Report No. SA-TR20-2818

FORTRAN PROGRAM FOR CALCULATING PROBABILITY OF A HIT ON A SQUARE TARGET

Technical Report

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SPRINGFIELD ARMORY
SPRINGFIELD, MASSACHUSETTS
Best Available Copy
FORTRAN PROGRAM
FOR CALCULATING PROBABILITY OF A HIT ON A SQUARE TARGET

Technical Report

Hazel E. Lundy

DA PROJECT TITLE: Investigation of Gun Type Aerial Weapons

DA PROJECT: 1X120301D02503

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ABSTRACT

Probability of a hit by a single shot or by a ten-shot burst at direct or angular approach to a square target is calculated. Parameters include dispersion in mils, distance from the target in meters, and size of the target in feet. A normal distribution is assumed. Solution by linear interpolation of normal curve areas from standard tables was accurate to 0.0002 when contrasted with integration of the normal curve by Simpson's 1/3 Rule in sample problems.
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(ii)
FORTRAN PROGRAM FOR CALCULATING PROBABILITY OF A HIT ON A SQUARE TARGET

1. PURPOSE

To record three variations of a computer program in FORTRAN which have been used for calculating the probability of a hit on a square upright target based on assumption of a normal distribution in both the horizontal and vertical directions.

2. DISCUSSION

a. Calculations described below may be performed by use of these FORTRAN programs:

(1) \( P_{\text{HIT}} \) on a square target - detailed calculations for single-shot hit probability based on normal curve areas (Program R453R).

(2) \( P_{\text{HIT}} \) on a square target - single shot and ten-shot bursts at direct approach and at any two angular approaches with provision for regular incrementation of radial standard deviation in mils, distance from the target in meters, and size of the target in feet.

   (a) Calculated by linear interpolation of normal curve areas from standard tables (Program R454R).

   (b) Calculated by integration of the normal curve by Simpson's 1/3 Rule (Program R455R).

b. Sample calculations in this report show the same problem solved in the following ways:

(1) By use of Program R455R with 101 incremental areas,

(2) By use of Program R455R with 11 incremental areas,

(3) By use of Program R454R.

c. Values of \( P_{\text{HIT}} \) for the sample problem, rounded to four decimal places, varied at most by .0002 whether calculated by Program R455R with 101 or with 11 incremental areas of integration or by the linear interpolation method of Program R454R. However, calculation by (1) involving the 101 incremental areas required approximately 3-1/2 times longer than calculations by (2) and (3). This calculation required 7 minutes on the Springfield Armory 8K computer as compared with 2 minutes each for (2) and (3).
3. PROGRAM R455R

a. DESCRIPTION

This program gives detailed calculations for probability of a hit by a single shot based on conversion of a projected radial standard deviation in miles to linear standard deviation in feet and linear interpolation of 400 stored values of area of the normal curve. Range (distance from the target) is given in meters. Load limits equal 2074 (DECIMAL) words.

b. OUTPUT AND SAMPLE CALCULATIONS

(1) Values of the normal curve as read in from cards are printed as the first page of output.

(2) Second and subsequent pages include columns described below. The sample calculations for one line of output are based on a 6.5-mil radial standard deviation delivered at 1500 meters to a 50-foot square target.

Column 1. Radial Standard Deviation

\[ RSD = \sqrt{\sigma_x^2 + \sigma_y^2} = 6.5, \text{ where } \sigma_x = \sigma_y \]

Column 2. Linear Standard Deviation

Conversion Factor for RSD in miles to LSD in feet

\[ \frac{1.5 \times 3.280833}{1.414214} = 3.47984 \]

\[ \text{LSD} = 6.5 \times 3.47984 = 22.6190 \text{ feet} \]

Column 3. Z

\[ Z = \frac{X}{\sigma} = \frac{25}{22.61896} = 1.1053 \]
3. PROGRAM R453R - Continued

b. OUTPUT AND SAMPLE CALCULATIONS

Column 4. Difference

Difference between values of normal curve area adjacent to 1.1033

<table>
<thead>
<tr>
<th>Z</th>
<th>Normal Curve Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.11</td>
<td>.3665</td>
</tr>
<tr>
<td>1.10</td>
<td>.3643</td>
</tr>
<tr>
<td>Difference</td>
<td>.0022</td>
</tr>
</tbody>
</table>

