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MEASUREMENTS OF RANGE, DEFLECTION,
TIME OF FLIGHT, AND HEIGHT OF BURST
FOR FIRED ARTILLERY SHELL
METHOD I - TRIANGULATION

NEAL P. ROBERTS

SEPTEMBER 1990

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BALLISTIC RESEARCH LABORATORY
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13. ABSTRACT Triangulation, the means by which test range measurements are converted into measurements of range, deflection, height of burst, and time of flight for a fired artillery shell, is explained. This is done by describing the engineering and mathematics behind the technique as currently practiced on today's proving grounds and, also, by discussing the associated accuracy. An alternative to triangulation is suggested under certain circumstances.				
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TABLE OF CONTENTS

	<u>Page</u>
LIST OF FIGURES	v
ACKNOWLEDGEMENTS	vii
1. INTRODUCTION	1
2. THE OPERATIONAL ASPECTS OF TRIANGULATION	1
3. TRIANGULATION	3
4. DISCUSSION.	4
5. CONCLUSION.	5
APPENDIX A: LISTING OF INPUT TO TRIANGULATION PROGRAM; DEFINITIONS OF INPUT TO TRIANGULATION PROGRAM; DESCRIPTION OF INPUT TO TRIANGULATION PROGRAM	13
APPENDIX B: LISTING OF TRIANGULATION COMPUTER PROGRAM WRITTEN FOR THE ABERDEEN PROVING GROUND, MARYLAND, BY DENNIS FLAHERTY	19
APPENDIX C: SAMPLE INPUT TO TRIANGULATION COMPUTER PROGRAM	35
APPENDIX D: SAMPLE OUTPUT FROM TRIANGULATION COMPUTER PROGRAM	39
BIBLIOGRAPHY	51
DISTRIBUTION LIST	53



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LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1.	One Tower Reading.	6
2.	Two Tower Readings.	7
3.	Three Tower Readings.	8
4.	Four Tower Readings.	9
5.	Illustration of How Range and Deflection are Computed.	10
6.	Illustration of How Height of Burst (HOB) is Computed.	11

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1. INTRODUCTION

Test range measurements for fired artillery shells are of great importance to ballisticians, members of the scientific community who study the motion of artillery projectiles and missiles. The accuracy of aiming data developed by ballisticians can only be expected to be as good as the accuracy of test range measurements taken at a proving ground. It follows that an understanding as to how measurements of range, deflection, time of flight, and height of burst for a fired artillery shell are obtained should be of value to the ballistician. Actually, such knowledge would benefit any weapon systems engineer who must make decisions either directly or indirectly by depending on the use of aiming data.

This report will deal with the actual engineering upon which triangulation is based, as well as the analytical and mathematical procedures by which observer measurements are converted into measurements of range, deflection, height of burst, and time of flight. It is designed to give an individual an introduction to the triangulation technique. However, a copy of the triangulation analytical computer program is included (Appendix B), as well as sample data input (Appendix C) and corresponding data output (Appendix D). This will also allow one to study triangulation in as much detail as desired.

2. THE OPERATIONAL ASPECTS OF TRIANGULATION

Suppose one wants to obtain test range measurements for a M483A1 projectile fired at a quadrant elevation of 950 mils from a M198 howitzer using a particular charge. Also, suppose that one wants the projectile to burst at a height of approximately 200 meters above ground.

The first step is to estimate how far the projectile will fly and to determine the fuze setting required to obtain the desired height of burst. From a tabular firing table or field computer, the test engineer will determine approximate range, deflection (drift), and fuze-setting-to-burst values. Then, knowing the position coordinates of the howitzer and its azimuth of fire from survey, the test engineer will have an idea as to where down range the projectile can be expected to burst.

Accordingly, up to four observers are stationed in towers most opportune in location to the expected burst and impact areas. From survey, the location and heights of the towers are known. Each tower observer will make use of an instrument called a modified transit, which is a transit equipped with a monocular lens with crosshairs that magnifies and has a wide field of view. With this instrument each observer can measure azimuth and elevation angular values with respect to the tower after sighting the burst event through the monocular lens.

During the shoot, each observer will be in radio contact with the gun. Thus, upon firing, each observer will know when to start his stopwatch and will know when to expect burst or impact. Whenever video is not used, it is customarily the responsibility of the observer to obtain time of flight of the round fired as well as angular measurements to burst or impact.

In a test situation, practice rounds called spotters are usually shot first so that it becomes relatively certain that each observer will be successful in obtaining all measurements for the actual firing of the round.

