FORTRAN Program for Expected Damage by Surface-to-surface Weapons

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ABSTRACT

This paper presents the FORTRAN program for expected damage by surface-to-surface weapons. One of the methods can be used to determine the effectiveness of general purpose (GP) bombs and cluster weapons against single unitary targets, linear targets, area targets, and areas of unitary target elements. The effectiveness index is in terms of fractional damage (F_D) or the number of volleys (N_V).

INTRODUCTION

This report contains detailed descriptions of two non-nuclear surface-to-surface indirect-fire weapons effectiveness programs which have been developed for use with FORTRAN language. The function of these programs is to evaluate the effectiveness of high-explosive (HE) munitions and improved conventional munitions (ICMs). This program computes as output the expected fractional damage for either HE munitions or ICMs when the number of volleys is input and the output the number of volleys for either HE munitions or ICMs when the desired fractional damage is input.

The programs require as input several values, including the number of volleys or the desired fractional damage, the lethal area of the round or submunition the radius or length and width of the target area, the dimensions of the volley pattern in the range and deflection directions, the number of rounds delivered in each volley, the reliability of the round, the mean point of impact circular error probable or range and deflection errors probable, the target location error, the precision circular error probable or range and deflection errors probable, the pattern adjustment factor, the angle of fall (for HE munitions), the number of submunitions in each round (for ICMs), the reliability of the submunition (for ICMs), and the single round submunition pattern radius or length and width (For ICMs).

The FORTRAN program presented here includes all surface-to-surface weapon's expected damage.

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THEORY

In weaponeering, probability is used as the measure of what can be expected to happen in any given strike situation. We apply probability theory to answer such questions as:

What is the likelihood of hitting a given target with a particular weapon?

What level of damage can be expected from hitting a particular target with a specified weapon?

How many hits must be made on a target in order to attain a specified level of damage?

How many weapons should be released in order to hit the target at least once (twice or any other specified number of times)?

How many passes must be made on a target in order to achieve a specified number of hits?

MUTUALLY EXCLUSIVE EVENTS

Where a situation can result in "f", favorable ways, and "u", unfavorable ways, the probability "p" that a favorable result will occur is:

$$p = \frac{f}{(f+u)}$$

INDEPENDENT EVENTS

In a situation where the occurrence of one event is unaffected by the occurrence (or non-occurrence) of another event, the events are termed "Independent Events". The probability that both events will occur is calculated by multiplying their respective probabilities together.

$$P_{\text{both hitting target}} = P_{\text{"A" hitting}} \times P_{\text{"B" hitting}}$$

PROBABILITY OF AT LEAST ONE OCCURRENCE

If the probability of hitting a target with one strike is known, but you wan to calculate the probability of hitting it at least once with several (N) independent strikes, the following equation is used:

$$P_{(\text{at least one hit})} = 1 - Q^N$$

where:

Q = probability of miss

N = number of independent strikes

NOTE: Q = 1 - probability of a hit.

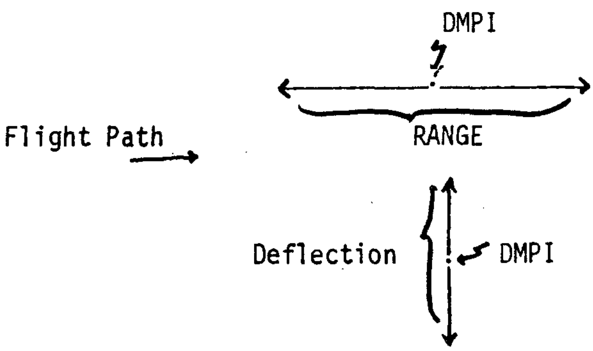
PROBABILITY OF MULTIPLE OCCURRENCE

In some circumstances, several direct hits may be required to destroy the target - a hardened missile site, for instance. Given the probability of hitting the target once (P), the probability of hitting it exactly "M" times in "N" attempts can be calculated from the following formula:

$$P_n(m) = \frac{n!}{m!(n-m)!} \times p^m \times q^{n-m}$$

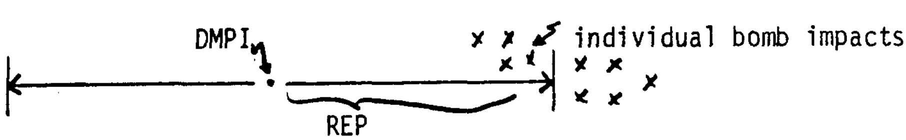
RANGE & DEFLECTION

Up to now, we have dealt with targets as only one-dimensional. But from the air, targets appear in two dimensions - length and width. Impact points are also described by two measurements - range and deflection. The range is a distance from the desired mean point of impact (DMPI) along the flight path, +, while the deflection is a distance from the desired mean point of impact (DMPI) across the flight path, left or right.



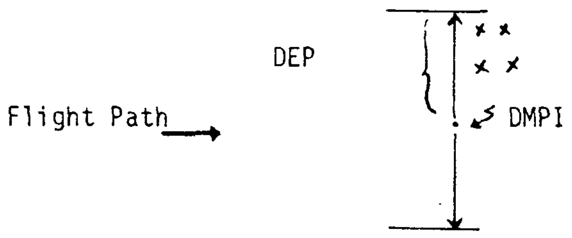
The measure of delivery accuracy in the range is called the Range Error Probable (REP). The REP is calculated as:

One-half of the distance in the range, centered on the DMPI, that contains 50% of the hits resulting from independent aiming



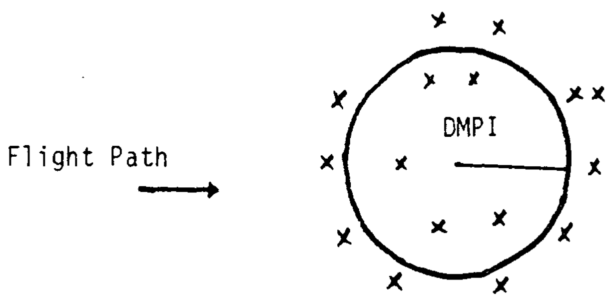
Similarly, the measure of delivery accuracy in the deflection is called the Deflection Error Probable (DEP). The DEP is calculated as:

> One-half of the distance in the deflection, centered on the DMPI, that contains 50% of the hits resulting from independent aiming



When the error probable for the range (REP) and the error probable for the deflection (DEP) have the same standard deviation, we consider that we have a circular normal distribution to work with, and we use only one measure - the circular error probable (CEP), calculated as:

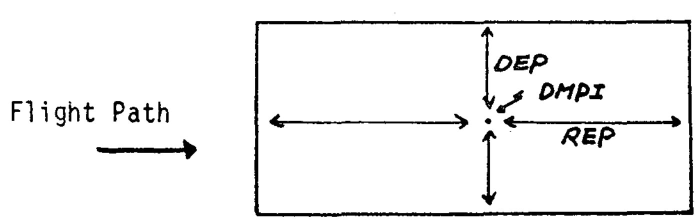
> The radius of the circle (i.e., one-half the diameter) centered on the DMPI that contains 50% of the hits resulting from independent aiming



A circle with a radius of 2 CEPs contains approximately 95% impacts and, with a radius of 3 CEPs, contains approximately 99% impacts. A CEP can also be calculated from REP and DEP as:

$$CEP = .873\ (REP + DEP),$$

if REP and DEP do not differ by more than a factor of two. Otherwise, when calculating, both REP and DEP are used and we estimate the probability of impacting within a rectangle the size of two REPs and 2 DEPs



The probability of a hit is then computed as:

Probability of a hit		Probability of impact within the range		Probability of impact within the deflection
P_H	=	P_R	x	P_D

it is usually assumed that the delivery error standard deviation in deflection (SD_{AD}) = 1.483 DEP, and the delivery error standard deviation in Range (SD_{AR}) = 1.483 REP.

FRAGMENTATION MEAN AREA OF EFFECTIVENESS (MAE_f)

This program discussed many effectiveness indexes but the only effectiveness index really applicable to surface-to-surface missiles is MAE_f. This is a casualty, or damage, index which measures the average number of target elements damaged when deployed over a larger target area. The target elements (for instance, personnel) are assumed to be evenly distributed over the target area. If there are "P" target elements per unit area, then the expected number of target elements damaged is

Expected number of target elements damaged (i.e., personnel casualties) $= P \times MAE_f$

MAE_f is the area over which a particular weapon will cause at least the specified damage to the target elements and varies according to the target vulnerability weapon used, angle of fall, burst height and velocity. Because effects of bombs and missile are elliptical rather than circular, the target area (which is considered to be rectangular) has to be adjusted to compensate for this difference, as follows:

$$LET = 1.128 \sqrt{MAE_f(a)}, \quad a = \frac{\text{minor axis of ellipse}}{\text{major axis of ellipse}}$$

$$WET = 1.128 \sqrt{\frac{MAE_f}{a}}$$

$$AET = MAE_f$$

If "a" is 1 (angle of impact 90 degrees), then the ellipse becomes a circle in the ground plane and LET and WET are equal. Hence LET = WET = 1.128 $\sqrt{MAE_f}$.

BASIC MATHEMATICAL EQUATIONS

The basic mathematical equations used in the program lists are:

$$F_D = EC_R(EC_D)\left[1 - \left(1 - \frac{Ael(N_R)(Y_R)}{Avp(OF)}\right)^{Nv(OF)}\right]$$

or

$$N_v = \frac{\ln\left(1 - \frac{F_D}{EC_R(EC_D)}\right)}{OF\left[\ln\left(1 - \frac{Ael(N_R)(Y_R)}{Avp(OF)}\right)\right]}$$

Where F_D is the expected or desired fractional damage, EC_R is the expected fractional coverage of the target by the weapon pattern in the range direction EC_D is the expected fractional coverage of the target by the weapon pattern in the deflection direction, Ael is the single round expected lethal area, N_R is the number of rounds in each volley, Y_R is the reliability of the round, Avp is the volley damage pattern area, OF is the overlap factor, and Nv is the number of volleys.

$$EC_R = \frac{2.96\ (REP_{TM})(Fr)}{L_T}$$

$$EC_D = \frac{2.96\ (DEP_{TM})(Fd)}{W_T}$$

Where REP_{TM} is the total mean point of impact probable error in the range direction, Fr is the range coverage factor, L_T is the dimension of the target area in the range direction, DEP_{TM} is the total mean point of impact probable error in the deflection direction, Fd is the deflection coverage factor, and W_T is the dimension of the target area in the deflection direction. The expected fractional coverage of the target by the weapon pattern (EC) is also computed and stored as output. EC is defined as:

