 2500, 3000 meters) |
| PHH(I,J) | = | Probability of a hit on a round following a hit. For I and J see P(I,J) |
| PHM(I,J) | = | Probability of a hit on a round following a miss. For I and J see P(I,J) |

PKH(I,J) = Probability of destroying a target given it is hit
 NBU = Number of Blue units
 NRU = Number of Red units
 FL(I) = Force level of unit i
 FO(I) = Initial force level of unit i
 NOI(I) = Number of intervals in the i^{th} route
 $I = 1,2,3)$
 XIC(I,J), YIC(I,J) = Coordinates of the center of the j^{th} interval in the i^{th} route
 IDIR(I,J) = Direction of the j^{th} interval in the i^{th} route
 AVSP = Average speed of moving non-firing units
 IUSTAT(I) = Status of unit i
 = $\left\{ \begin{array}{l} 0 \text{ does not fire} \\ 1 \text{ fires} \\ 2 \text{ destroyed} \end{array} \right\}$
 II(I) = Interval index for unit i
 LOST(I,J) = $\left\{ \begin{array}{l} 0 \text{ no line-of-sight between unit i and unit j} \\ 1 \text{ line-of-sight exists between unit i and unit j} \end{array} \right.$
 VISFRA = Fraction of unit A (height fraction) as seen by unit B
 VISFRB = Fraction of unit B (height fraction) as seen by unit A
 SIZETK = Height of a tank
 SIZETW = Height of a TOW vehicle
 NT(I) = Number of targets of unit i
 NF(I) = Number of time intervals unit i is firing continuously at the same route interval
 DISMAX = The maximum horizontal distance allowed between the two Red units before delaying the faster one

NLOSC(I,J) = Number of continuous time intervals that line-of-sight does not exist between unit i and unit j
 VISFR(I,J) = The height fraction of unit i as seen by unit j
 RMINTK = Minimum firing range for a tank
 RMINTW = Minimum firing range for a TOW
 RMXTK = Maximum firing range for a tank
 RMXTW = Maximum firing range for a TOW
 TOWFR = Tow fire rate
 TNKFR = Tank fire rate
 NOD = Number of time intervals that a firing Red unit is delayed at the same route interval before moving to next route interval
 RF = Detection rate reduction factor for a firing unit (in comparison with non-firing unit)
 PM = The proportion of time a moving unit is busy with targets search
 PTT(I,J) = Proportion of the surviving firepower allocated to the i^{th} target if there are j targets available
 LOT(I,J) = The number of the j^{th} target of unit i
 ROT(I,J) = The range of the j^{th} target of unit i
 POA(I,J) = The proportion of the j^{th} attacker of unit i allocated to fire on unit i
 APOA(I,J) = The average proportion of the j^{th} attacker of unit i allocated to fire on unit i
 LOA(I,J) = The number of the j^{th} attacker of unit i
 NA(I) = Number of attackers of unit i
 OFL(I) = Force level of unit i at the previous time interval

POL(I) = Percentage of lost of unit i during the
current time interval

TPOL(I) = Total percentage of lost (since the
battle began) of unit i

RTPOL = Red total percentage of lost

BTPOL = Blue total percentage of lost

APPENDIX C
SENSITIVITY ANALYSIS RESULTS CONCERNING
FIRE ALLOCATION

FIRE ALLOCATION POLICY 1

TIME= 10 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3260.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LCST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 2 | 3.000 | 0 | 0.0 | |
| 2 | 2 | 3.000 | 0 | 0.0 | |
| 3 | 2 | 3.000 | 0 | 0.0 | |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 3.000 | 0 | 0.0 | |

RED TOTAL PERCENTAGE OF LOST=0.0
 BLUE TOTAL PERCENTAGE OF LOST=0.0

TIME= 20 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3220.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 3 | 3.000 | 1 | 0.0 | 6 |
| 2 | 3 | 3.000 | 1 | 0.0 | 6 |
| 3 | 3 | 2.382 | 1 | 0.206 | 6 |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 1.889 | 1 | 0.370 | 3 2 1 |

RED TOTAL PERCENTAGE OF LOST=0.069
 BLUE TOTAL PERCENTAGE OF LOST=0.123

TIME= 30 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3220.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 3 | 3.000 | 1 | 0.0 | 6 |
| 2 | 3 | 3.000 | 1 | 0.0 | 6 |
| 3 | 3 | 1.992 | 1 | 0.336 | 6 |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.836 | 1 | 0.721 | 3 2 |

RED TOTAL PERCENTAGE OF LOST=0.112
 BLUE TOTAL PERCENTAGE OF LOST=0.240

TIME= 40 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3659.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 3 | 3.000 | 1 | 0.0 | 6 |
| 2 | 3 | 3.000 | 1 | 0.0 | 6 |
| 3 | 3 | 1.820 | 1 | 0.393 | 6 |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | 3 2 |

RED TOTAL PERCENTAGE OF LOST=0.131
 BLUE TOTAL PERCENTAGE OF LOST=0.333

TIME= 50 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3620.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 4 | 3.000 | 0 | 0.0 | |
| 2 | 4 | 3.000 | 0 | 0.0 | |
| 3 | 4 | 1.820 | 0 | 0.393 | |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333

TIME= 60 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3580.6 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 5 | 3.000 | 0 | 0.0 | |
| 2 | 5 | 3.000 | 0 | 0.0 | |
| 3 | 5 | 1.820 | 0 | 0.393 | |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333