Column 5. Interpolation

.0022 x (1.1053 - 1.10) x 100 = .0012

Column 6. Area of Normal Curve

The low adjacent value of Z = .3643

Column 7. PHX on Half of Target

Probability of a hit on half of the target in the X direction equals .3643 plus .0012 = .3655

Column 8. PHX on Full Target

2 x .3655 = .7310

Column 9. P_HIT on Full Target, X and Y Directions

.7310 x .7310 = .5342

Column 10. Percentage

100 x .5342 = 53.42 Per Cent
3. PROGRAM RA53 - Continued

c. INPUT

(1) Set of 50 cards with values of the normal curve area from standard tables, 8 values per card, total of 400 values.

<table>
<thead>
<tr>
<th>Column</th>
<th>First Card</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-4</td>
<td>0040</td>
<td>41-44</td>
</tr>
<tr>
<td></td>
<td>11-14</td>
<td>0080</td>
<td>51-54</td>
</tr>
<tr>
<td></td>
<td>21-24</td>
<td>0120</td>
<td>61-64</td>
</tr>
<tr>
<td></td>
<td>31-34</td>
<td>0160</td>
<td>71-74</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Column</th>
<th>Fiftieth Card</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-4</td>
<td>5000</td>
<td>41-44</td>
</tr>
<tr>
<td></td>
<td>11-14</td>
<td>5000</td>
<td>51-54</td>
</tr>
<tr>
<td></td>
<td>21-24</td>
<td>5000</td>
<td>61-64</td>
</tr>
<tr>
<td></td>
<td>31-34</td>
<td>5000</td>
<td>71-74</td>
</tr>
</tbody>
</table>

(2) Followed by Data Cards

<table>
<thead>
<tr>
<th>Column</th>
<th>Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10</td>
<td>RSDIN</td>
<td>Initial radial std. dev. - mils</td>
</tr>
<tr>
<td>11-20</td>
<td>RING</td>
<td>Increments of RBD</td>
</tr>
<tr>
<td>21-30</td>
<td>RSDFI</td>
<td>Final RSD - mils</td>
</tr>
<tr>
<td>31-40</td>
<td>TARC</td>
<td>Length and width of target - feet</td>
</tr>
<tr>
<td>41-50</td>
<td>DIST</td>
<td>Range - meters</td>
</tr>
</tbody>
</table>
**PROGRAM R453R**

PROBABILITY OF A HIT ON A --- FOOT SQUARE TARGET AT --- METERS
PROGRAM NO. R453R - CHARGE TO R701R

DIMENSION Z(400), AREA(I)

ARIN = 0.
READ 680, (AREA(I), I = 1, 400)
DO 5 I = 1, 400
Z I = I
5 Z(I) = ZI/100.
XMETFT = 3.2808333
PRINT 704, (Z(I), AREA(I), I = 1, 400)
PRINT 706
READ 681, RSDIN, RINC, RSDFI, TARG, DIST
IF(RSDIN) 999, 999.12
PRINT 700, TARG, DIST
PRINT 701
PRINT 702
PRINT 703
CONV = (XMETFT * DIST) / 1414.214
RSD = RSDIN
15 COL2 = RSD * CONV
COL3 = (TARG + .5) / COL2
DO 35 I = 2, 400
IF(COL3 - Z(I)) 20, 20, 25
20 COL4 = AREA(I)
COL5 = COL3 * COL4 * 100.
COL6 = ARIN
GO TO 50
25 IF(COL3 - Z(I)) 30, 30, 35
30 COL4 = AREA(I) - AREA(I-1)
COL5 = (COL3 - Z(I-1)) * COL4 * 100.
COL6 = AREA(I-1)
GO TO 50
35 CONTINUE
50 COL7 = COL5 + COL6
PHX = 2.5*COL7
PH = PHX + PHX
PRCMT = PH = 100.
PRINT 705, RSD,COL7,COL3,COL4,COL5,COL6,COL7,PHX,PH,PRCNT
RSD = RSD + MNC
IF[RSD = RSDFI] 15, 15, 55
55 PRINT 706
GO TO 10
999 STOP
680 FORMAT [8(F4.4,6X)]
681 FORMAT [5F10.0]
700 FORMAT [8X,25MPROBABILITY OF A HIT ON A. F6.2,23H FOOT SQUARE TA
1RGET AT,F6.0,8H METERS/]
701 FORMAT [74H RADIAL LINEAR INTER- AREA OF
1PMX PMX PH] 702 FORMAT [82H STD DEV STD DEV POLA- NORMAL ON
1 HALF FULL FULL TGT PER] 703 FORMAT [83H -MILS -FEET Z DIFF TION CURVE OF
1 TGT TARGET X AND Y CENT/]
704 FORMAT[10(F5.2,F7.4)]
705 FORMAT [F7.1,F12.4,F8.4,F9.2]
706 FORMAT [1M1]
END
4. PROGRAM R454R