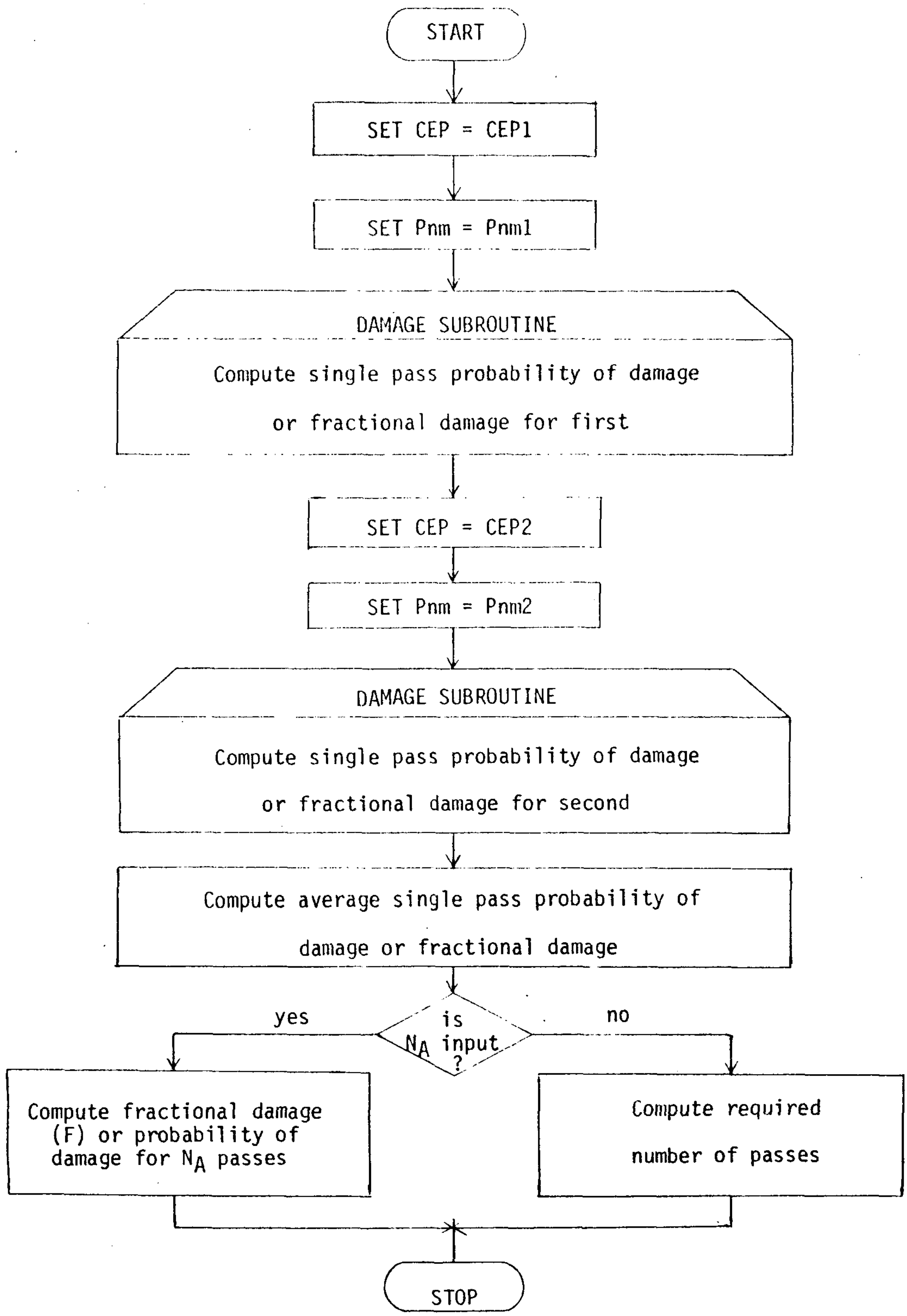
$$EC = EC_R(EC_P)$$

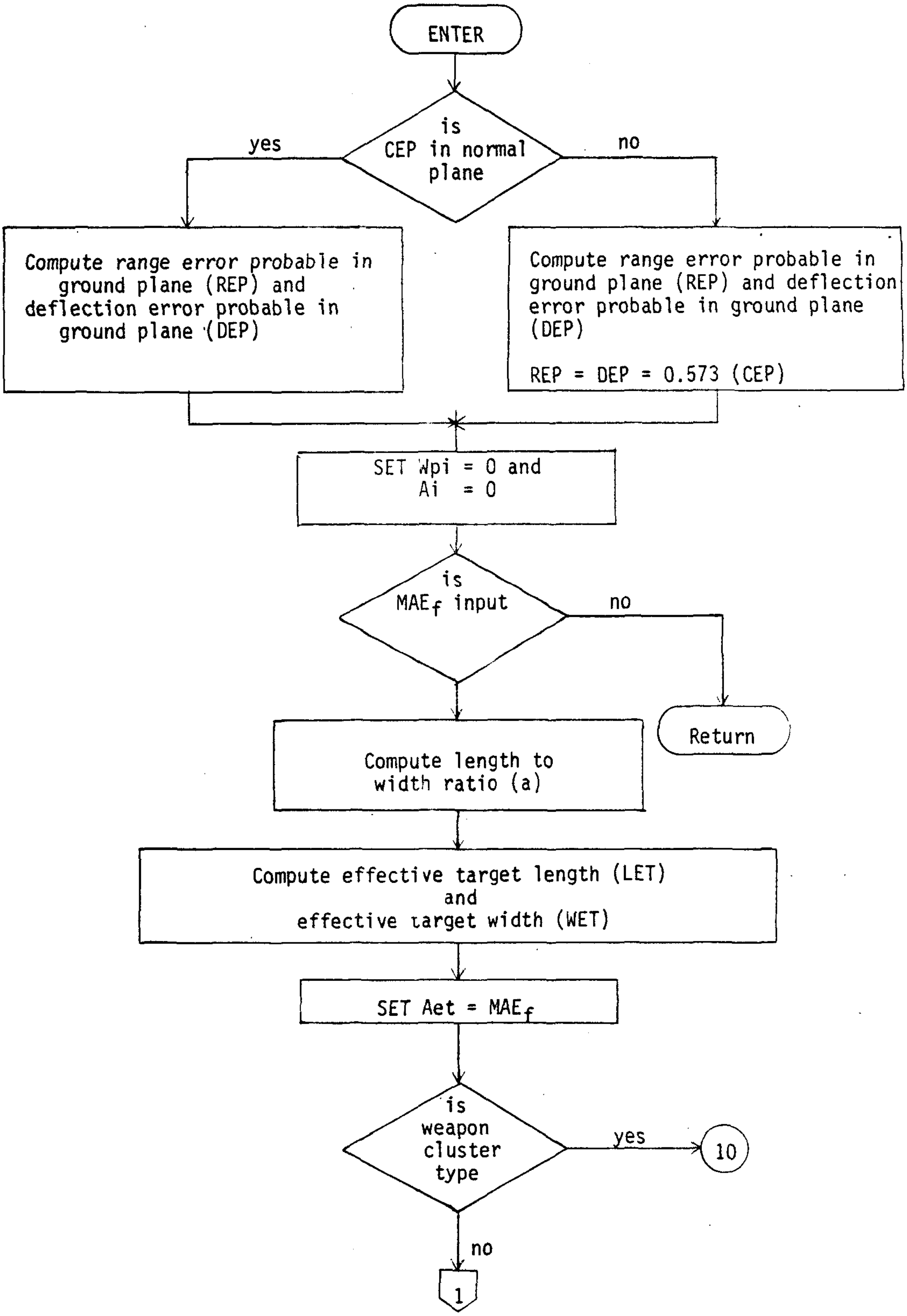
INPUT AND OUTPUT VARIABLES USED IN FORTRAN PROGRAM

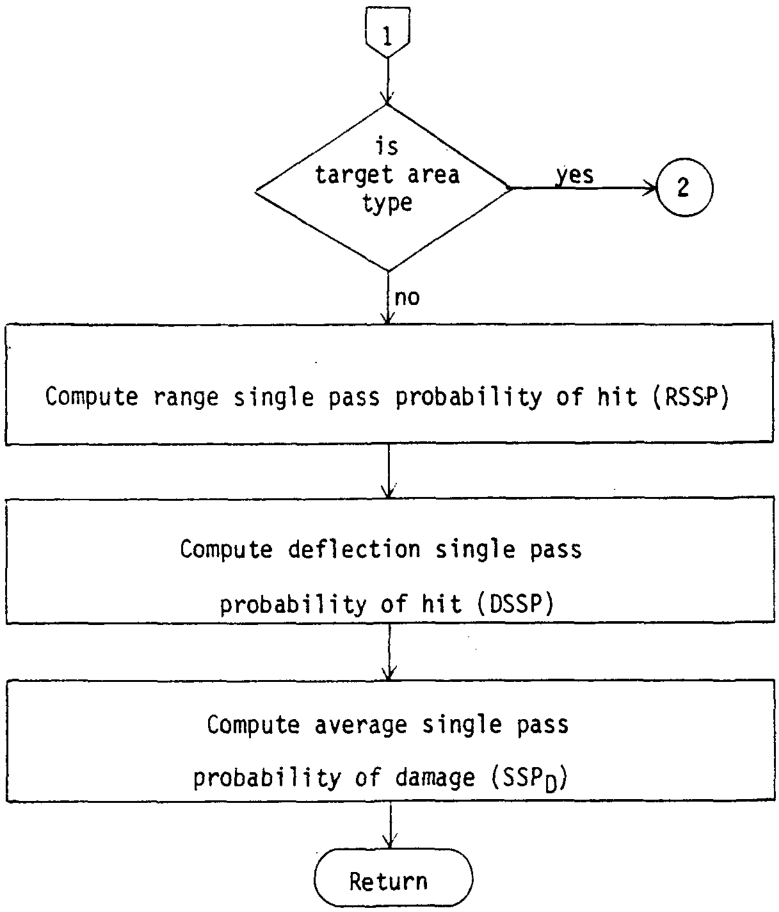
MATH MODEL SYMBOL	PRINTED OUTPUT SYMBOL	DEFINITION	UNITS
A	A	The probable error in estimating and correcting for wind	feet per second
BEI	none	The bridge effectiveness index in the ground plane	feet
CEP	CEP	The circular error probable in the normal or ground plane	miles x 10^{-3} or feet
CEP_1	CEP	The first circular error probable in the normal or ground plane	feet
Do	DO	The distance in deflection from the desired mean point of impact to the center of the target	feet
DEP	DEP	The deflection error probable in the normal or ground plane	miles x 10^{-3} or feet
EI	EI	The effectiveness index (i.e., MAE_f, MAE_b, EMD, BEI)	square feet or feet
EI TYPE	EI TYPE	A number which specifies the type of effectiveness index (1 denotes MAE_f, 2 denotes VA_N, 3 denotes MAE_b, 4 denotes EMD, 5 denotes BEI)	none
EMD	EMD	The effective miss distance in the ground plane	feet
F	F	The desired fractional damage or the fractional damage for N_A passes (for area target)	none

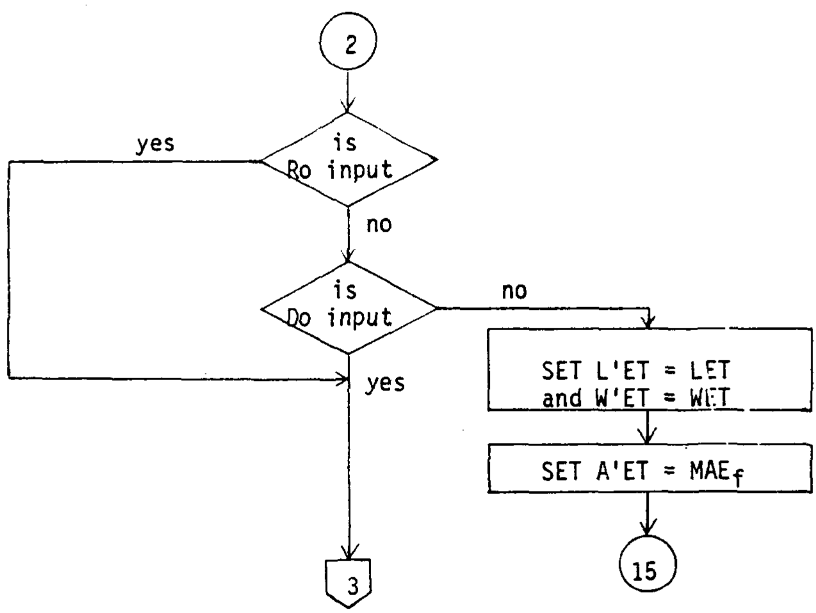
MATH MODEL SYMBOL	PRINTED OUTPUT SYMBOL	DEFINITION	UNITS
Fc	FC	The average single pass fractional damage (for area targets)	none
H_T	HT	The height of the target element	feet
I	I	The weapon impact angle	degrees
L	L	The length of the rectangular pattern	feet
L_T	LT	The dimension of the target element which is parallel to the missile flight path	feet
MAE_b	none	The blast mean area of effectiveness in the ground plane	square feet
MAE_f	none	The fragmentation mean area of effectiveness in the ground plane	square feet
N_A	NA	For the guided and unguided weapon, projectile/rocket, the number of available passes	none
N_b	NB	The number of submunitions in each dispenser	none
P	P	For the guided and unguided weapon and projectile/rocket methods, the probability of damage for N_A available passes	none
P_D	PD	For the guided and unguided weapon and projectile/rocket methods, the desired probability of damage (for unitary targets)	none
Phd	PHD	The probability of damage given a hit	none
Pnm1	PNM1	The first probability of a near miss for guided weapons	none
Pnm2	PNM2	The second probability of a near miss for guided weapons	none
R	R	The reliability of the weapon or dispenser	none
Ro	RO	The distance in range from the desired mean point of impact to the center of the target	feet