TIME= 70 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3541.0 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 6 | 3.000 | 0 | 0.0 | |
| 2 | 6 | 3.000 | 0 | 0.0 | |
| 3 | 6 | 1.820 | 0 | 0.393 | |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333

TIME= 80 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3501.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 7 | 3.000 | 0 | 0.0 | |
| 2 | 7 | 3.000 | 0 | 0.0 | |
| 3 | 7 | 1.820 | 0 | 0.393 | |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333

TIME= 90 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3462.0 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 8 | 2.406 | 1 | 0.198 | 4 |
| 2 | 8 | 3.000 | 0 | 0.0 | |
| 3 | 8 | 1.820 | 0 | 0.393 | |
| 4 | *** | 2.751 | 1 | 0.083 | 1 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.197
 BLUE TOTAL PERCENTAGE OF LOST=0.361

TIME= 100 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3435.6 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 8 | 1.861 | 1 | 0.380 | 4 |
| 2 | 9 | 3.000 | 0 | 0.0 | |
| 3 | 9 | 1.820 | 0 | 0.393 | |
| 4 | *** | 2.558 | 1 | 0.147 | 1 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.258
 BLUE TOTAL PERCENTAGE OF LOST=0.382

TIME= 110 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3409.3 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 8 | 1.354 | 1 | 0.549 | 4 |
| 2 | 10 | 3.000 | 0 | 0.0 | |
| 3 | 17 | 1.820 | 0 | 0.393 | |
| 4 | *** | 2.417 | 1 | 0.194 | 1 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.314
 BLUE TOTAL PERCENTAGE OF LOST=0.398

TIME= 120 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3369.8 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.874 | 1 | 0.709 | 4 |
| 2 | 11 | 3.000 | 0 | 0.0 | |
| 3 | 11 | 1.820 | 0 | 0.393 | |
| 4 | *** | 2.327 | 1 | 0.224 | 1 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.367
 BLUE TOTAL PERCENTAGE OF LOST=0.408

TIME= 130 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3343.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.412 | 1 | 0.863 | 4 |
| 2 | 12 | 3.000 | 1 | 0.0 | 4 |
| 3 | 12 | 1.820 | 0 | 0.393 | |
| 4 | *** | 1.973 | 1 | 0.342 | 1 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.419
 BLUE TOTAL PERCENTAGE OF LOST=0.447

TIME= 140 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3343.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.020 | 1 | 0.993 | 4 |
| 2 | 12 | 3.000 | 1 | 0.0 | 4 |
| 3 | 12 | 1.820 | 0 | 0.393 | |
| 4 | *** | 1.660 | 1 | 0.447 | 1 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.462
 BLUE TOTAL PERCENTAGE OF LOST=0.482

TIME= 150 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3334.3 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | 4 |
| 2 | 12 | 3.000 | 1 | 0.0 | 4 |
| 3 | 13 | 1.820 | 0 | 0.393 | |
| 4 | *** | 1.345 | 1 | 0.550 | 1 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.464
 BLUE TOTAL PERCENTAGE OF LOST=0.517

TIME= 160 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3295.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 13 | 2.732 | 1 | 0.089 | 4 |
| 3 | 14 | 1.820 | 0 | 0.393 | |
| 4 | *** | 1.066 | 1 | 0.645 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.494
 BLUE TOTAL PERCENTAGE OF LOST=0.548

TIME= 170 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3276.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 13 | 2.521 | 1 | 0.160 | 4 |
| 3 | 15 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.804 | 1 | 0.732 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.518
BLUE TOTAL PERCENTAGE OF LOST=0.577

TIME= 180 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3256.6 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 13 | 2.361 | 1 | 0.213 | 4 |
| 3 | 16 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.560 | 1 | 0.813 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.535
BLUE TOTAL PERCENTAGE OF LOST=0.604

TIME= 190 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3217.8 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 2.249 | 1 | 0.250 | 4 |
| 3 | 17 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.326 | 1 | 0.891 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.548
BLUE TOTAL PERCENTAGE OF LOST=0.630

TIME= 200 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3217.8 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 2.184 | 1 | 0.272 | 4 |
| 3 | 17 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.100 | 1 | 0.967 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.555
BLUE TOTAL PERCENTAGE OF LOST=0.656

TIME= 210 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3623.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 2.164 | 1 | 0.279 | 4 |
| 3 | 17 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.0 | 2 | 1.000 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 220 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3583.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 15 | 2.164 | 0 | 0.279 | |
| 3 | 18 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 230 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3543.2 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 16 | 2.164 | 0 | 0.279 | |
| 3 | 19 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 240 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3503.2 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 17 | 2.164 | 0 | 0.279 | |
| 3 | 20 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 250 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3463.3 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 18 | 2.164 | 0 | 0.279 | |
| 3 | 21 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 260 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3423.3 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 19 | 2.164 | 0 | 0.279 | |
| 3 | 22 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 270 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3383.3 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 20 | 2.164 | 0 | 0.279 | |
| 3 | 23 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 280 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3343.4 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 21 | 2.164 | 0 | 0.279 | |
| 3 | 24 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 290 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3303.4 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 22 | 2.164 | 0 | 0.279 | |
| 3 | 25 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 300 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3263.4 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 23 | 2.164 | 0 | 0.279 | |
| 3 | 26 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 310 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3223.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 24 | 2.164 | 0 | 0.279 | |
| 3 | 27 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 320 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3183.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 25 | 2.164 | 0 | 0.279 | |
| 3 | 28 | 1.820 | 0 | 0.393 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.557
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 330 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3143.6 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LOST-PCT | TARGETS |
|-------------------------------------|----------|-------|-------|--------|----------|---------|
| 1 | 10 | 0.0 | | 2 | 1.000 | |
| 2 | 26 | 2.164 | | 0 | 0.279 | |
| 3 | 29 | 1.820 | | 0 | 0.393 | |
| 4 | *** | 0.0 | | 2 | 1.000 | |
| 5 | *** | 3.000 | | 0 | 0.0 | |
| 6 | *** | 0.0 | | 2 | 1.000 | |
| RED TOTAL PERCENTAGE OF LOST=0.557 | | | | | | |
| BLUE TOTAL PERCENTAGE OF LOST=0.667 | | | | | | |