It follows from the engineering behind triangulation that the test range measurements obtained for a fired projectile are as follows:

- 1) tower locations and heights
- 2) azimuth, elevation, and time of flight measurements from each tower
- 3) location and azimuth of gun.

The test range measurements obtained above must be converted into range, deflection, height of burst, and average time of flight. The next section of this report will show how mathematical procedures can be used to do this.

3. TRIANGULATION

Triangulation is the analytical mathematical procedure for obtaining ranges, deflections, heights of burst, and time of flights for fired projectiles from raw test range data. For an air burst round, one first wants to compute the range and deflection from the gun point to the perpendicular projection of the air burst point to the ground ("impact point"). The range is the distance from the weapon to the perpendicular projected point on the ground and the deflection is the angular and linear distance from the weapon line-of-fire to the same point.

"Impact points" are computed from azimuth readings taken from one, two, three, or four towers. There are four modes of computing impacts - one for each tower combination.

For one tower, the "impact point" is determined by the intersection of the gun azimuth and tower azimuth. On the computer output, the deflection will be dashes. The range is the distance from the point of intersection to the weapon position (Figure 1).

For two towers, the "impact point" is determined by intersecting both tower azimuths. Range is defined as above. Deflection from line-of-fire is computed as a perpendicular distance from "impact" to the line-of-fire and as an angle between the line-of-fire and vector from weapon to "impact point" (Figure 2).

For three towers, the "impact point" is computed as the average of three intersection points of the three azimuth readings with the restriction that the area of the triangle determined by the three intersection points be less than a specified test area, usually 50 square meters. If the area is greater than this specified test area, the azimuths are considered erroneous and the output consists of azimuth corrections. If the computed area is less than or equal to the test area, the "impact" is taken to be the average of the three intersection points. The range and deflection are computed in the same manner described in the case for two towers (Figure 3).

For four towers, the towers are grouped three to a set to form various combinations. That combination which forms the smallest triangular area will be used to determine the range and

deflection, provided its area is less than or equal to the specified test area. "Impact" is the average of the three intersections. Range and deflection are computed as before (Figure 4).

The geometry and trigonometry of how range and deflection are computed for two, three, or four tower readings are illustrated in Figure 5.

Computing altitude (height of burst) for an airburst round from the elevation measured from a tower is illustrated in Figure 6. Altitudes are computed for each tower and then averaged. Times of flight measured with stop clocks from each tower are also averaged.

The triangulation computer program written for the Aberdeen Proving Ground (APG) by Dennis Flaherty and related information are shown in Appendices A, B, C, and D. It should be noticed in his program that azimuths are measured clockwise from due south. Notice also that the cartesian coordinate system with origin at the gun has its x-axis inclined 35 degrees from due south and is right-handed with the positive z-axis going into the ground. The program can easily be modified for use at Yuma and Dugway Proving Grounds where azimuths are measured clockwise from due north and where the cartesian coordinate system with origin at the gun has its x-axis due north and its y-axis due east.

4. DISCUSSION

The accuracy of triangulation is very good if we can assume that at least three tower azimuth readings are good and if we can assume that the true impact is within the formed triangle. Making such assumptions and supposing that the formed triangle is a square right triangle of 50 square meters, the range and deflection errors cannot be larger than 7.46 meters.

For small ground impact firing tests, it is possible for a person to mark the crater location formed by the impacting round with a stake and to have all towers triangulate on the stake. If one does this, one should obtain near perfect accuracy for range and deflection values. However, this process is very laborious and time consuming, and is impractical to be used for large test firing plans. In such cases,

and for air burst occasions, burst sightings from towers are relied upon. When so, it is conceivable that all towers can triangulate perfectly but because of like systematic tower errors, be off the true mark.

Triangulation, which is based on burst sightings, does have its critics. Mr. Robert Lieske, a supervisor and colleague of mine, has argued that when four tower readings are used under such circumstances and all four readings are relatively good, triangulation does not use all the information it has access to. When using many towers, he has suggested an alternative technique based on a least squares method which minimizes angular error and which selectively uses all the information. Mr. Lieske believes that minimizing angular error is more efficient than minimizing the area of a triangle. Hopefully, this technique can be explained in a subsequent report.

5. CONCLUSION

In conclusion, it is hoped by the author that the objectives in writing this report and mentioned in the introduction have been achieved. The triangulation computer program is on the Vax 8600 and 780 computers in the Launch and Flight Division of BRL.