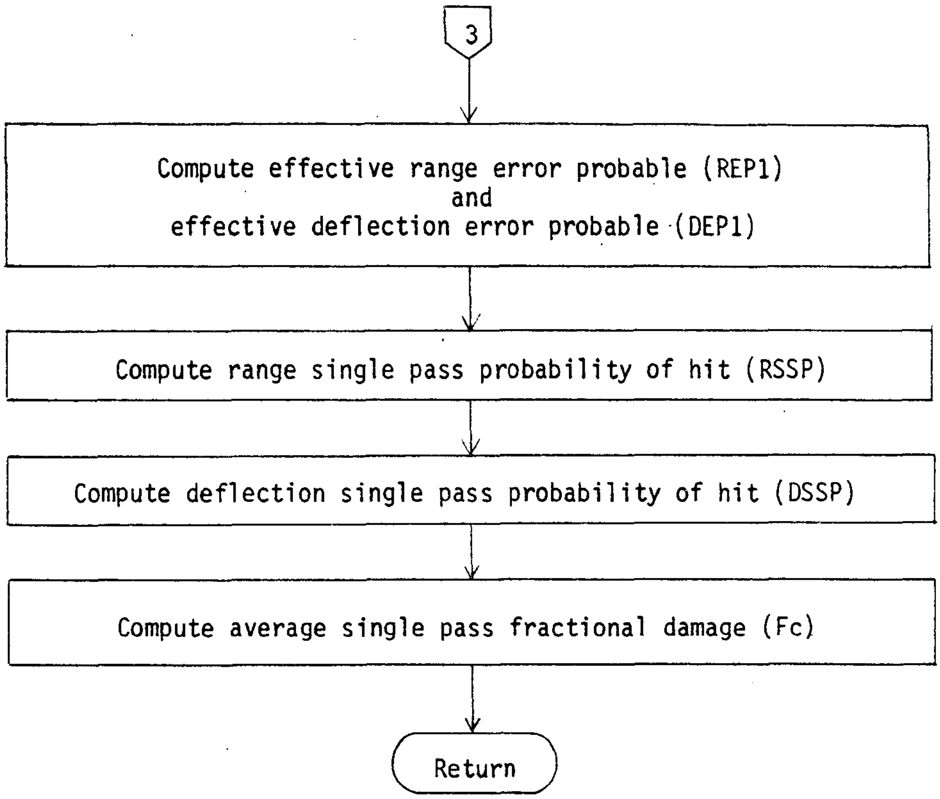
MATH MODEL SYMBOL	PRINTED OUTPUT SYMBOL	DEFINITION	UNITS
R_b	RB	The reliability of the submunition	none
R_p	RP	The radius of the circular pattern or the outer radius of the toroidal pattern	feet
R_{pi}	RPI	The inner radius of the toroidal pattern	feet
REP	REP	The range error probable in the normal or ground plane	feet
SSP_D	SSPD	The single pass probability of damage (for unitary targets)	none
W	W	The width of the rectangular pattern	feet
W_A	WA	The dimension of the target area which is perpendicular to the missile flight path	feet
W_T	WT	The dimension of the target element which is perpendicular to the missile flight path	feet

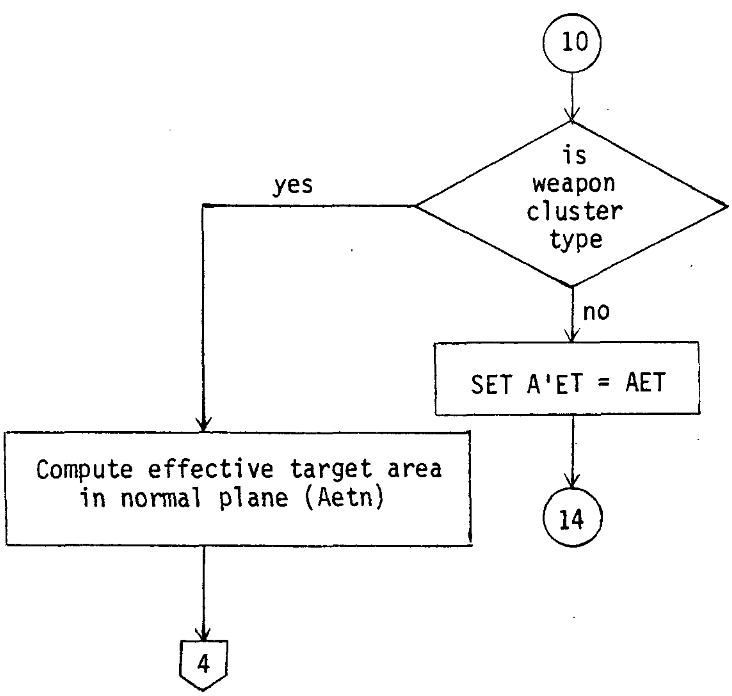

START
SET CEP = CEP1
SET Pnm = Pnm1
DAMAGE SUBROUTINE
Compute single pass probability of damage or fractional damage for first
SET CEP = CEP2
SET Pnm = Pnm2
DAMAGE SUBROUTINE
Compute single pass probability of damage or fractional damage for second
Compute average single pass probability of damage or fractional damage
yes
is N_A input ?
no
Compute fractional damage (F) or probability of damage for N_A passes
Compute required number of passes
STOP

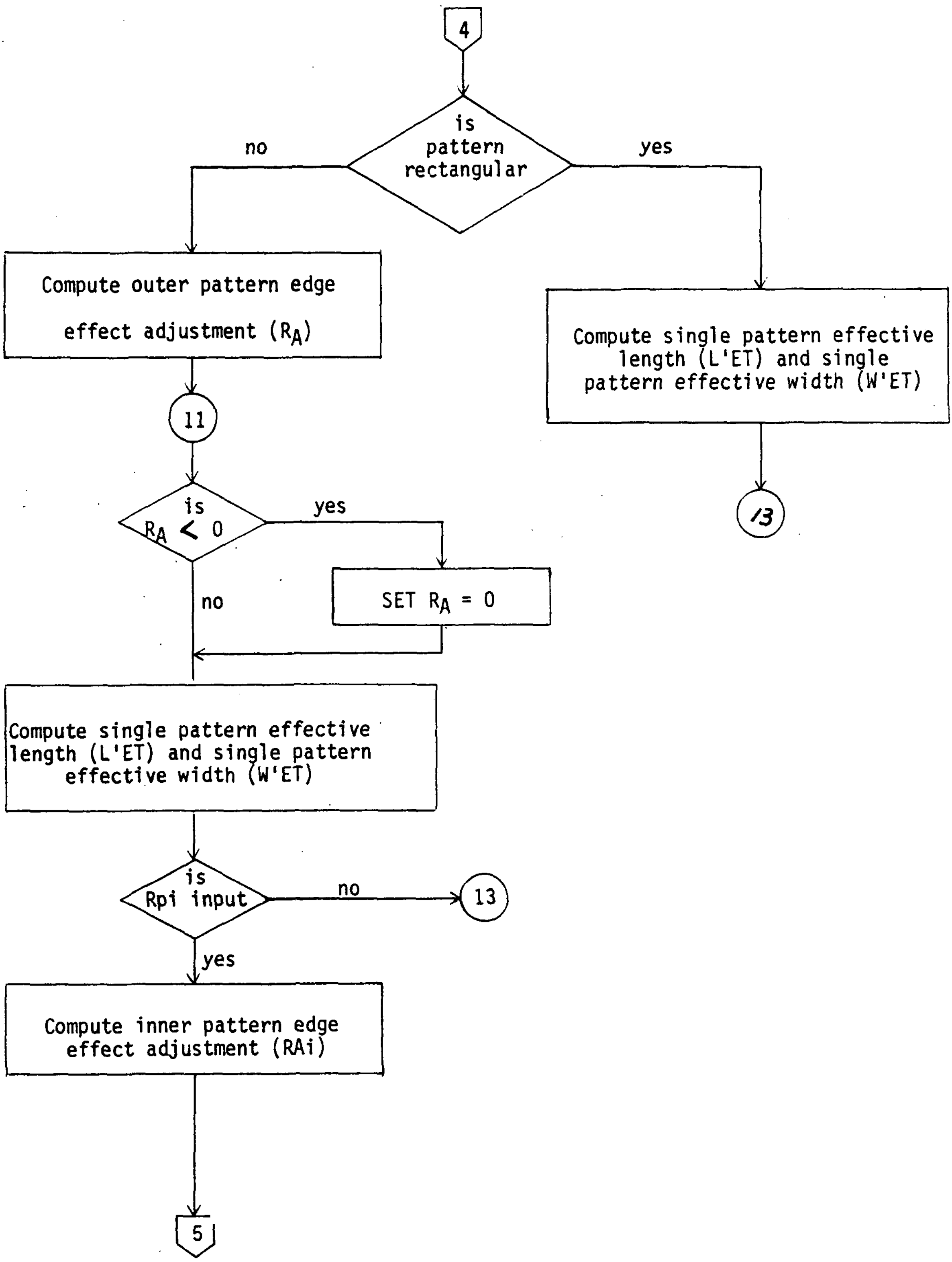

ENTER
is
CEP in normal
plane
yes
no
Compute range error probable in
ground plane (REP) and
deflection error probable in
ground plane (DEP)
Compute range error probable in
ground plane (REP) and deflection
error probable in ground plane
(DEP)
REP = DEP = 0.573 (CEP)
SET Wpi = 0 and
Ai = 0
is
MAE_f input
no
Return
Compute length to
width ratio (a)
Compute effective target length (LET)
and
effective target width (WET)
SET Aet = MAE_f
is
weapon
cluster
type
yes
10
no
1