TIME= 340 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3103.6 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LOST-PCT | TARGETS |
|-------------------------------------|----------|-------|-------|--------|----------|---------|
| 1 | 10 | 0.0 | | 2 | 1.000 | |
| 2 | 27 | 2.164 | | 0 | 0.279 | |
| 3 | 30 | 1.820 | | 0 | 0.393 | |
| 4 | *** | 0.0 | | 2 | 1.000 | |
| 5 | *** | 3.000 | | 0 | 0.0 | |
| 6 | *** | 0.0 | | 2 | 1.000 | |
| RED TOTAL PERCENTAGE OF LOST=0.557 | | | | | | |
| BLUE TOTAL PERCENTAGE OF LOST=0.667 | | | | | | |

TIME= 350 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3063.7 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LOST-PCT | TARGETS |
|-------------------------------------|----------|-------|-------|--------|----------|---------|
| 1 | 10 | 0.0 | | 2 | 1.000 | |
| 2 | 28 | 2.164 | | 0 | 0.279 | |
| 3 | 31 | 1.820 | | 0 | 0.393 | |
| 4 | *** | 0.0 | | 2 | 1.000 | |
| 5 | *** | 3.000 | | 0 | 0.0 | |
| 6 | *** | 0.0 | | 2 | 1.000 | |
| RED TOTAL PERCENTAGE OF LOST=0.557 | | | | | | |
| BLUE TOTAL PERCENTAGE OF LOST=0.667 | | | | | | |

TIME= 360 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3023.7 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LOST-PCT | TARGETS |
|-------------------------------------|----------|-------|-------|--------|----------|---------|
| 1 | 10 | 0.0 | | 2 | 1.000 | |
| 2 | 29 | 2.164 | | 0 | 0.279 | |
| 3 | 32 | 1.225 | | 1 | 0.592 | 5 |
| 4 | *** | 0.0 | | 2 | 1.000 | |
| 5 | *** | 2.873 | | 1 | 0.042 | 3 |
| 6 | *** | 0.0 | | 2 | 1.000 | |
| RED TOTAL PERCENTAGE OF LOST=0.623 | | | | | | |
| BLUE TOTAL PERCENTAGE OF LOST=0.681 | | | | | | |

TIME= 370 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3003.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 30 | 2.164 | 0 | 0.279 | |
| 3 | 32 | 0.656 | 1 | 0.781 | 5 |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 2.805 | 1 | 0.065 | 3 |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.687
 BLUE TOTAL PERCENTAGE OF LOST=0.688

TIME= 380 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=2983.8 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 31 | 2.164 | 0 | 0.279 | |
| 3 | 32 | 0.100 | 1 | 0.967 | 5 |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 2.795 | 1 | 0.068 | 3 |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.748
 BLUE TOTAL PERCENTAGE OF LOST=0.689

TIME= 390 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=2961.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 32 | 2.164 | 1 | 0.279 | 5 |
| 3 | 33 | 0.0 | 2 | 1.000 | 5 |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 2.570 | 1 | 0.143 | 3 2 |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.760
 BLUE TOTAL PERCENTAGE OF LOST=0.714

TIME= 400 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=2961.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 32 | 1.654 | 1 | 0.449 | 5 |
| 3 | 33 | 0.0 | 2 | 1.000 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 2.395 | 1 | 0.200 | 2 |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.816
 BLUE TOTAL PERCENTAGE OF LOST=0.733

TIME= 410 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2961.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 32 | 1.178 | 1 | 0.607 | 5 |
| 3 | 33 | 0.0 | 2 | 1.000 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 2.277 | 1 | 0.241 | 2 |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.869
BLUE TOTAL PERCENTAGE OF LOST=0.747

TIME= 420 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2921.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 33 | 0.724 | 1 | 0.759 | 5 |
| 3 | 33 | 0.0 | 2 | 1.000 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 2.202 | 1 | 0.266 | 2 |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.920
BLUE TOTAL PERCENTAGE OF LOST=0.755

TIME= 430 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2921.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 33 | 0.286 | 1 | 0.905 | 5 |
| 3 | 33 | 0.0 | 2 | 1.000 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 2.172 | 1 | 0.276 | 2 |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.968
BLUE TOTAL PERCENTAGE OF LOST=0.759

TIME= 440 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2921.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 33 | 0.0 | 2 | 1.000 | 5 |
| 3 | 33 | 0.0 | 2 | 1.000 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 2.172 | 1 | 0.276 | 2 |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=1.000
BLUE TOTAL PERCENTAGE OF LOST=0.759

*** RED FORCE IS ELIMINATED. END OF BATTLE.

FIRE ALLOCATION POLICY 2

TIME= 10 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3260.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 2 | 3.000 | 0 | 0.0 | |
| 2 | 2 | 3.000 | 0 | 0.0 | |
| 3 | 2 | 3.000 | 0 | 0.0 | |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 3.000 | 0 | 0.0 | |