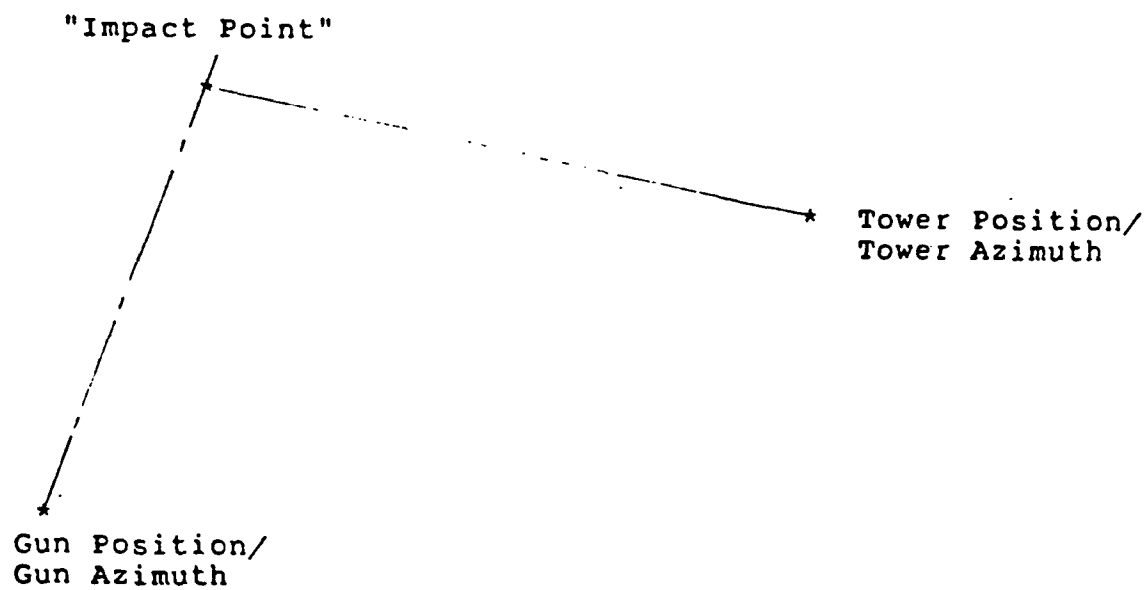


Figure 1. One Tower Reading.