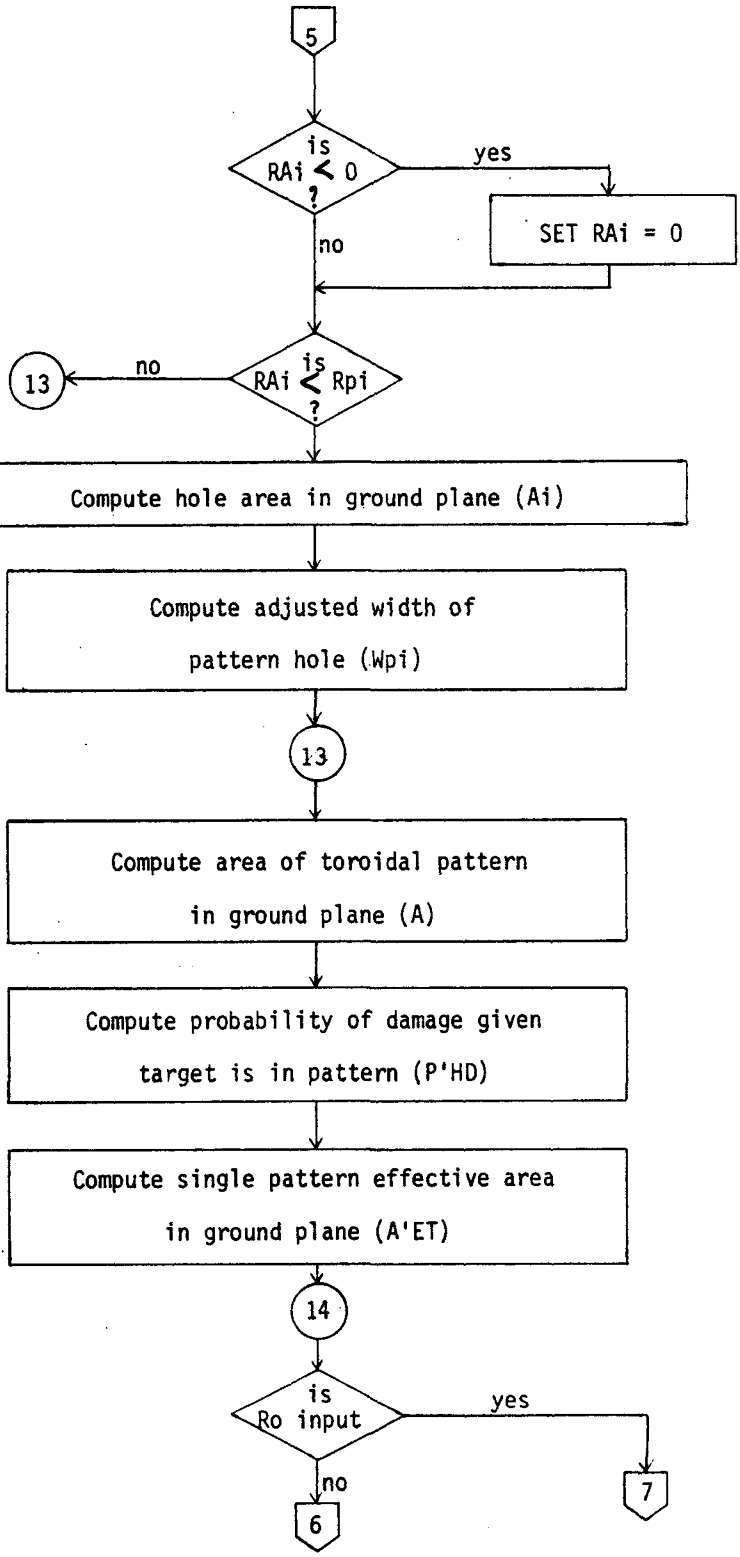

1
is
target area
type
yes
2
no
Compute range single pass probability of hit (RSSP)
Compute deflection single pass
probability of hit (DSSP)
Compute average single pass
probability of damage (SSP_D)
Return

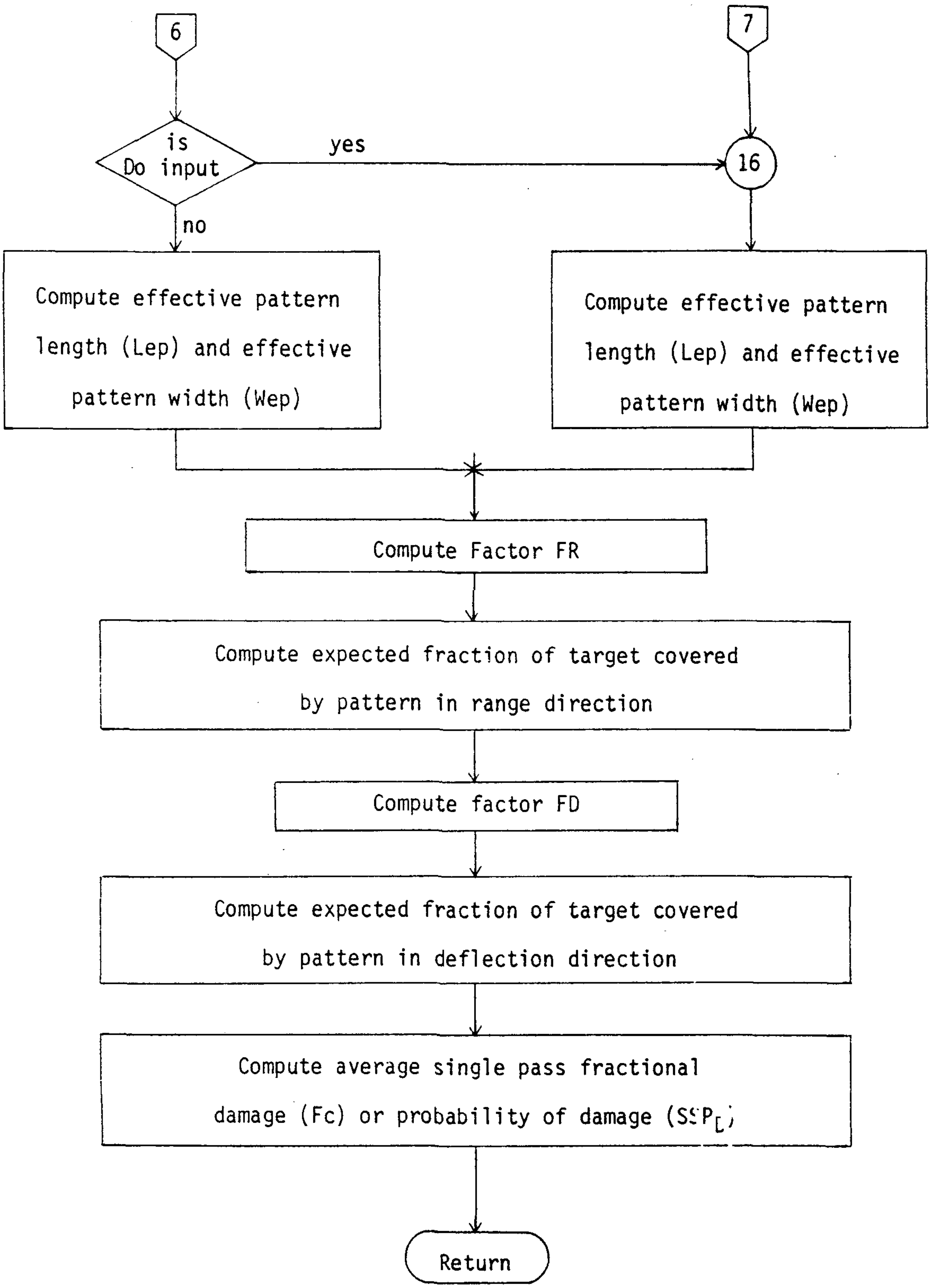

2
yes
is
Ro input
no
is
Do input
no
yes
SET L'ET = LET
and W'ET = WET
SET A'ET = MAE_f
3
15


3
Compute effective range error probable (REP1)
and
effective deflection error probable (DEP1)
Compute range single pass probability of hit (RSSP)
Compute deflection single pass probability of hit (DSSP)
Compute average single pass fractional damage (Fc)
Return

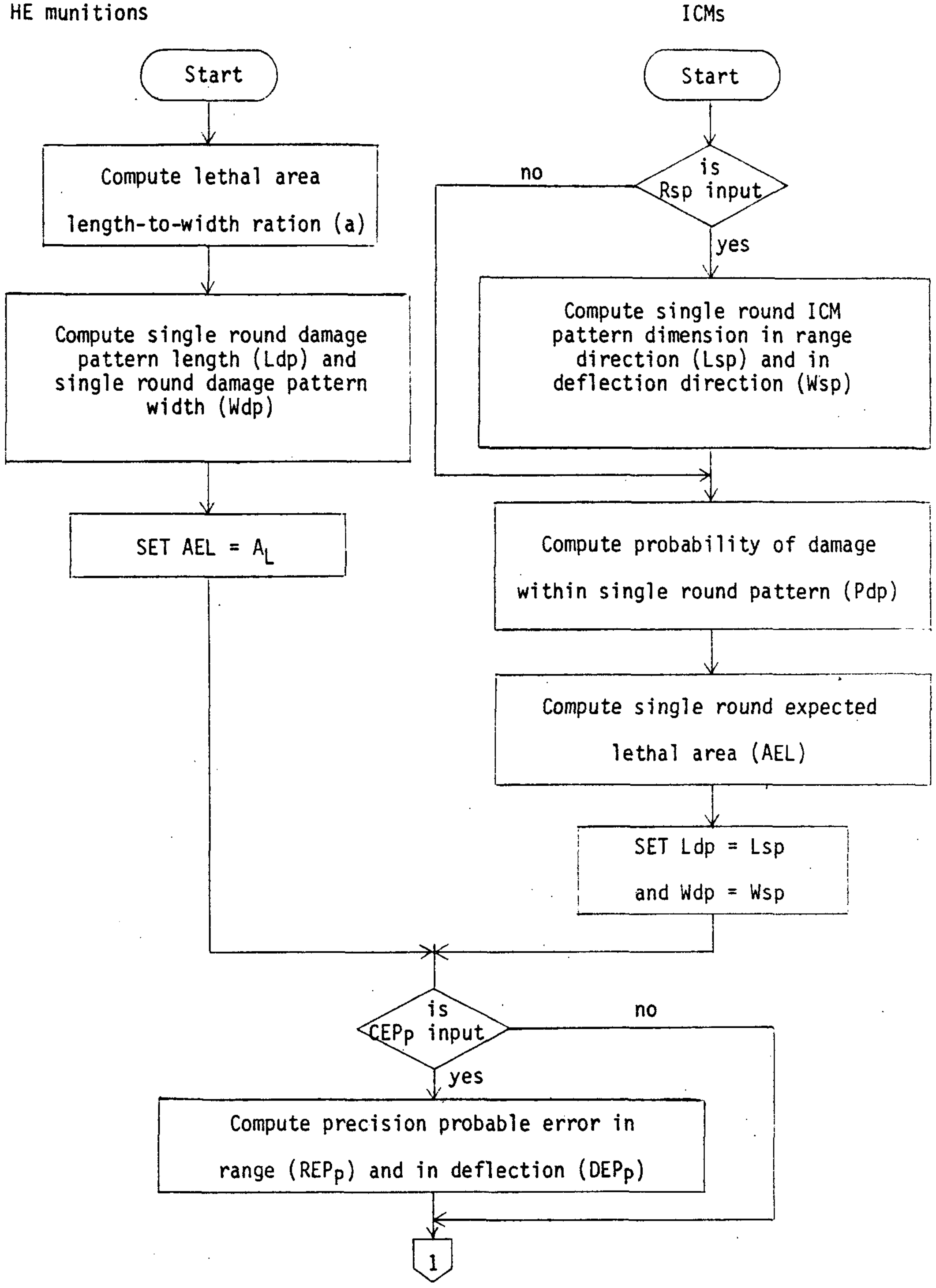

10
is
weapon
cluster
type
yes
no
SET A'ET = AET
14
Compute effective target area
in normal plane (Aetn)
4