RED TOTAL PERCENTAGE OF LOST=0.0
 BLUE TOTAL PERCENTAGE OF LOST=0.0

TIME= 20 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3220.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 3 | 2.970 | 1 | 0.010 | 6 |
| 2 | 3 | 2.908 | 1 | 0.031 | 6 |
| 3 | 3 | 2.505 | 1 | 0.165 | 6 |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 1.887 | 1 | 0.371 | 3 2 1 |

RED TOTAL PERCENTAGE OF LOST=0.068
 BLUE TOTAL PERCENTAGE OF LOST=0.124

TIME= 30 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3220.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 3 | 2.951 | 1 | 0.016 | 6 |
| 2 | 3 | 2.851 | 1 | 0.050 | 6 |
| 3 | 3 | 2.194 | 1 | 0.269 | 6 |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.832 | 1 | 0.723 | 3 2 1 |

RED TOTAL PERCENTAGE OF LOST=0.112
 BLUE TOTAL PERCENTAGE OF LOST=0.241

TIME= 40 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3659.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 3 | 2.943 | 1 | 0.019 | 6 |
| 2 | 3 | 2.825 | 1 | 0.058 | 6 |
| 3 | 3 | 2.057 | 1 | 0.314 | 6 |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | 3 2 1 |

RED TOTAL PERCENTAGE OF LOST=0.131
 BLUE TOTAL PERCENTAGE OF LOST=0.333

TIME= 50 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3620.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 4 | 2.943 | 0 | 0.019 | |
| 2 | 4 | 2.825 | 0 | 0.058 | |
| 3 | 4 | 2.057 | 0 | 0.314 | |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333

TIME= 60 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3580.6 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 5 | 2.943 | 0 | 0.019 | |
| 2 | 5 | 2.825 | 0 | 0.058 | |
| 3 | 5 | 2.057 | 0 | 0.314 | |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333

TIME= 70 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3541.0 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 6 | 2.943 | 0 | 0.019 | |
| 2 | 6 | 2.825 | 0 | 0.058 | |
| 3 | 6 | 2.057 | 0 | 0.314 | |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333

TIME= 80 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3501.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 7 | 2.943 | 0 | 0.019 | |
| 2 | 7 | 2.825 | 0 | 0.058 | |
| 3 | 7 | 2.057 | 0 | 0.314 | |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.131
BLUE TOTAL PERCENTAGE OF LOST=0.333

TIME= 90 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3462.0 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 8 | 2.349 | 1 | 0.217 | 4 |
| 2 | 8 | 2.825 | 0 | 0.058 | |
| 3 | 8 | 2.057 | 0 | 0.314 | |
| 4 | *** | 2.757 | 1 | 0.081 | 1 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.197
BLUE TOTAL PERCENTAGE OF LOST=0.360

TIME= 100 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3435.6 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 8 | 1.803 | 1 | 0.399 | 4 |
| 2 | 9 | 2.825 | 0 | 0.058 | |
| 3 | 9 | 2.057 | 0 | 0.314 | |
| 4 | *** | 2.570 | 1 | 0.143 | 1 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.257
BLUE TOTAL PERCENTAGE OF LOST=0.381

TIME= 110 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3409.3 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 8 | 1.294 | 1 | 0.569 | 4 |
| 2 | 10 | 2.825 | 0 | 0.058 | |
| 3 | 10 | 2.057 | 0 | 0.314 | |
| 4 | *** | 2.436 | 1 | 0.188 | 1 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.314
BLUE TOTAL PERCENTAGE OF LOST=0.396

TIME= 120 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3369.8 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.810 | 1 | 0.730 | 4 |
| 2 | 11 | 2.825 | 0 | 0.058 | |
| 3 | 11 | 2.057 | 0 | 0.314 | |
| 4 | *** | 2.352 | 1 | 0.216 | 1 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.368
BLUE TOTAL PERCENTAGE OF LOST=0.405

TIME= 130 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3343.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|-------------------------------------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.436 | 1 | 0.855 | 4 |
| 2 | 12 | 2.732 | 1 | 0.089 | 4 |
| 3 | 12 | 2.057 | 0 | 0.314 | |
| 4 | *** | 2.023 | 1 | 0.326 | 1 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |
| RED TOTAL PERCENTAGE OF LOST=0.419 | | | | | |
| BLUE TOTAL PERCENTAGE OF LOST=0.442 | | | | | |

TIME= 140 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3343.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|-------------------------------------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.115 | 1 | 0.962 | 4 |
| 2 | 12 | 2.652 | 1 | 0.116 | 4 |
| 3 | 12 | 2.057 | 0 | 0.314 | |
| 4 | *** | 1.736 | 1 | 0.421 | 1 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |
| RED TOTAL PERCENTAGE OF LOST=0.464 | | | | | |
| BLUE TOTAL PERCENTAGE OF LOST=0.474 | | | | | |

TIME= 150 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3334.3 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|-------------------------------------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | 4 |
| 2 | 12 | 2.583 | 1 | 0.139 | 4 |
| 3 | 13 | 2.057 | 0 | 0.314 | |
| 4 | *** | 1.469 | 1 | 0.510 | 1 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |
| RED TOTAL PERCENTAGE OF LOST=0.484 | | | | | |
| BLUE TOTAL PERCENTAGE OF LOST=0.503 | | | | | |

TIME= 160 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3295.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|-------------------------------------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 13 | 2.291 | 1 | 0.236 | 4 |
| 3 | 14 | 2.057 | 0 | 0.314 | |
| 4 | *** | 1.231 | 1 | 0.590 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |
| RED TOTAL PERCENTAGE OF LOST=0.517 | | | | | |
| BLUE TOTAL PERCENTAGE OF LOST=0.530 | | | | | |