a. DESCRIPTION

This program gives calculations for single-shot and ten-shot hit probabilities in a direct approach to the target. In addition, it gives single- and ten-shot hit probabilities for targets approached at two different angles from the horizontal where, for a 50-foot target at approach angle of 25 degrees,

\[
x = 25
\]

\[
y = 25 \cos 25^\circ
\]

Load limits equal 2586 (DECIMAL) words.

b. OUTPUT

(1) First page - Values of the normal curve as read in from 80-column cards.

(2) Second and subsequent pages -

<table>
<thead>
<tr>
<th>Column</th>
<th>Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>RSDIN</td>
<td>Initial radial standard deviation - mils</td>
</tr>
<tr>
<td>6-10</td>
<td>RINC</td>
<td>Increments of RSD</td>
</tr>
<tr>
<td>11-15</td>
<td>RSDFI</td>
<td>Final RSD</td>
</tr>
<tr>
<td>16-20</td>
<td>DSTIN</td>
<td>Initial distance from target - meters</td>
</tr>
<tr>
<td>21-25</td>
<td>DEINC</td>
<td>Increments of distance</td>
</tr>
</tbody>
</table>

-10-
c. **INPUT**

<table>
<thead>
<tr>
<th>Column</th>
<th>Name</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>26-30</td>
<td>DSTFI</td>
<td>Final distance from target</td>
</tr>
<tr>
<td>31-35</td>
<td>TRGIN</td>
<td>Initial length and width of target - feet</td>
</tr>
<tr>
<td>36-40</td>
<td>TINC</td>
<td>Increments of target edge</td>
</tr>
<tr>
<td>41-45</td>
<td>TRGFI</td>
<td>Final target edge</td>
</tr>
<tr>
<td>46-50</td>
<td>APP1</td>
<td>First approach angle</td>
</tr>
<tr>
<td>51-55</td>
<td>APP2</td>
<td>Second approach angle</td>
</tr>
<tr>
<td>56-60</td>
<td>COUNT</td>
<td>Line count per page</td>
</tr>
</tbody>
</table>

Line count of the sample problem was 44 lines, which includes a 4-line count for the heading and 40 printed lines of data. Title lines and page numbers are not included in the count.

-11-
PROGRAM R454R  PHIT ON A SQUARE TARGET AT DIRECT AND TWO ANGULAR APPROACHES

START

DIMENSION E(400), AREA(400)

697 TITLE: // 698 SUBHEADIN: // 699 COL HEAD:

READ 680 AREA(I), I=1,400

DO 5 I = 1, 400
   ZI = 1
   Z(I) = ZI/100.

PRINT 711 Z(I), AREA(I)
   I = 1, 400
   PRINT 705 SLEW

IDENT = 3.28082333
DEGAR = .0174533
KN = 0
KDE = 1
IPG = 0
ICODE = 1

READ 681 RSIN, KIXG, RSDOF
DSTIN, DINC, DSTD

CONV = (QDMFT*DST)/1414.214
DEVST = RS*CONV

TRG = TRGIN

50

ZINC = (TRG*5)/DEVST

55

DO 75 I = 2, 400

60

IF Z(I) > ZINC = ZINC*AREA(I)+200.

65

IF Z(I) < ZINC = ZINC*AREA(I)+200.

70

PH = ((ZINC-Z(I-I)**(ARE(I)-ARE(I-1)**100)+ARE(I-1)**2).