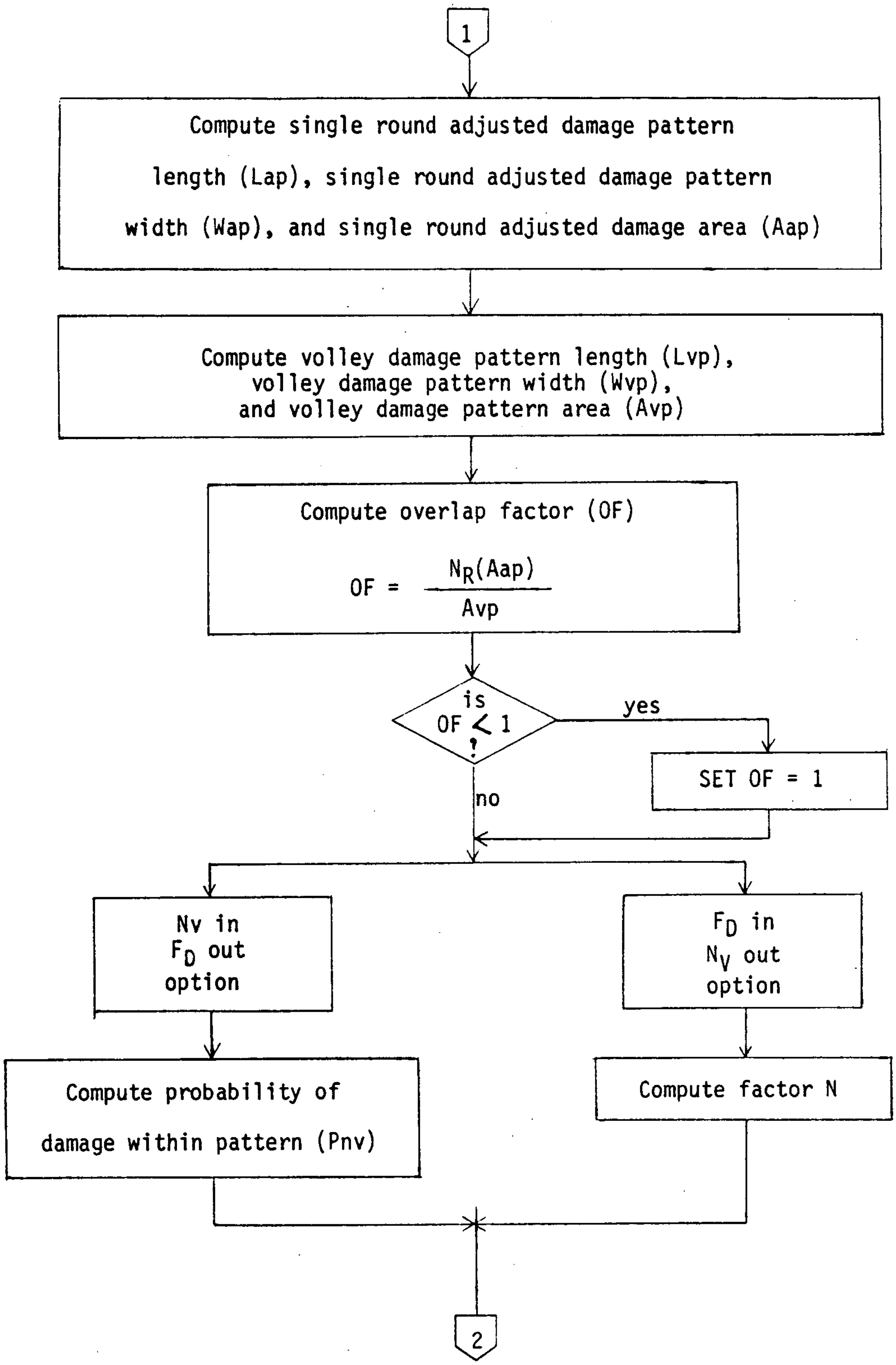

4
is
pattern
rectangular
no
yes
Compute outer pattern edge
effect adjustment (RA)
Compute single pattern effective
length (L'ET) and single
pattern effective width (W'ET)
11
13
is
RA < 0
yes
SET RA = 0
no
Compute single pattern effective
length (L'ET) and single pattern
effective width (W'ET)
is
Rpi input
no
13
yes
Compute inner pattern edge
effect adjustment (RAi)
5

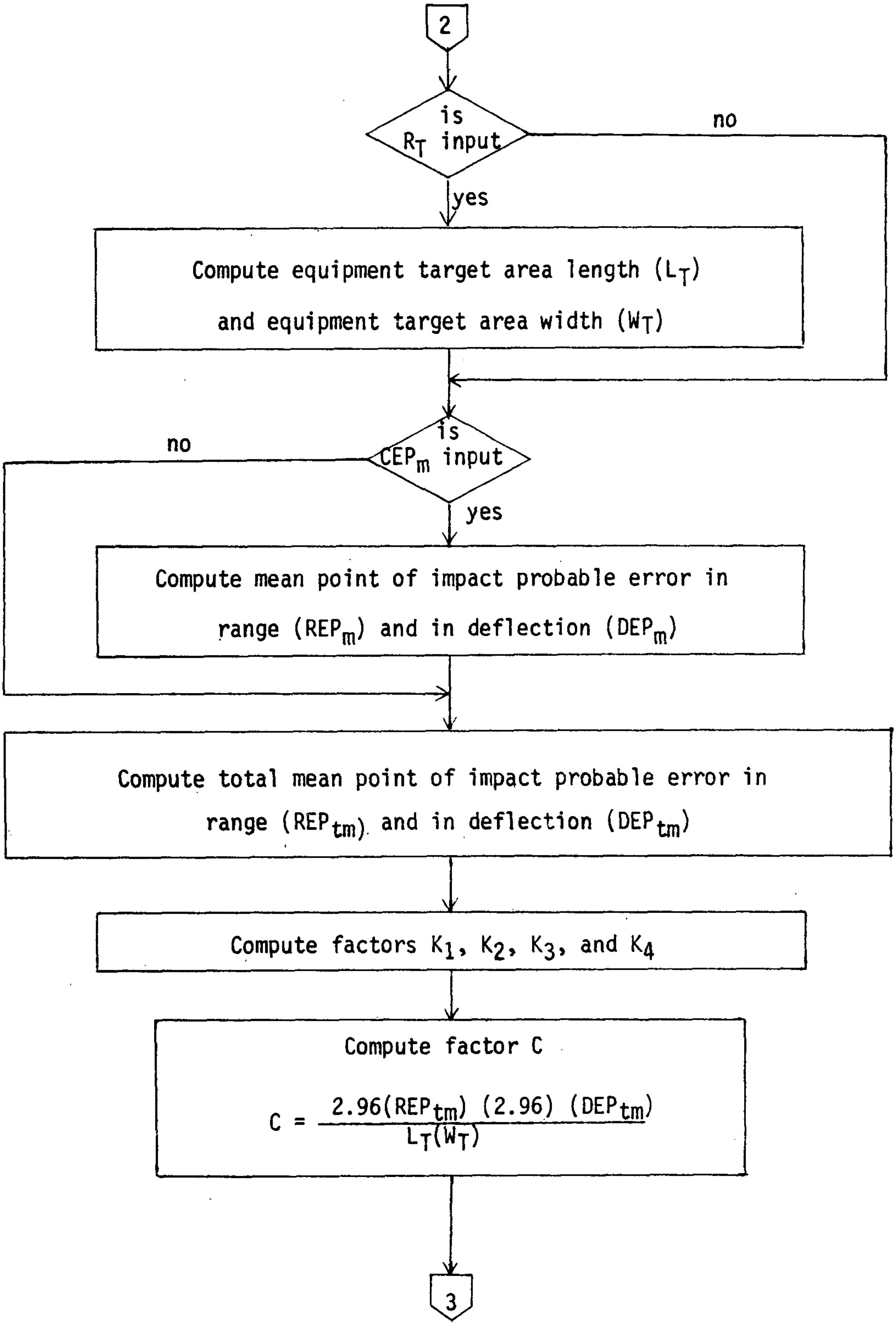

5
is
RAi < 0
?
yes
SET RAi = 0
no
13
no
is
RAi < Rpi
?
Compute hole area in ground plane (Ai)
Compute adjusted width of
pattern hole (Wpi)
13
Compute area of toroidal pattern
in ground plane (A)
Compute probability of damage given
target is in pattern (P'HD)
Compute single pattern effective area
in ground plane (A'ET)
14
is
Ro input
yes
no
6
7


6
7
is
Do input
yes
no
16
Compute effective pattern length (Lep) and effective pattern width (Wep)
Compute effective pattern length (Lep) and effective pattern width (Wep)
Compute Factor FR
Compute expected fraction of target covered by pattern in range direction
Compute factor FD
Compute expected fraction of target covered by pattern in deflection direction
Compute average single pass fractional damage (Fc) or probability of damage (SSPD)
Return

FLOW CHART FOR PROGRAM LIST 2




1
Compute single round adjusted damage pattern length (Lap), single round adjusted damage pattern width (Wap), and single round adjusted damage area (Aap)
Compute volley damage pattern length (Lvp), volley damage pattern width (Wvp), and volley damage pattern area (Avp)
Compute overlap factor (OF)
OF = NR(Aap) / Avp
is OF < 1 ?
yes
SET OF = 1
no
Nv in FD out option
FD in NV out option
Compute probability of damage within pattern (Pnv)
Compute factor N
2


2
is R_T input
no
yes
Compute equipment target area length (L_T) and equipment target area width (W_T)
is CEP_m input
no
yes
Compute mean point of impact probable error in range (REP_m) and in deflection (DEP_m)
Compute total mean point of impact probable error in range (REP_{tm}) and in deflection (DEP_{tm})
Compute factors K_1, K_2, K_3, and K_4
Compute factor C
$C = \frac{2.96(REP_{tm})\ (2.96)\ (DEP_{tm})}{L_T(W_T)}$
3

3

Compute range coverage factor (Fr)

$a = K_1 + K_3$ $\qquad$ $b = \left| K_1 - K_3 \right|$

$$F_r = \left[\frac{a}{\sqrt{2\pi}} \int_0^a e^{-\frac{x^2}{2}} dx + \frac{1}{\sqrt{2\pi}} e^{-\frac{a^2}{2}} \right] - \left[\frac{b}{\sqrt{2\pi}} \int_0^b e^{-\frac{x^2}{2}} dx + \frac{1}{\sqrt{2\pi}} e^{-\frac{b^2}{2}} \right]$$

Compute deflection coverage factor (Fd)

$c = K_2 + K_4$ $\qquad$ $d = \left| K_2 - K_4 \right|$

$$F_d = \left[\frac{c}{\sqrt{2\pi}} \int_0^c e^{-\frac{x^2}{2}} dx + \frac{1}{\sqrt{2\pi}} e^{-\frac{c^2}{2}} \right] - \left[\frac{d}{\sqrt{2\pi}} \int_0^d e^{-\frac{x^2}{2}} dx + \frac{1}{\sqrt{2\pi}} e^{-\frac{d^2}{2}} \right]$$

Compute expected fractional coverage of target by weapon pattern (EC)

EC = Fr(Fd) (C)

Nv in Fd out option

Compute expected fractional damage (Fd)

Fd = EC(Pnv)

Fd in Nv out option

Compute number of volleys required to produce desired level of damage (Nv)

STOP

DESCRIPTION OF INPUT AND OUTPUT OF PROGRAM LIST 1

	VARIABLE	NOTES
INPUT	F, PD, or NA	1
	-L or RP	2, 3
	-W or RPI	2, 4
	I	5
	CEP1	6, 7
	CEP2	6, 7
	PNM1	6, 8
	PNM2	6, 8
	PL	9
	EI Type	10
	EI	11
	Ro	12
	DDo	12
	LT or RT	13
	WT	13, 14
	HT	13, 15
	PHD	16
	LA	17
	WA	17
	NS	
	RB	18, 19
	NB	19
OUTPUT	FC or SSPD	
	N, F, or P	1

DESCRIPTION OF INPUT AND OUTPUT

NOTES

1. If F or PD is entered, N will be computed. If NA is entered, F or P will be computed.

2. Obtain from the weapon's basic manual.

3. The pattern length must be entered as a negative number. If the weapon is not a cluster type, a zero must be entered.

4. The pattern width must be entered as a negative number. If the pattern is circular but not toroidal, a zero must be entered.