TIME= 170 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3276.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 13 | 2.047 | 1 | 0.318 | 4 |
| 3 | 15 | 2.057 | 0 | 0.314 | |
| 4 | *** | 1.015 | 1 | 0.660 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.544
BLUE TOTAL PERCENTAGE OF LOST=0.553

TIME= 180 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3256.6 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 13 | 1.845 | 1 | 0.385 | 4 |
| 3 | 16 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.828 | 1 | 0.724 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.566
BLUE TOTAL PERCENTAGE OF LOST=0.575

TIME= 190 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3217.8 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 1.680 | 1 | 0.440 | 4 |
| 3 | 17 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.654 | 1 | 0.782 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.585
BLUE TOTAL PERCENTAGE OF LOST=0.594

TIME= 200 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3217.8 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 1.550 | 1 | 0.483 | 4 |
| 3 | 17 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.493 | 1 | 0.836 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.599
BLUE TOTAL PERCENTAGE OF LOST=0.612

TIME= 210 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3217.8 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 1.452 | 1 | 0.516 | 4 |
| 3 | 17 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.342 | 1 | 0.886 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.610
BLUE TOTAL PERCENTAGE OF LOST=0.629

TIME= 220 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3179.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 15 | 1.383 | 1 | 0.539 | 4 |
| 3 | 18 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.195 | 1 | 0.934 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.618
BLUE TOTAL PERCENTAGE OF LOST=0.645

TIME= 230 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3179.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 15 | 1.344 | 1 | 0.552 | 4 |
| 3 | 18 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.060 | 1 | 0.980 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.622
BLUE TOTAL PERCENTAGE OF LOST=0.660

TIME= 240 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3583.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 15 | 1.332 | 1 | 0.556 | 4 |
| 3 | 18 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.0 | 2 | 1.000 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667

AD-A078 265

NAVAL POSTGRADUATE SCHOOL MONTEREY CA
OPERATIONAL LANCHESTER-TYPE MODEL OF SMALL UNIT LAND COMBAT.(U)
SEP 79 J SMOLER

F/8 15/7

UNCLASSIFIED

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2 OF 2

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A078265



END
DATE
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TIME= 250 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3543.2 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 16 | 1.332 | 0 | 0.556 | |
| 3 | 19 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 260 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3503.2 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 17 | 1.332 | 0 | 0.556 | |
| 3 | 20 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 270 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3463.3 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 18 | 1.332 | 0 | 0.556 | |
| 3 | 21 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 280 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3423.3 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 19 | 1.332 | 0 | 0.556 | |
| 3 | 22 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 290 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3383.3 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 20 | 1.332 | 0 | 0.556 | |
| 3 | 23 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 300 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3343.4 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 21 | 1.332 | 0 | 0.556 | |
| 3 | 24 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 310 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3303.4 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 22 | 1.332 | 0 | 0.556 | |
| 3 | 25 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 320 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3263.4 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 23 | 1.332 | 0 | 0.556 | |
| 3 | 26 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 330 SEC.
AVERAGE RANGE BETWEEN FED AND BLUE=3223.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 24 | 1.332 | 0 | 0.556 | |
| 3 | 27 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 340 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3183.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 25 | 1.332 | 0 | 0.556 | |
| 3 | 28 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 350 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3143.6 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 26 | 1.332 | 0 | 0.556 | |
| 3 | 29 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 360 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3103.6 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 27 | 1.332 | 0 | 0.556 | |
| 3 | 30 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.623
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 370 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3063.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 28 | 1.332 | 0 | 0.556 | |
| 3 | 31 | 2.057 | 0 | 0.314 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.623
 BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 380 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3023.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 29 | 1.332 | 0 | 0.556 | |
| 3 | 32 | 1.462 | 1 | 0.513 | 5 |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 2.848 | 1 | 0.051 | 3 |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.690
 BLUE TOTAL PERCENTAGE OF LOST=0.684

TIME= 390 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3003.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 30 | 1.332 | 0 | 0.556 | |
| 3 | 32 | 0.898 | 1 | 0.701 | 5 |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 2.755 | 1 | 0.082 | 3 |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.752
 BLUE TOTAL PERCENTAGE OF LOST=0.694

TIME= 400 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=2983.8 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 31 | 1.332 | 0 | 0.556 | |
| 3 | 32 | 0.352 | 1 | 0.883 | 5 |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 2.719 | 1 | 0.094 | 3 |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.813
 BLUE TOTAL PERCENTAGE OF LOST=0.698

TIME= 410 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2961.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 32 | 1.224 | 1 | 0.592 | 5 |
| 3 | 33 | 0.0 | 2 | 1.000 | 5 |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 2.592 | 1 | 0.136 | 3 2 |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.864
BLUE TOTAL PERCENTAGE OF LOST=0.712

TIME= 420 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2961.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 32 | 0.709 | 1 | 0.764 | 5 |
| 3 | 33 | 0.0 | 2 | 1.000 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 2.519 | 1 | 0.160 | 2 |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.921
BLUE TOTAL PERCENTAGE OF LOST=0.720

TIME= 430 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2961.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 32 | 0.209 | 1 | 0.930 | 5 |
| 3 | 33 | 0.0 | 2 | 1.000 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 2.497 | 1 | 0.168 | 2 |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.977
BLUE TOTAL PERCENTAGE OF LOST=0.723