75

CONTINUE

80

ICODE = 1

88

PH1 = PH+PH
PH4 = 1.-(1.-PH1)**10
PHY = PH
ZING = ZING
ICODE = 1
APCO = COS(F2*DEGAR)
ZINC = ZINC*APCO

93

PH2 = PH+PHY
PH5 = 1.-(1.-PH2)**10
ICODE = 3
APCO = COS(AP2*DEGAR)
ZINC = ZINC*APCO

98

PH6 = 1.-1.-PH2)**10
ICODE = 1

103
PROGRAM R454H  CHARGE TO 9701R  BY H. LUNDY
PROBABILITY OF A HIT ON A SQUARE TARGET AT DIRECT AND 2 ANGULAR APPROACHES
INTERPOLATED FROM 400 VALUES OF THE NORMAL CURVE READ IN FROM CARDS
ICODE = STORAGE CONTROL
IPG = COUNT OF PAGES
KNT AND KOUNT = COUNT OF PRINTED LINES
ICODE = FORMAT CONTROL
DIMENSION Z(400), AREA(400)
PRINT 697
PRINT 698
PRINT 699
READ 680,(AREA(I), I = 1, 400)
DO 5 I = 1, 400
ZI = I
5 Z(I) = ZI/100,
PRINT 711,(Z(I), AREA(I), I = 1, 400)
PRINT 705
XMETFT = 3.2808333
DEGRAD = .0174533
KNT = 0
ICODE = 0
IPG = 0
ICODE = 1
20 READ 681,RSDIN,RINC,RSDFI,DSTIN,DINC,DSTFI, TKGIN,TINC,TRGFI, APP1
1,APP2,COUNT
IF(RSDIN) 999,999,25
25 KAPP1 = APP1
KAPP2 = APP2
KOUNT = COUNT
IF(KNT) 28,28,30
28 PRINT 700
PRINT 701
PRINT 702,KAPP1,KAPP2,KAPP1,KAPP2
KNT = KNT + 4
IPG = IPG + 1
30 RSD = RSDIN
35 DST = DSTD
40 IDST = DST
CONV = (XMETFT * DST) / 1414.214
DEVST = RSD * CONV
45 TRG = TRGIN
50 ZING = [TRG * .5] / DEVST
55 DO 75 I = 2, 400
IF(ZING = Z[1]) 60, 60, 65
60 PH = [ZING * AREA[1] * 200.]
   GO TO 80
65 IF(ZING = Z[1]) 70, 70, 75
70 PH = [[ZING - Z[I-1]) * (AREA[I] - AREA[I-1]) * 100.] + AREA[I-1]
   1/2,
   GO TO 80
75 CONTINUE
80 GO TO [88, 93, 98], ICODE
88 PH1 = PH = PH
   PH4 = 1. - [1. - PH1]**10
   PHY = PH
   ZING0 = ZING
   ICODE = 2
   APICO = COSF(APP1 + DEGRA8)
   ZING = ZING * APICO
   GO TO 55
93 PH2 = PH = PHY
   PH5 = 1. - [1. - PH2]**10
   ICODE = 3
   AP2CO = COSF(APP2 + DEGRA8)
   ZING = ZING0 * AP2CO
   GO TO 55
98 PH3 = PH = PHY
   PH6 = 1. - [1. - PH3]**10
   ICODE = 1
103 IF(KNT = KOUNT) 110, 105, 105
105 PRINT 703
PRINT 704,IPG
PRINT 705
PRINT 706
PRINT 707
PRINT 708,THG,PH1,PH2,PH3,PH4,PH5,PH6
KNT = KNT + 1
GO TO 130
110 GO TO [115,120,125], KODE
115 PRINT 706,RSO,IDST,THG,PH1,PH2,PH3,PH4,PH5,PH6
GO TO 130
120 PRINT 707,IDST,THG,PH1,PH2,PH3,PH4,PH5,PH6
GO TO 130
125 PRINT 708, THG,PH1,PH2,PH3,PH4,PH5,PH6
130 KNT = KNT + 1
IF(TINC) 140,140,135
135 TRG = TRG + TINC
KODE = 3
IF(TRG = TRGFI) 50,50,140
140 IF(DINC) 150,150,140
145 DST = DST + DINC
KODE = 2
IF(DST = DSTFI) 40,40,150
150 IF(RINC) 20,20,155
155 RSD = RSD + RINC
KODE = 1
IF(RSD = RSDFI) 35,35,20
999 PRINT 703
PRINT 709
STOP
680 FORMAT (8(F4.4,6X))
681 FORMAT (12F5.0)
697 FORMAT (13X,93H PROGRAM NO R454R PROBABILITY OF A HIT ON A SQUARE
1TARGET AT DIRECT AND 2 ANGULAR APPROACHES//)
698 FORMAT (49X,22H AREA OF A NORMAL CURVE//)
699 FORMAT (10(12H / AREA )//)
700 FORMAT (23H RADIAL TARGET,25X,15WHIT PROBABILITY)
701 FORMAT (22H STD DEV RANGE SIZE,17X,11HSINGLE SHOT,15X,9HTEN SHO
1TS)
702 FORMAT (40H -MILS METERS FT X FT APPROACH 0 DEG,14.4H DEG,14.