5. Obtain from the weapon's basic manual.

6. Obtain from the weapon's basic manual.

7. If only one CEP for the weapon is given, enter that value and enter .01. CEP values in the normal plane must be entered as negative numbers.

8. If only one PNM for the weapon is given, enter that value. If PH is given, enter that value. If neither PNM2 nor PH is given, enter a zero. To include hard-target reliabilities for delay fuzed bombs, multiply PNM1 and PNM2 times R and enter these new values.

9. This value must be greater than the sum of PNM1 and PNM2. If a value is not available, enter a 1; do not enter a zero.

10. Enter 1 only for MAE_f.

11. Obtain from the weapon's basic manual.

12. The entry can be a positive or negative number.

13. No entry is required if MAE_f.

14. Enter a zero if RT is entered.

15. Enter a zero if target height is not to be considered.

16. If a zero is entered, the program will automatically assign a value of 1 to PHD.

17. Enter .01 for a single unitary target.

18. Obtain from the weapon's basic manual.

19. An entry is required only if cluster weapons are being evaluated.

INPUT AND OUTPUT DATA SHEET OF PROGRAM LIST 2

	VARIABLE	
	HE MUNITIONS	ICMs
INPUT	Nv or Fd[a]	Nv or F_D[a]
	AL	AL
	L_T or R_T	L_T or R_T
	W_T[b]	W_T[b]
	Lv	Lv
	Wv	Wv
	N_R	N_R
	Yr	Yr
	REPm or CEPm	REPm or CEPm
	DEPm[c]	DEPm[c]
	TLE	TLE
	REPp or CEPp	REPp or CEPp
	DEPp[d]	DEPp[d]
	K	K
	W	Ns
	Not used	Ys
	Not used	Lsp or Rsp
	Not used	Wsp[e]
OUTPUT	EC	EC
	F_D or Nv[a]	F_D or Nv[a]

a If Nv is input and F_D is to be computed, use F_D out card; if F_D is input and Nv is to be computed, use Nv out card.

b If R_T is entered, enter a zero.

c If CEPm is entered, enter a zero.

d If CEPp is entered, enter a zero.

e. If Rsp is entered, enter a zero.