TIME= 440 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=2961.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 10 | 0.0 | 2 | 1.000 | |
| 2 | 33 | 0.0 | 2 | 1.000 | 5 |
| 3 | 33 | 0.0 | 2 | 1.000 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 2.497 | 1 | 0.168 | 2 |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=1.000
BLUE TOTAL PERCENTAGE OF LOST=0.723

*** RED FORCE IS ELIMINATED. END OF BATTLE.

FIRE ALLOCATION POLICY 3

TIME= 10 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3260.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 2 | 3.000 | 0 | 0.0 | |
| 2 | 2 | 3.000 | 0 | 0.0 | |
| 3 | 2 | 3.000 | 0 | 0.0 | |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 3.000 | 0 | 0.0 | |

RED TOTAL PERCENTAGE OF LOST=0.0
 BLUE TOTAL PERCENTAGE OF LOST=0.0

TIME= 20 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3220.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 3 | 2.800 | 1 | 0.067 | 6 |
| 2 | 3 | 2.796 | 1 | 0.068 | 6 |
| 3 | 3 | 2.794 | 1 | 0.069 | 6 |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 1.875 | 1 | 0.374 | 3 2 1 |

RED TOTAL PERCENTAGE OF LOST=0.068
 BLUE TOTAL PERCENTAGE OF LOST=0.125

TIME= 30 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3220.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 3 | 2.675 | 1 | 0.108 | 6 |
| 2 | 3 | 2.669 | 1 | 0.110 | 6 |
| 3 | 3 | 2.665 | 1 | 0.112 | 6 |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.805 | 1 | 0.730 | 3 2 1 |

RED TOTAL PERCENTAGE OF LOST=0.110
 BLUE TOTAL PERCENTAGE OF LOST=0.243

TIME= 40 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3659.7 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 3 | 2.621 | 1 | 0.126 | 6 |
| 2 | 3 | 2.614 | 1 | 0.129 | 6 |
| 3 | 3 | 2.610 | 1 | 0.130 | 6 |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | 3 2 1 |

RED TOTAL PERCENTAGE OF LOST=0.128
 BLUE TOTAL PERCENTAGE OF LOST=0.333

TIME= 50 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3620.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 4 | 2.621 | 0 | 0.126 | |
| 2 | 4 | 2.614 | 0 | 0.129 | |
| 3 | 4 | 2.610 | 0 | 0.130 | |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.128
BLUE TOTAL PERCENTAGE OF LOST=0.333

TIME= 60 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3580.6 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 5 | 2.621 | 0 | 0.126 | |
| 2 | 5 | 2.614 | 0 | 0.129 | |
| 3 | 5 | 2.610 | 0 | 0.130 | |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.128
BLUE TOTAL PERCENTAGE OF LOST=0.333

TIME= 70 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3541.0 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 6 | 2.621 | 0 | 0.126 | |
| 2 | 6 | 2.614 | 0 | 0.129 | |
| 3 | 6 | 2.610 | 0 | 0.130 | |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.128
BLUE TOTAL PERCENTAGE OF LOST=0.333

TIME= 80 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3501.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 7 | 2.621 | 0 | 0.126 | |
| 2 | 7 | 2.614 | 0 | 0.129 | |
| 3 | 7 | 2.610 | 0 | 0.130 | |
| 4 | *** | 3.000 | 0 | 0.0 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.128
BLUE TOTAL PERCENTAGE OF LOST=0.333

TIME= 90 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3462.0 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 8 | 2.026 | 1 | 0.325 | 4 |
| 2 | 8 | 2.614 | 0 | 0.129 | |
| 3 | 8 | 2.610 | 0 | 0.130 | |
| 4 | *** | 2.790 | 1 | 0.070 | 1 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.194
 BLUE TOTAL PERCENTAGE OF LOST=0.357

TIME= 100 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3435.6 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 8 | 1.474 | 1 | 0.509 | 4 |
| 2 | 9 | 2.614 | 0 | 0.129 | |
| 3 | 9 | 2.610 | 0 | 0.130 | |
| 4 | *** | 2.637 | 1 | 0.121 | 1 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.256
 BLUE TOTAL PERCENTAGE OF LOST=0.374

TIME= 110 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3409.3 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 8 | 0.952 | 1 | 0.683 | 4 |
| 2 | 10 | 2.614 | 0 | 0.129 | |
| 3 | 10 | 2.610 | 0 | 0.130 | |
| 4 | *** | 2.535 | 1 | 0.154 | 1 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.314
 BLUE TOTAL PERCENTAGE OF LOST=0.385

TIME= 120 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3369.8 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.447 | 1 | 0.851 | 4 |
| 2 | 11 | 2.614 | 0 | 0.129 | |
| 3 | 11 | 2.610 | 0 | 0.130 | |
| 4 | *** | 2.492 | 1 | 0.169 | 1 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.370
 BLUE TOTAL PERCENTAGE OF LOST=0.390

TIME= 130 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3343.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.200 | 1 | 0.933 | 4 |
| 2 | 12 | 2.367 | 1 | 0.211 | 4 |
| 3 | 12 | 2.610 | 0 | 0.130 | |
| 4 | *** | 2.226 | 1 | 0.258 | 1 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.425
BLUE TOTAL PERCENTAGE OF LOST=0.419

TIME= 140 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3353.8 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | 4 |
| 2 | 12 | 2.147 | 1 | 0.284 | 4 |
| 3 | 12 | 2.610 | 0 | 0.130 | |
| 4 | *** | 2.003 | 1 | 0.332 | 1 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.472
BLUE TOTAL PERCENTAGE OF LOST=0.444