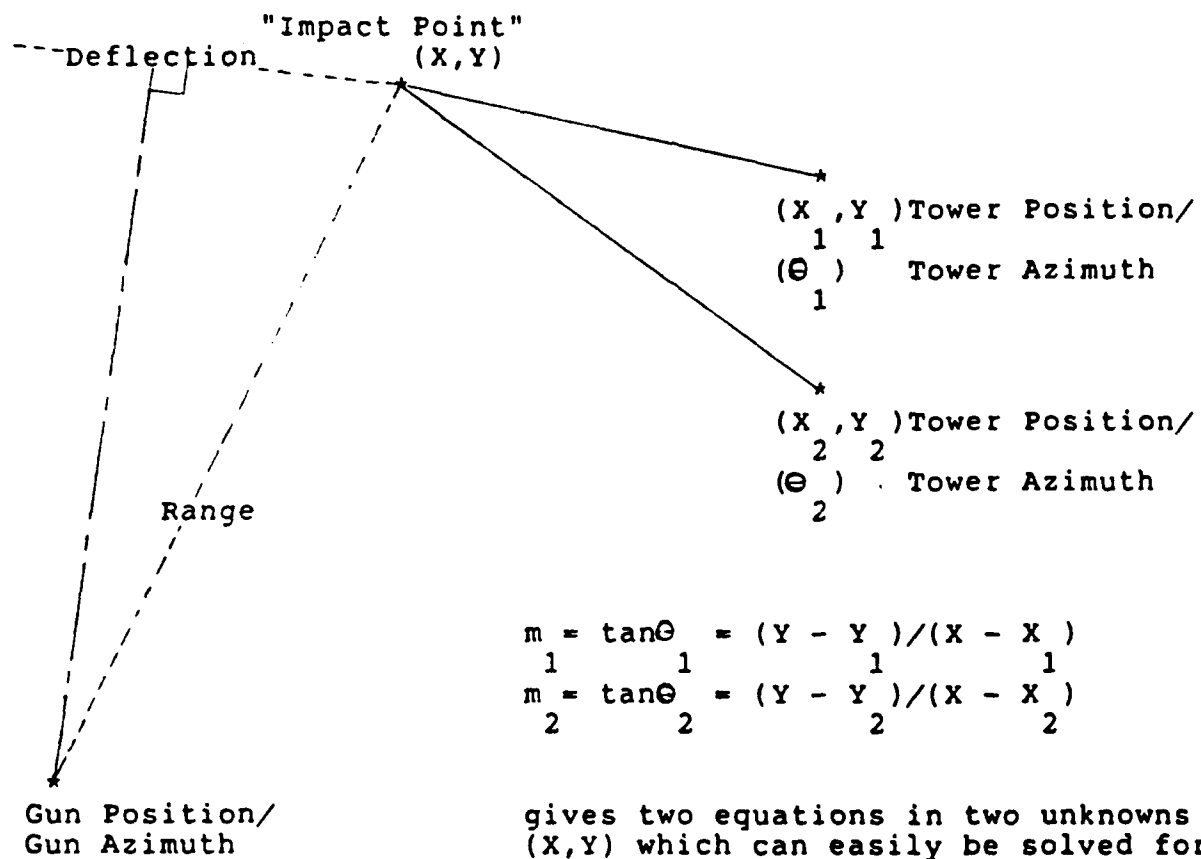


Figure 2. Two Tower Readings.

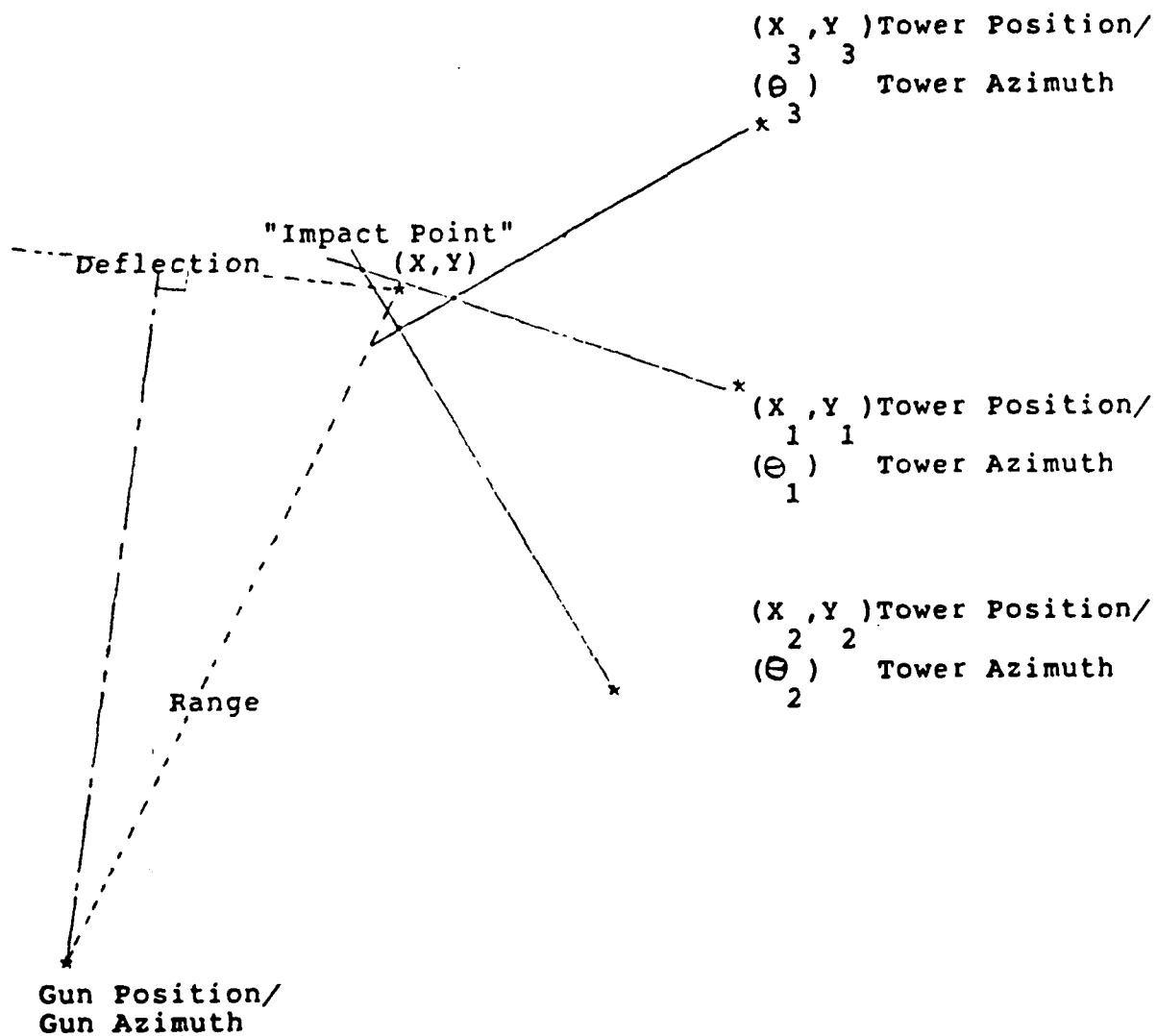


Figure 3. Three Tower Readings.