PROGRAM LIST 1 FOR LANCE, NIKE-HERCULES-KOREA.

```
      IMPLICIT REAL*4(I-N)
      COMMON F,PD,NA,L,RP,W,RPI,I,CEP,PNM,PL,MAEF,MAEB,BEI,
     *VAN,EMD,DC,EI,RO,DDO,LT,RT,WT,HT,PHD,LA,WA,NS,RB,NB
  300 READ(I,400,END=600,ERR=700) NA,RP,RPI,I,CEP1,CEP2,
     *PNM1,PNM2,PL,MAEF,MAEB,BEI,VAN,EMD,DC,EI,
     *RO,DDO,LT,RT,WT,HT,PHD,LA,WA,NS,RB,NB
  400 FORMAT(6F10.5,/,6F10.5,/,6F10.5,/,6F10.5,/,4F10.5)
      WRITE(3,900) NA,RP,RPI,I,CEP1,CEP2,PNM1,PNM2,PL,MAEF,MAEB,BEI,VAN,
     *EMD,DC,EI,RO,DDO,LT,RT,WT,HT,PHD,LA,WA,NS,RB,NB
      CEP=CEP1
      PNM=PNM1
      I=0.01745329*I
C     DAMAGE SUBROUTINE
C     COMPUTE SINGLE PASS PROBABILITY OF DAMAGE
C    *OR FRACTIONAL DAMAGE FOR FIRST CEP/PNM
C    *COMBINATION (SSPD1 OR FC1)
      CALL DAMA(FC)
C     SSPD1=SSPD
      FC1=FC
      CEP=CEP2
      PNM=PNM2
C     DAMAGE SUBROUTINE
C     COMPUTE SINGLE PASS PROBABILITY OF DAMAGE OR
C    *FRACTIONAL DAMAGE FOR SECOND CEP/PNM
C    *COMBINATION (SSPD2 OR FC)
      CALL DAMA(FC)
C     SSPD2=SSPD
      FC2=FC
C     COMPUTE AVERAGE SINGLE PASS PROBABILITY OF
C    *DAMAGE OR FRACTIONAL DAMAGE(SSPD OR FC)
C     SSPD=PL*(1-(1-(SSPD1+SSPD2))**NS)
      FC=PL*(1.-(1.-(FC1+FC2))**NS)
      IF(NA.NE.0.0) GO TO 10
C     COMPUTE REQUIRED NUMBER OF PASSES (N)
      N=ALOG(1-F)/ALOG(1-FC)
C     N=ALOG(1.-PD)/ALOG(1.-SSPD)
      GO TO 200
C     COMPUTE FRACTIONAL DAMAGE(F) OR PROBABILITY
C    *OF DAMAGE(P) FOR NA PASSES
   10 F=1-(1.-FC)**NA
C  10 P=1.-(1.-SSPD)**NA
  200 WRITE(3,500) FC,F
  500 FORMAT(6(/),22X,'FC   =',F15.8,//,22X,
     *'F    =',F15.8)
C
C
C
      GO TO 300
  700 WRITE(3,800)
  800 FORMAT(6(/),2X,33(1H*),4(15HINPUT   ERROR***)
     *,33(1H*))
```

```
  900 FORMAT(1H1,6(/),10X,'NA   =',F10.5,/,
     *10X,'RP   =',F10.5,/,10X,'RPI =',F10.5,/,
     *10X,'I    =',F10.5,/,10X,'CEP1=',F10.5,/,
     *10X,'CEP2=',F10.5,/,10X,'PNM1=',F10.5,/,
     *10X,'PNM2=',F10.5,/,10X,'PL   =',F10.5,/,
     *10X,'MAEF=',F10.5,/,10X,'MAEB=',F10.5,/,
     *10X,'DEI =',F10.5,/,10X,'VAN =',F10.5,/,
     *10X,'EMD =',F10.5,/,10X,'DC   =',F10.5,/,
     *10X,'EI  =',F10.5,/,10X,'RD   =',F10.5,/,
     *10X,'DDD =',F10.5,/,10X,'LT   =',F10.5,/,
     *10X,'RT  =',F10.5,/,10X,'WT   =',F10.5,/,
     *10X,'HT  =',F10.5,/,10X,'PHD =',F10.5,/,
     *10X,'LA  =',F10.5,/,10X,'WA   =',F10.5,/,
     *10X,'NS  =',F10.5,/,10X,'RB   =',F10.5,/,
     *10X,'NB  =',F10.5,/)
  600 STOP
      END


      SUBROUTINE DAMA(FC)
C
C
      IMPLICIT REAL*4(I-N)
      COMMON F,PD,NA,L,RP,W,RPI,I,CEP,PNM,PL,MAEF,MAEB,DEI,VAN,
     *EMD,DC,EI,RD,DDD,LT,RT,WT,HT,PHD,LA,WA,NS,RB,NB
C
      IF(CEP.LT.0.0) GO TO 25
C     COMPUTE RANGE ERROR PROBABLE IN GROUND PLANE (REP)
C    *AND DEFLECTION ERROR PROBABLE IN GROUND PLANE (DEP)
      REP=0.573*CEP
      DEP=REP
      GO TO 30
C     COMPUTE RANGE ERROR PROBABLE IN GROUND PLANE (REP)
C    *AND DEFLECTION ERROR PROBABLE IN GROUND PLANE (DEP)
   25 REP=(0.573*CEP)/SIN(I)
      DEP=0.573*CEP
   30 WPI=0.
      AI=0.
      IF(MAEF.EQ.0.0) GO TO 40
C     COMPUTE LENGTH-TO-WIDTH RATIO(A)
      A=1.-0.8*COS(I)
C     COMPUTE EFFECTIVE TARGET LENTH (LET) AND
C    *EFFECTIVE TARGET WIDTH (WET)
      LET=2*SQRT(MAEF*A/3.14)
      WET=LET/A
      AET=MAEF
      IF(RP.EQ.0.0) GO TO 20
      GO TO 100
```

```
C      COMPUTE RANGE SINGLE PASS PROBABILITY
C     *OF HIT (RSSP)
C      RSSP=(LET/SQRT(17.6*REP**2+LET**2))*EXP(-(4*DDD**2)/
C     *(17.6*REP**2+LET**2))
C      COMPUTE DEFLECTION SINGLE PASS PROBABILITY
C     *OF HIT (DSSP)
C      DSSP=(WET/SQRT(17.6*DEP**2+WET**2))*EXP(-(4*DDD**2)/
C     *(17.6*DEP**2+WET**2))
C      COMPUTE AVERAGE SINGLE PASS PROBABILITY
C     *OF DAMAGE (SSPD)
C      SSPD=(RSSP*DSSP*PNM)/PL
C      RETURN
   20 IF(RO.NE.0.0) GO TO 21
      IF(DDD.NE.0.0) GO TO 21
      L1ET=LET
      W1ET=WET
      A1ET=MAEF
      GO TO 150
C      COMPUTE EFFECTIVE RANGE ERROR PROBABLE (REP1)
C     *AND EFFECTIVE DEFLECTION ERROR
C     *PROBABLE (DEP1)
   21 REP1=SQRT(LET**2/17.6+REP*REP)
      DEP1=SQRT(WET**2/17.6+DEP*DEP)
C      COMPUTE RANGE SINGLE PASS PROBABILITY
C     *OF HIT (RSSP)
      UA=(LA+2*RO)/(2.96*REP1)
      UB=ABS(LA-2*RO)/(2.96*REP1)
      SSI=LA-2*RO
      EXXP=EXP(-0.63*UA**2)
      EEXP=EXP(-0.63*UB**2)
      RSSPP=0.5*SQRT(1-EXXP)*UA
      RRSSP=0.5*SQRT(1-EEXP)*UB
      IF(SSI)88,99,99
   88 RSSP=RSSPP-RRSSP
      GO TO 22
   99 RSSP=RSSPP+RRSSP
C      COMPUTE DEFLECTION SINGLE PASS
C     *PROBABILITY OF HIT (DSSP)
   22 UC=(WA+2*DDD)/(2.96*DEP1)
      UD=ABS(WA-2*DDD)/(2.96*DEP1)
      EXXP=EXP(-0.63*UC**2)
      EEXP=EXP(-0.63*UD**2)
      DSSPP=0.5*SQRT(1-EXXP)*UC
      DDSSP=0.5*SQRT(1-EEXP)*UD
      SSI=WA-2*DDD
      IF(SSI)89,98,98
   89 DSSP=DSSPP-DDSSP
      GO TO 31
   98 DSSP=DSSPP+DDSSP
C      COMPUTE AVERAGE SINGLE PASS
C     *FRACTIONAL DAMAGE (FC)
```

```
   31 FC=(RSSP*DSSP*MAEF*PNM)/(LA*WA*PL)
      RETURN
   40 IF(MAEB.EQ.0.0) GO TO 41
      IF(VAN.EQ.0.) GO TO 50
C     COMPUTE EFFECTIVE TARGET LENGTH (LET)
C    *AND EFFECTIVE TARGET WIDTH (WET)
      LET=SQRT(VAN)/SIN(I)
      WET=SQRT(VAN)
      GO TO 90
C     COMPUTE EFFECTIVE TARGET LENGTH (LET)
C    *AND EFFECTIVE TARGET WIDTH (WET)
   41 LET=SQRT(MAEB)
      WET=LET
      GO TO 90
C
C
   50 IF(EMD.EQ.0.0) GO TO 70
      IF(RT.EQ.0.0) GO TO 51
C     COMPUTE EFFECTIVE TARGET LENGTH (LET)
C    *AND EFFECTIVE TARGET WIDTH (WET)
      LET=SQRT(3.14)*(RT+EMD)
      WET=LET
      GO TO 52
C     COMPUTE EFFECTIVE TARGET LENGTH (LET)
C    *AND EFFECTIVE TARGET WIDTH (WET)
   51 LET=LT+2*EMD
      WET=WT+2*EMD
   52 IF(HT.EQ.0.0) GO TO 90
C     COMPUTE SHADOW LENGTH (LSH)
      LSH=HT/TAN(I)
      IF(LSH.LT.EMD) GO TO 90
C     RECOMPUTE EFFECTIVE TARGET LENGTH (LET)
      LET=((LT+2*EMD)*WET+WT*(LSH-EMD))/WET
C     LET=(3.14*(RT+EMD)**2+2*RT*(LSH-EMD))/WET
      GO TO 90
C
C
   70 IF(BEI.EQ.0.0) GO TO 71
C     COMPUTE EFFECTIVE TARGET LENGTH (LET)
C    *AND EFFECTIVE TARGET WIDTH (WET)
      LET=LT
      WET=WT
C     COMPUTE BRIDGE WIDTH (WB)
      WB=MIN(LT,WT)
C     RECOMPUTE PROBABILITY OF DAMAGE
C     GIVE A HIT (PHD)
      PHD=1-EXP(-BEI/WB)
      GO TO 90
   71 IF(LT.LT.WT) GO TO 30
```

```
C      COMPUTE EFFECTIVE TARGET LENGTH (LET)
C     *AND EFFECTIVE TARGET WIDTH (WET)
       LET=1*10**7
       WET=DC-WT
       GO TO 90
C      COMPUTE EFFECTIVE TARGET LENGTH (LET)
C     *AND EFFECTIVE TARGET WIDTH (WET)
   80  LET=DC-LT
       WET=1*10**7
C      COMPUTE EFFECTIVE TARGET AREA IN
C      ROUND PLANE (AET)
   90  AET=LET*WET*PHD
       IF(AET.LT.0) STOP
  100  IF(RP.NE.0.0) GO TO 101
       A1ET=AET
       GO TO 140
C      COMPUTE EFFECTIVE TARGET AREA IN
C     *NORMAL PLANE (AETN)
  101  AETN=AET*SIN(I)
       GO TO 102
C      COMPUTE SINGLE PATTERN EFFECTIVE LENGTH(L1ET)
C     *AND SINGLE PATTERN EFFECTIVE WIDTH (W1ET)
C      L1ET=L
C      W1ET=W
C      GO TO 130
C      COMPUTE OUTER PATTERN EDGE EFFECT
C     *ADJUSTMENT (RA)
  102  RA=SQRT(AETN/3.14)-0.055*RP
       IF(RA.LT.0.0) RA=0.0
C      COMPUTE SINGLE PATTERN EFFECTIVE LENGTH (L1ET)
C     *AND SINGLE PATTERN EFFECTIVE WIDTH (W1ET)
       W1ET=SQRT(3.14)*(RP+RA)
       L1ET=W1ET/SIN(I)
       IF(RPI.EQ.0.0) GO TO 130
C      COMPUTE INNER PATTERN EDGE EFFECT
C     *ADJUSTMENT (RAI)
       RAI=SQRT(AETN/3.14)-0.055*RPI
       IF(RAI.LT.0.0) RAI=0.0
       IF(RAI.GT.RPI) GO TO 130
C      COMPUTE HOLE AREA IN GROUND PLANE (AI)
       AI=(3.14*(RPI-RAI)**2)/SIN(I)
C      COMPUTE ADJUSTED WIDTH OF PATTERN HOLE (WPI)
       WPI=SQRT(AI*SIN(I))
C      COMPUTE AREA OF TOROIDAL PATTERN IN
C     *GROUND PLANE (A)
  130  A=L1ET*W1ET-AI
C      COMPUTE PROBABILITY OF DAMAGE GIVEN
C     *TARGET IS IN PATTERN (P1HD)
       P1HD=1-EXP(-(NB*RB*AET)/A)
C      COMPUTE SINGLE PATTERN EFFECTIVE AREA
C     *IN GROUND PLANE (A1ET)
```

```
      A1ET=A*P1HD
  140 IF(RO.NE.0.0) GO TO 160
      IF(DDD.NE.0.0) GO TO 160
C     COMPUTE EFFECTIVE PATTERN LENGTH (LEP)
C    *AND EFFECTIVE PATTERN WIDTH (WEP)
  150 LEP=AMAX1(L1ET,LA)
C
      WEP=AMAX1(W1ET,WA)
      GO TO 141
C     COMPUTE EFFECTIVE PATTERN LENGTH (LEP)
C    *AND EFFECTIVE PATTERN WIDTH (WEP)
  160 LEP=L1ET
      WEP=W1ET
C     COMPUTE FACTOR FR1
  141 UA=(LEP+(LA+2*RO))/(2.96*REP)
      UB=ABS(LEP-(LA+2*RO))/(2.96*REP)
      EXXP=EXP(-0.63*UA**2)
      EEXP=EXP(-0.63*UB**2)
      FL1=(0.5*SQRT(1-EXXP)*UA+1./SQRT(6.28)*EXP(-(UA**2/2.)))
     *-(0.5*SQRT(1-EEXP)*UB+1./SQRT(6.28)*EXP(-(UB**2/2.)))
      FR1=(2.96*REP*FL1)/LA
C     COMPUTE FACTOR FR2
      UUU=ABS(LA-2*RO)
      UC=(LEP+UUU)/(2.96*REP)
      UD=ABS(LEP-UUU)/(2.96*REP)
      EXXP=EXP(-0.63*UC**2)
      EEXP=EXP(-0.63*UD**2)
      FL2=(0.5*SQRT(1-EXXP)*UC+1./SQRT(6.28)*EXP(-(UC**2/2.)))
     *-(0.5*SQRT(1-EEXP)*UD+1./SQRT(6.28)*EXP(-(UD**2/2.)))
      FR2=(2.96*REP*FL2)/LA
C     COMPUTE EXPECTED FRACTION OF TARGET COVERED
C    *BY PATTERN IN RANGE DIRECTION (FR1)
      SSI=LA-2*RO
      IF(SSI)142,143,143
  142 FR1=(FR1-FR2)/2.
      GO TO 170
  143 FR1=(FR1+FR2)/2.
C     COMPUTE FACTOR FD1
  170 UE=(WEP+(WA+2*DDD))/(2.96*DEP)
      UF=ABS(WEP-(WA+2*DDD))/(2.96*DEP)
      EXXP=EXP(-0.63*UE**2)
      EEXP=EXP(-0.63*UF**2)
      FW1=(0.5*SQRT(1-EXXP)*UE+1./SQRT(6.28)*EXP(-(UE**2/2.)))
     *-(0.5*SQRT(1-EEXP)*UF+1./SQRT(6.28)*EXP(-(UF**2/2.)))
      FD1=(2.96*DEP*FW1)/WA
C     COMPUTE FACTOR FD2
      UUU=ABS(WA-2*DDD)
      UG=(WEP+UUU)/(2.96*DEP)
      UH=ABS(WEP-UUU)/(2.96*DEP)
      EXXP=EXP(-0.63*UG**2)
      EEXP=EXP(-0.63*UH**2)
```

```
      FW2=(0.5*SQRT(1-EXXP)*UG+1./SQRT(6.28)*EXP(-(UG**2/2.)))
     *-(0.5*SQRT(1-EEXP)*UH+1./SQRT(6.28)*EXP(-(UF**2/2.)))
      FD2=(2.96*DEP*FW2)/WA
C     COMPUTE EXPECTED FRACTION OF TARGET COVERED
C    *BY PATTERN IN DEFLECTION DIRECTION (FD1)
      SSI=WA-2*DDD
      IF(SSI)171,172,172
  171 FD1=(FD1-FD2)/2.
      GO TO 173
  172 FD1=(FD1+FD2)/2.
  173 LPI=WPI/SIN(I)
C     COMPUTE FACTOR FR3
      UA=(LPI+(LA+2*RO))/(2.96*R
      UB=ABS(LPI-(LA+2*RO))/(2.96*REP)
      EXXP=EXP(-0.63*UA**2)
      EEXP=EXP(-0.63*UB**2)
      FL1=(0.5*SQRT(1-EXXP)*UA+1./SQRT(6.28)*EXP(-(UA**2/2.)))
     *-(0.5*SQRT(1-EEXP)*UB+1./SQRT(6.28)*EXP(-(UB**2/2.)))
      FR3=(2.96*REP*FL1)/LA
C     COMPUTE FACTOR FR4
      UUU=ABS(LA-2*RO)
      UC=(LPI+UUU)/(2.96*REP)
      UD=ABS(LPI-UUU)/(2.96*REP)
      EXXP=EXP(-0.63*UC**2)
      EEXP=EXP(-0.63*UD**2)
      FL2=(0.5*SQRT(1-EXXP)*UC+1./SQRT(6.28)*EXP(-(UC**2/2.)))
     *-(0.5*SQRT(1-EEXP)*UD+1./SQRT(6.28)*EXP(-(UD**2/2.)))
      FR4=(2.96*REP*FL2)/LA
C     COMPUTE EXPECTED FRACTION OF TARGET COVERED
C    *BY PATTERN HOLE IN RANGE DIRECTION (FR2)
      SSI=LA-2*RO
      IF(SSI)181,182,182
  181 FR2=(FR3-FR4)/2.
      GO TO 190
  182 FR2=(FR3+FR4)/2.
C     COMPUTE FACTOR FD3
  190 UE=(WPI+(WA+2*DDD))/(2.96*DEP)
      UF=ABS(WPI-(WA+2*DDD))/(2.96*DEP)
      EXXP=EXP(-0.63*UE**2)
      EEXP=EXP(-0.63*UF**2)
      FW1=(0.5*SQRT(1-EXXP)*UE+1./SQRT(6.28)*EXP(-(UE**2/2.)))
     *-(0.5*SQRT(1-EEXP)*UF+1./SQRT(6.28)*EXP(-(UF**2/2.)))
      FD3=(2.96*DEP*FW1)/WA
C     COMPUTE FACTOR FD4
      UUU=ABS(WA-2*DDD)
      UG=(WPI+UUU)/(2.96*DEP)
      UH=ABS(WPI-UUU)/(2.96*DEP)
      EXXP=EXP(-0.63*UG**2)
      EEXP=EXP(-0.63*UH**2)
```

```
      FW2=(0.5*SQRT(1-EXXP)*UG+1./SQRT(6.28)*EXP(-(UG**2/2.)))
     *-(0.5*SQRT(1-EEXP)*UH+1./SQRT(6.28)*EXP(-(UH**2/2.)))
      FD4=(2.96*DEP*FW2)/WA
C     COMPUTE EXPECTED FRACTION OF TARGET COVERED
C    *BY PATTERN HOLE IN DEFLECTION DIRECTION (FD2)
      SSI=WA-2*DDO
      IF(SSI)191,192,192
  191 FD2=(FD3-FD4)/2.
      GO TO 193
  192 FD2=(FD3+FD4)/2.
C     COMPUTE AVERAGE SINGLE PASS FRACTIONAL
C    *DAMAGE (FC) OR PROBABILITY OF DAMAGE (SSPD)
  193   FC=(A1ET*PNM*(FR1*FD1-FR2*FD2))/(LEP*WEP*PL)
      RETURN
      END
```

```
NA   =    1.00000
RP   =  145.00000
RPI  =   50.00000
I    =   53.00000
CEP1=    78.15999
CEP2=     0.01000
PNM1=     0.96000
PNM2=     0.0
PL   =    1.00000
MAEF=   546.00000
MAEB=     0.0
BEI  =    0.0
VAN  =    0.0
EMD  =    0.0
DC   =    0.0
EI   =    1.00000
RO   =    0.0
DDO  =    0.0
LT   =    0.0
RT   =    0.0
WT   =    0.0
HT   =    0.0
PHD  =    1.00000
LA   =  150.00000
WA   =  100.00000
NS   =    1.00000
RB   =    0.94500
NB   =  825.00000

          FC   =      0.64588165

          F    =      0.64588165
```

PROGRAM LIST 2 FOR HONEST JOHN, NIKE-HERCULES, AND MIDDLE RANGE ROCKET.