TIME= 150 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3334.3 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 12 | 1.750 | 1 | 0.417 | 4 |
| 3 | 13 | 2.610 | 0 | 0.130 | |
| 4 | *** | 1.822 | 1 | 0.393 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.516
BLUE TOTAL PERCENTAGE OF LOST=0.464

TIME= 160 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3295.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 13 | 1.388 | 1 | 0.537 | 4 |
| 3 | 14 | 2.610 | 0 | 0.130 | |
| 4 | *** | 1.678 | 1 | 0.441 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.556
BLUE TOTAL PERCENTAGE OF LOST=0.480

TIME= 170 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3276.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 13 | 1.055 | 1 | 0.648 | 4 |
| 3 | 15 | 2.610 | 0 | 0.130 | |
| 4 | *** | 1.569 | 1 | 0.477 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.593
 BLUE TOTAL PERCENTAGE OF LOST=0.492

TIME= 180 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3256.6 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 13 | 0.744 | 1 | 0.752 | 4 |
| 3 | 16 | 2.610 | 0 | 0.130 | |
| 4 | *** | 1.492 | 1 | 0.503 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.627
 BLUE TOTAL PERCENTAGE OF LOST=0.501

TIME= 190 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3217.8 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 0.447 | 1 | 0.851 | 4 |
| 3 | 17 | 2.610 | 0 | 0.130 | |
| 4 | *** | 1.445 | 1 | 0.518 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.660
 BLUE TOTAL PERCENTAGE OF LOST=0.506

TIME= 200 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3217.8 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 0.159 | 1 | 0.947 | 4 |
| 3 | 17 | 2.610 | 0 | 0.130 | |
| 4 | *** | 1.429 | 1 | 0.524 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.692
 BLUE TOTAL PERCENTAGE OF LOST=0.508

TIME= 210 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3231.1 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 0.0 | 2 | 1.000 | 4 |
| 3 | 17 | 2.610 | 0 | 0.130 | |
| 4 | *** | 1.429 | 1 | 0.524 | 2 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.710
BLUE TOTAL PERCENTAGE OF LOST=0.508

TIME= 220 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3193.2 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 0.0 | 2 | 1.000 | |
| 3 | 18 | 2.610 | 0 | 0.130 | |
| 4 | *** | 1.429 | 0 | 0.524 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.710
BLUE TOTAL PERCENTAGE OF LOST=0.508

TIME= 230 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3155.4 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 0.0 | 2 | 1.000 | |
| 3 | 19 | 2.327 | 1 | 0.224 | 4 |
| 4 | *** | 1.188 | 1 | 0.604 | 3 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.741
BLUE TOTAL PERCENTAGE OF LOST=0.535

TIME= 240 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3155.4 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 0.0 | 2 | 1.000 | |
| 3 | 19 | 2.091 | 1 | 0.303 | 4 |
| 4 | *** | 0.571 | 1 | 0.676 | 3 |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.768
BLUE TOTAL PERCENTAGE OF LOST=0.559

TIME= 250 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3155.4 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LCST-PCT | TARGETS |
|------|----------|-------|-------|--------|----------|---------|
| 1 | 9 | 0.0 | | 2 | 1.000 | |
| 2 | 14 | 0.0 | | 2 | 1.000 | |
| 3 | 19 | 1.895 | | 1 | 0.367 | 4 |
| 4 | *** | 0.774 | | 1 | 0.742 | 3 |
| 5 | *** | 3.000 | | 0 | 0.0 | |
| 6 | *** | 0.0 | | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.789
BLUE TOTAL PERCENTAGE OF LOST=0.581

TIME= 260 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3117.7 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------|-------|--------|----------|---------|
| 1 | 9 | 0.0 | | 2 | 1.000 | |
| 2 | 14 | 0.0 | | 2 | 1.000 | |
| 3 | 20 | 1.745 | | 1 | 0.418 | 4 |
| 4 | *** | 0.593 | | 1 | 0.802 | 3 |
| 5 | *** | 3.000 | | 0 | 0.0 | |
| 6 | *** | 0.0 | | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.806
BLUE TOTAL PERCENTAGE OF LOST=0.601

TIME= 270 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3117.7 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------|-------|--------|----------|---------|
| 1 | 9 | 0.0 | | 2 | 1.000 | |
| 2 | 14 | 0.0 | | 2 | 1.000 | |
| 3 | 20 | 1.627 | | 1 | 0.458 | 4 |
| 4 | *** | 0.425 | | 1 | 0.858 | 3 |
| 5 | *** | 3.000 | | 0 | 0.0 | |
| 6 | *** | 0.0 | | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.819
BLUE TOTAL PERCENTAGE OF LOST=0.619

TIME= 280 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3117.7 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------|-------|--------|----------|---------|
| 1 | 9 | 0.0 | | 2 | 1.000 | |
| 2 | 14 | 0.0 | | 2 | 1.000 | |
| 3 | 20 | 1.543 | | 1 | 0.486 | 4 |
| 4 | *** | 0.265 | | 1 | 0.912 | 3 |
| 5 | *** | 3.000 | | 0 | 0.0 | |
| 6 | *** | 0.0 | | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.829
BLUE TOTAL PERCENTAGE OF LOST=0.637

TIME= 290 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3080.0 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------|-------|--------|----------|---------|
| 1 | 9 | 0.0 | | 2 | 1.000 | |
| 2 | 14 | 0.0 | | 2 | 1.000 | |
| 3 | 21 | 1.490 | | 1 | 0.503 | 4 |
| 4 | *** | 0.110 | | 1 | 0.963 | 3 |
| 5 | *** | 3.000 | | 0 | 0.0 | |
| 6 | *** | 0.0 | | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.834
BLUE TOTAL PERCENTAGE OF LOST=0.654