14H DEG,8H 0 DEG,14.4H DEG,14.4H DEG/)  
703 FORMAT (//)
704 FORMAT (37X,4HPAGE,I3)
705 FORMAT (1H1)
706 FORMAT (F6.1,18,F9.2,F17.4,5F8.4)
707 FORMAT (6X,18,F9.2,F17.4,5F8.4)
708 FORMAT (14X, F9.2,F17.4,5F8.4)
709 FORMAT (14H END OF REPORT)
711 FORMAT (10(F5.2,F7.4))
END
<table>
<thead>
<tr>
<th>RADIAL STD DEV</th>
<th>RANGE METERS</th>
<th>TARGET SIZE FT X FT</th>
<th>SINGLE SHOT APPROACH 0 DEG 25 DEG 45 DEG</th>
<th>HIT PROBABILITY 0 DEG 25 DEG 45 DEG</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.5</td>
<td>1000</td>
<td>50.00</td>
<td>0.6146 0.7826 0.6859 1.0000 1.0000</td>
<td>0.6146 0.7826 0.6859 1.0000 1.0000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100.00 0.9080 0.9996 0.9000 1.0000</td>
<td>0.9080 0.9996 0.9000 1.0000 1.0000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1500 0.5342 0.4995 0.4133 0.9995</td>
<td>0.9995 0.9995 0.9995 0.9995 0.9995</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2000 0.9464 0.9289 0.9580 1.0000</td>
<td>0.9464 0.9289 0.9580 1.0000 1.0000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2500 0.3514 0.3246 0.2621 0.9882</td>
<td>0.3514 0.3246 0.2621 0.9882 0.9922</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3000 0.8146 0.7826 0.6850 1.0000</td>
<td>0.8146 0.7826 0.6850 1.0000 1.0000</td>
</tr>
<tr>
<td></td>
<td>50.00</td>
<td></td>
<td>0.2479 0.2226 0.1778 0.9313</td>
<td>0.2479 0.2226 0.1778 0.9313 0.9313</td>
</tr>
<tr>
<td></td>
<td>100.00</td>
<td></td>
<td>0.6646 0.6282 0.5313 1.0000</td>
<td>0.6646 0.6282 0.5313 1.0000 1.0000</td>
</tr>
<tr>
<td></td>
<td>150.00</td>
<td></td>
<td>0.4179 0.4069 0.3437 1.0000</td>
<td>0.4179 0.4069 0.3437 1.0000 1.0000</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td></td>
<td>0.3542 0.4995 0.4133 0.9995</td>
<td>0.3542 0.4995 0.4133 0.9995 0.9995</td>
</tr>
<tr>
<td></td>
<td>2500</td>
<td></td>
<td>0.9464 0.9289 0.9580 1.0000</td>
<td>0.9464 0.9289 0.9580 1.0000 1.0000</td>
</tr>
<tr>
<td></td>
<td>3000</td>
<td></td>
<td>0.3514 0.3246 0.2621 0.9882</td>
<td>0.3514 0.3246 0.2621 0.9882 0.9922</td>
</tr>
</tbody>
</table>

PAGE 1
5. PROGRAM R455R

a. DESCRIPTION

This program gives the same 9-column output as Program R454R, but the calculations are based on integration of the normal curve by Simpson's 1/3 Rule. The actual integration is carried out by use of the equation

\[ Y(I) = \frac{1}{\sqrt{2\pi}} e^{-\frac{t^2}{2}} \]

or

\[ Y(I) = 0.392944 \times \text{EXP}(-X \times X \times 0.5) \]

in the SUBROUTINE CVNORM. Load limits equal 2151 (DECIMAL) words, including the SUBROUTINE.

b. OUTPUT

Same as second and subsequent pages of Program R454R except that the final page also gives the number of incremental areas considered in the calculations.

c. INPUT

(1) First Card, Columns 1-5, number of increments - area to be calculated, I format.