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C      DEFINITION OF VARIABLES                                  C
C      AL : THE LETHAL AREA FOR THE SINGLE ROUND OR             C
C     *SUBMUNITION (SQUARE METERS)                              C
C      CEPM : THE MEAN POINT OF IMPACT CIRCULAR ERROR           C
C     *PROBABLE (EXCLUDING TARGET LOCATION ERROR) METERS        C
C      CEPP : THE PRECISION CIRCULAR ERROR PROBABLE (METERS)    C
C      EC : THE EXPECTED FRACTIONAL COVERAGE OF THE TARGET      C
C     *BY THE WEAPON PATTERN                                    C
C      DEPM : THE MEAN POINT OF IMPACT PROBABLE ERROR IN        C
C     *DEFLECTION (EXCLUDING TARGET LOCATION ERROR)             C
C      FD : THE DESIRED OR EXPECTED FRACTIONAL DAMAGE           C
C      K : THE PATTERN ADJUSTMENT FACTOR                        C
C      LSP : THE SINGLE ROUND SUBMUNITION PATTERN DIMENSION     C
C     *IN THE RANGE DIRECTION (FOR ICM ONLY)                    C
C      LT : THE DIMENSION OF THE TARGET AREA IN THE RANGE       C
C     *DIRECTION                                                C
C      LV : THE DIMENSION OF THE VOLLERY PATTERN IN THE         C
C     *RANGE DIRECTION                                          C
C      NR : THE NUMBER OF ROUNDS IN EACH VOLLERY                C
C      NS : THE NUMBER OF SUBMUNITION IN EACH ROUND             C
C     *(FOR ICM ONLY)                                           C
C      NV : THE NUMBER OF VOLLERYS                              C
C      RR : THE RELIABILITY OF THE ROUND                        C
C      RT : THE RADIUS OF THE TARGET AREA                       C
C      RSP : THE SINGLE ROUND SUBMUNITION PATTERN               C
C     *RADIUS (FOR ICM ONLY)                                    C
C      RS : THE RELIABILITY OF THE SUBMUNITION                  C
C     *(FOR ICM ONLY)                                           C
C      REPM : THE MEAN POINT OF IMPACT PROBABLE ERROR           C
C     *IN RANGE (EXCLUDING TARGET LOCATION ERROR)               C
C      REPP : THE PRECISION PROBABLE ERROR IN RANGE             C
C      TLE : THE TARGET LOCATION ERROR(IN CIRCULAR              C
C     *ERRORS PROBABLE)                                         C
C      WSP : THE SINGLE ROUND SUBMUNITION PATTERN DIMENSION     C
C     *IN THE DEFLECTION DIRECTION (FOR ICM ONLY)               C
C      WT : THE DIMENSION OF THE TARGET AREA IN THE             C
C     *DEFLECTION DIRECTION                                     C
C      WV : THE DIMENSION OF THE VOLLEY PATTERN IN              C
C     *THE DEFLECTION DIRECTION                                 C
C      W : THE ANGLE OF FALL (REQUIRED ONLY FOR HE              C
C     *MUNITIONS)                                               C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
       DIMENSION VNAME(18),FF(18)
       REAL K1,K2,K3,K4,NV,LTT,LV,NR,K,NS,LVP
       EQUIVALENCE(FF(1),NV),(FF(2),AL),(FF(3),LTT),(FF(4),WT),
      *(FF(5),LV),(FF(6),WV),(FF(7),NR),(FF(8),RR),
      *(FF(9),REPM),(FF(10),DEPM),(FF(11),TLE),(FF(12),REPP),
      A(FF(13),DEPP),(FF(14),K),(FF(15),NS),(FF(16),RS),
      B(FF(17),RSP),(FF(18),WSP)
```

```
      DATA VNAME/4HNV  ,4HAL  ,4HLTT ,4HWT  ,
     C4HLV  ,4HWV  ,4HNR  ,4HRR  ,4HREPM,4HDEPM,
     D4HTLE ,4HREPP,4HDEPP,4HK   ,4HNS  ,4HRS  ,
     E4HRSP ,4HWSP /
      READ(1,6)(FF(I),I=1,18)
    6 FORMAT(5F10.5,/,5F10.5,/,5F10.5,/,3F10.5)
      IF(RSP.EQ.0.0) GO TO 10
C     COMPUTE SINGLE ROUND ICM PATTERN DIMENSION
C    *IN RANGE DIRECTION (LSP) AND IN DEFLECTION
C    *DIRECTION (WSP)
      LSP=SQRT(3.14)*RSP
      WSP=LSP
C     COMPUTE PROBABILITY OF DAMAGE WITHIN
C    *SINGLE ROUND PATTERN (PDP)
   10 PDP=1.0-EXP(-((NS*RS*AL)/(LSP*WSP)))
C     COMPUTE SINGLE ROUND EXPECTED LETHAL AREA (AEL)
      AEL=LSP*WSP*PDP
      LDP=LSP
      WDP=WSP
      CEPP=0.
      IF(CEPP.EQ.0.0) GO TO 2
C     COMPUTE PRECISION PROBABLE ERROR IN RANGE(REPP) AND
C    *IN DEFLECTION(DEPP)
      REPP=0.573*CEPP
      DEPP=REPP
C     COMPUTE SINGLE ROUND ADJUSTED DAMAGE PATTERN LENGTH(LAP),
C    *SINGLE ROUND ADJUSTED DAMAGE PATTERN WIDTH(WAP), AND
C    *SINGLE ROUND ADJUSTED DAMAGE AREA(AAP)
    2 LAP=LDP+K*REPP
      WAP=WDP+K*DEPP
      AAP=LAP*WAP
C     COMPUTE VOLLEY DAMAGE PATTERN LENGTH(LVP), VOLLEY DAMAGE
C     PATTERN WIDTH(WVP), AND VOLLEY DAMAGE PATTERN AREA(AVP)
      LVP=LAP+LV
      WVP=WAP+WV
      AVP=LVP*WVP
C     COMPUTE OVERLAP FACTOR (OF)
      OF=NR*AAP/AVP
      IF(OF.LT.1) OF=1
C     COMPUTE PROBABILITY OF DAMAGE WITHIN PATTERN (PNV)
      PNV=1-(1-(AEL*NR*RR)/(AVP*OF))**(NV*OF)
      RT=0.0
      IF(RT.EQ.0.0) GO TO 13
C     COMPUTE EQUIVALENT TARGET AREA LENGTH(LT) AND
C    *EQUIVALENT TARGET AREA WIDTH(WT)
      LTT=SQRT(3.14)*RT
      WT=LTT
   13 CEPM=0.
      IF(CEPM.EQ.0.0) GO TO 4
C     COMPUTE MEAN POINT OF IMPACT PROBABLE ERROR IN RANGE(REPM)
C    *AND IN DEFLECTION(DEPM)
```

```
      REPM=0.573*CEPM
      DEPM=REPM
C     COMPUTE TOTAL MEAN POINT OF IMPACT PROBABLE ERROR IN
C    *RANGE(REPTM) AND IN DEFLECTION(DEPTM)
    4 REPTM=SQRT(REPM**2+(.573*TLE)**2)
      DEPTM=SQRT(DEPM**2+(.573*TLE)**2)
C     COMPUTE FACTORS K1,K2,K3 AND K4
      K1=LVP/(2.96*REPTM)
      K2=WVP/(2.96*DEPTM)
      K3=LTT/(2.96*REPTM)
      K4=WT/(2.96*DEPTM)
C     COMPUTE FACTOR C
      C=2.96*REPTM*2.96*DEPTM/(LTT*WT)
C     COMPUTE RANGE COVERAGE FACTOR(FR)
      U1=K1+K3
      U2=ABS(K1-K3)
      EXXP=EXP(-(0.63*U1**2))
      EEXP=EXP(-(0.63*U2**2))
      FR=(U1*0.5*SQRT(1-EXXP)+1./SQRT(6.28)*EXP(-(U1**2/2.)))
     *-(U2*0.5*SQRT(1-EEXP)+1./SQRT(6.28)*EXP(-(U2**2/2.)))
C     COMPUTE DEFLECTION COVERAGE FACTOR (FD)
      UC=K2+K4
      UD=ABS(K2-K4)
      EXXP=EXP(-(0.63*UC**2))
      EEXP=EXP(-(0.63*UD**2))
      FD=(UC*0.5*SQRT(1-EXXP)+1./SQRT(6.28)*EXP(-(UC**2/2.)))
     *-(UD*0.5*SQRT(1-EEXP)+1./SQRT(6.28)*EXP(-(UD**2/2.)))
C     COMPUTE EXPECTED FRACTIONAL COVERAGE OF TARGET BY WEAPON PATTERN(EC)
      EC=FR*FD*C
C     COMPUTE EXPECTED FRACTIONAL DAMAGE (FD)
      FD=EC*PNV
      WRITE(3,50)(VNAME(I),FF(I),I=1,18)
   50 FORMAT(6(/),18(10X,A4,' =',F12.5,/))
      WRITE(3,60) EC,FD
   60 FORMAT(//,10X,'EC    =',F10.5,/,10X,'FD    =',F10.5)
      STOP
      END
/*
```

```
NV    =     1.00000
AL    =    38.70000
LTT   =   180.00000
WT    =   100.00000
LV    =     0.0
WV    =     0.0
NR    =     1.00000
RR    =     0.97000
REPM  =    90.00000
DEPM  =   145.00000
TLE   =   100.00000
REPP  =    84.00000
DEPP  =   101.00000
K     =     4.00000
NS    =  4800.00000
RS    =     0.97000
RSP   =   271.00000
WSP   =   480.00000


EC    =   0.92450
FD    =   0.15540
```

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2. Target Vulnerability, Joint Munitions Effectiveness Manual, Surface-to-Surface, 3 November 1975.

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4. Joint Munitions Effectiveness Manual, 61JTCG/ME-77-14.

5. Weaponeering Principles for Air-to-Surface Warfare, HQ 314th Air Div., June 1978.