TIME= 300 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3423.4 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------|-------|--------|----------|---------|
| 1 | 9 | 0.0 | | 2 | 1.000 | |
| 2 | 14 | 0.0 | | 2 | 1.000 | |
| 3 | 21 | 1.468 | | 1 | 0.511 | 4 |
| 4 | *** | 0.0 | | 2 | 1.000 | 3 |
| 5 | *** | 3.000 | | 0 | 0.0 | |
| 6 | *** | 0.0 | | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 310 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3423.4 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------|-------|--------|----------|---------|
| 1 | 9 | 0.0 | | 2 | 1.000 | |
| 2 | 14 | 0.0 | | 2 | 1.000 | |
| 3 | 21 | 1.468 | | 0 | 0.511 | |
| 4 | *** | 0.0 | | 2 | 1.000 | |
| 5 | *** | 3.000 | | 0 | 0.0 | |
| 6 | *** | 0.0 | | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 320 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3383.7 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------|-------|--------|----------|---------|
| 1 | 9 | 0.0 | | 2 | 1.000 | |
| 2 | 14 | 0.0 | | 2 | 1.000 | |
| 3 | 22 | 1.468 | | 0 | 0.511 | |
| 4 | *** | 0.0 | | 2 | 1.000 | |
| 5 | *** | 3.000 | | 0 | 0.0 | |
| 6 | *** | 0.0 | | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 330 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3344.0 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 0.0 | 2 | 1.000 | |
| 3 | 23 | 1.468 | 0 | 0.511 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 340 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3304.3 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 0.0 | 2 | 1.000 | |
| 3 | 24 | 1.468 | 0 | 0.511 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 350 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3264.6 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 0.0 | 2 | 1.000 | |
| 3 | 25 | 1.468 | 0 | 0.511 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 360 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3224.9 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 0.0 | 2 | 1.000 | |
| 3 | 26 | 1.468 | 0 | 0.511 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 370 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3185.2 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 0.0 | 2 | 1.000 | |
| 3 | 27 | 1.46E | 0 | 0.511 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 380 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3145.5 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 0.0 | 2 | 1.000 | |
| 3 | 28 | 1.468 | 0 | 0.511 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 390 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3105.9 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 0.0 | 2 | 1.000 | |
| 3 | 29 | 1.468 | 0 | 0.511 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 400 SEC.
AVERAGE RANGE BETWEEN RED AND BLUE=3066.2 M

| UNIT | LOCATION | FORCE LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------------|--------|----------|---------|
| 1 | 9 | 0.0 | 2 | 1.000 | |
| 2 | 14 | 0.0 | 2 | 1.000 | |
| 3 | 30 | 1.46E | 0 | 0.511 | |
| 4 | *** | 0.0 | 2 | 1.000 | |
| 5 | *** | 3.000 | 0 | 0.0 | |
| 6 | *** | 0.0 | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.837
BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 410 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=3026.5 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------|-------|--------|----------|---------|
| 1 | 9 | 0.0 | | 2 | 1.000 | |
| 2 | 14 | 0.0 | | 2 | 1.000 | |
| 3 | 31 | 1.468 | | 0 | 0.511 | |
| 4 | *** | 0.0 | | 2 | 1.000 | |
| 5 | *** | 3.000 | | 0 | 0.0 | |
| 6 | *** | 0.0 | | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.837
 BLUE TOTAL PERCENTAGE OF LOST=0.667

TIME= 420 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=2986.9 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------|-------|--------|----------|---------|
| 1 | 9 | 0.0 | | 2 | 1.000 | |
| 2 | 14 | 0.0 | | 2 | 1.000 | |
| 3 | 32 | 0.874 | | 1 | 0.709 | 5 |
| 4 | *** | 0.0 | | 2 | 1.000 | |
| 5 | *** | 2.909 | | 1 | 0.030 | 3 |
| 6 | *** | 0.0 | | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.903
 BLUE TOTAL PERCENTAGE OF LOST=0.677

TIME= 430 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=2986.9 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------|-------|--------|----------|---------|
| 1 | 9 | 0.0 | | 2 | 1.000 | |
| 2 | 14 | 0.0 | | 2 | 1.000 | |
| 3 | 32 | 0.297 | | 1 | 0.901 | 5 |
| 4 | *** | 0.0 | | 2 | 1.000 | |
| 5 | *** | 2.879 | | 1 | 0.040 | 3 |
| 6 | *** | 0.0 | | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=0.967
 BLUE TOTAL PERCENTAGE OF LOST=0.680

TIME= 440 SEC.
 AVERAGE RANGE BETWEEN RED AND BLUE=2986.9 M

| UNIT | LOCATION | FORCE | LEVEL | STATUS | LOST-PCT | TARGETS |
|------|----------|-------|-------|--------|----------|---------|
| 1 | 9 | 0.0 | | 2 | 1.000 | |
| 2 | 14 | 0.0 | | 2 | 1.000 | |
| 3 | 32 | 0.0 | | 2 | 1.000 | 5 |
| 4 | *** | 0.0 | | 2 | 1.000 | |
| 5 | *** | 2.879 | | 1 | 0.040 | 3 |
| 6 | *** | 0.0 | | 2 | 1.000 | |

RED TOTAL PERCENTAGE OF LOST=1.000
 BLUE TOTAL PERCENTAGE OF LOST=0.680

*** RED FORCE IS ELIMINATED. END OF BATTLE.

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