(2) Second Card, Data Card fully described under Program R454R.
PROGRAM R455R.  "HIT ON A SQUARE TARGET AT DIRECT AND TWO ANGULAR APPROACHES"

INTEGRATION OF THE NORMAL CURVE BY SIMPSON'S 1/3 RULE

START

COMMON
ZINC,ZAREA,N,NN

PRINT 697 TITLE

XMETHFT = 3.28083333
DEGRAD = .0174533
KNT = 0
KODE = 1
IPG = 0
ICODE = 1

READ 680

READ 681
RSDIN,RINC,RDSDFI
DSTIN,DINC,DSTIFI
TRGIN,TINC,TRGFI
APP1,APP2,COUNT

CALL CVNORM

ICODE = 1

PH = ZAREA*2,

ICODE = 2

PH2 = PH*PH
PH4 = 1.-(1.-PH2)**10
PH5 = PH
PH6 = 1.-(1.-PH4)**10
ICODE = 3
APICO = COSF(APP2*DEGRAD)
ZINC = ZINC*APICO

ICODE = 3

PH3 = PH*PH
PH6 = 1.-(1.-PH3)**10
ICODE = 1

STOP

HEADINGS

KNT = KNT+1

END
~ PROGRAM R455H  CHARGE TO R701R  BY M. LUNNY
~ PROBABILITY OF A HIT ON A SQUARE TARGET AT DIRECT AND 2 ANGULAR APPROACHES
~ INTEGRATION OF THE NORMAL CURVE BY SIMPSONS 1/3 RULE
~ SUBROUTINE CVNORM IS CALLED
~ N MUST BE ODD
~ ICODE  = STORAGE CONTROL
~ IPG   = COUNT OF PAGES
~ KNT AND KOUNT = COUNT OF PRINTED LINES
~ KODE  = FORMAT CONTROL
~ COMMON ZING, ZAKEA, N, NN
~ PRINT 697
~ XMETFT = 3.28083333
~ DEGRAD = .0174533
~ KNT = 0
~ KODE = 1
~ IPG = 0
~ ICODE = 1
~ 20 READ 680, N
~ READ 681,KRSN1,KINC,RSDF1,DSTN,DINC,DSTF1,THGIN,TINC,T96F1,APP1
~ 1,APP2,COUNT
~ IF(KRSN1) 999,999,25
~ 25 KAPP1 = APP1
~ KAPP2 = APP2
~ KOUNT = COUNT
~ IF(KNT) 28,28,30
~ 28 PRINT 700
~ PRINT 701
~ PRINT 702,KAPP1,KAPP2,KAPP1,KAPP2
~ KNT = KNT + 4
~ IPG = IPG + 1
~ 30 RSD = RSDN
~ 35 DST = DSTN
~ 40 IDST = DST
~ CONV = [XMETFT * UST] / 1414.214
~ DEVST = RSD * CONV
~ 45 TRG = THGIN
~ 50 ZING = (TRG * .5) / DEVST
55 CALL CVNOHM
   PH = ZAKHA * 2.
80 GO TO [6H,93,98], ICODE
88 PH1 = PH * PH
   PH4 = 1. - (1. - PH1) * 10
   PHY = PH
   ZINGO = ZING
   ICODE = 2
   AP1CO = COSFAPP1 * UEGRAD
   ZING = ZING * AP1CO
   GO TO 55
93 PH2 = PH * PHY
   PH5 = 1. - (1. - PH2) * 10
   ICODE = 3
   AP2CO = COSFAPP2 * UEGRAD
   ZING = ZING * AP2CO
   GO TO 55
98 PH3 = PH * PHY
   PH6 = 1. - (1. - PH3) * 10
   ICODE = 1
103 IF(KNT = KOUNT) 110,105,105
105 PRINT 703
   PRINT 704,IPG
   PRINT 705
   PRINT 700
   PRINT 701
   PRINT 702,KAPP1,KAPP2,KAPP1,KAPP2
   PRINT 706,RSU,IDST,THG,PH1,PH2,PH3,PH4,PH5,PH6
   KNT = 4
   IPG = IPG + 1
   GO TO 130
110 GO TO [115,120,125], KODE
115 PRINT 706,RSU,IDST,THG,PH1,PH2,PH3,PH4,PH5,PH6
   GO TO 130
120 PRINT 707,IST,THG,PH1,PH2,PH3,PH4,PH5,PH6
   GO TO 130
125 PRINT 704,THG,PH1,PH2,PH3,PH4,PH5,PH6
130 KNT = KNT + 1
IF (TINC) 140, 140, 135
135 TRG = TRG + TINC
KODE = 0
IF (TRG = TRG PAY) 50, 50, 140
140 IF (TINC) 150, 150, 145
145 UST = DST + TINC
KODE = 2
IF (UST = UST PAY) 40, 40, 150
150 IF (TINC) 20, 20, 155
155 RSD = RSD + TINC
KODE = 1
IF (RSD = RSD PAY) 35, 35, 20
999 PRINT 703
PRINT 712, WN
PRINT 709
STOP
680 FORMAT (15)
681 FORMAT (12F9.0)
697 FORMAT (30H PROGRAM R455R BY M. LUNDY 77H PROBABILITY OF A
1 HIT ON A SQUARE TARGET AT DIRECT AND 2 ANGULAR APPROACHES/)
700 FORMAT (23H RADIAL TARGET, 25X, 13H HIT PROBABILITY/)
701 FORMAT (23H STD DEV RANGE SIZE, 11H SINGLE SHOT, 15X, 9HTEN SHO
ITS/)
702 FORMAT (4H MILS METERS FT X FT APPROACH 0 DEG, 14, 4H DEG, 14,
14H DEG, 8H 0 DEG, 14, 4H DEG, 14, 4H DEG/)
703 FORMAT (//1)
704 FORMAT (37X, 4HPAGE, 15)
705 FORMAT (1MH1)
706 FORMAT (F6.1, 13, F9.2, F17.4, 5F8.4)
707 FORMAT (6X, 13, F9.2, F17.4, 5F8.4)
708 FORMAT (14X, F9.2, F17.4, 5F8.4)
709 FORMAT (14H END OF REPORT)
712 FORMAT (13H HIT PROBABILITY CALCULATIONS BASED ON, 14, 39H INCRE
MENTAL AREAS OF THE NORMAL CURVE/)
END

SA-TR-20-2818
SUBROUTINE CVNORM
COMMON ZING, ZAREA, N, NN
DIMENSION Y(500)
XN = N
NN = N + 1
CON = .3989422
Y(1) = CON
SUM = 0.
X = 0.
DX = ZING / (XN - 1.)
DO 58 I = 2,N
   X = X + DX
   58 Y(I) = CON * EXPF(-X * X * .5)
   DO 60 I = 1,NN,2
   60 SUM = SUM + Y(I) + 4.*Y(I+1) + Y(I+2)
ZAREA = DX * SUM / 3.
RETURN
END
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<th>RADIAL RANGE</th>
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<th>HIT PROBABILITY</th>
<th>TEN SHOTS</th>
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Page 1
### RADIAL STD DEV RANGE SIZE

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**Hit Probability Calculations Based on 100 Incremental Areas of the Normal Curve**

**End of Report**
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Note: The table represents the probability of a hit on a square target at direct and angular approaches. The values indicate the percentage of hits within the specified radial error at each target size.
**Abstract**

Probability of a hit by a single shot or by a ten-shot burst at direct or angular approach to a square target is calculated. Parameters include dispersion in mils, distance from the target in meters, and size of the target in feet. A normal distribution is assumed. Solution by linear interpolation of normal curve areas from standard tables was accurate to 0.0002 when contrasted with integration of the normal curve by Simpson's 1/3 Rule in sample problems.
### UNCLASSIFIED

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2. Target
3. Digital computer
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