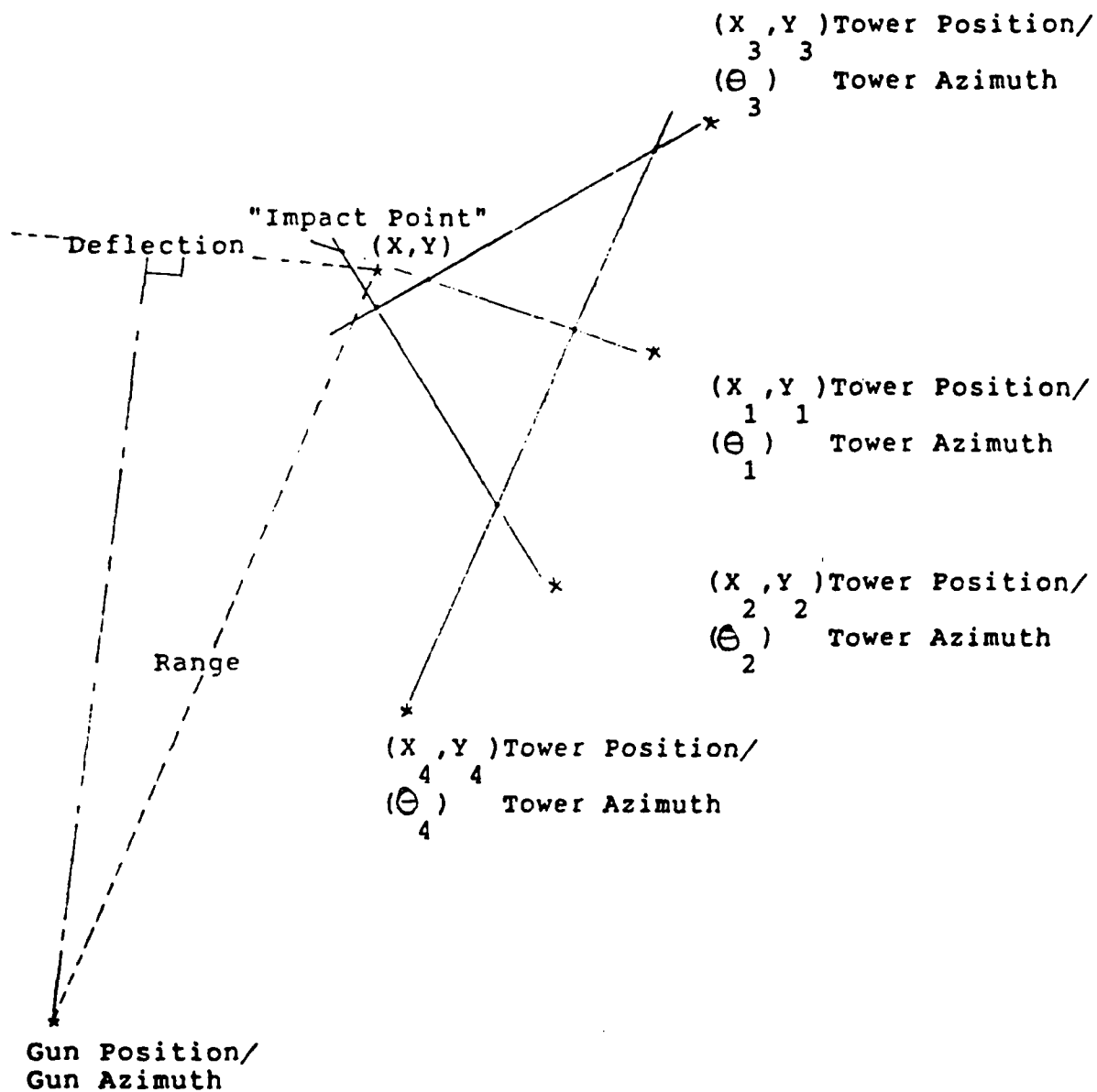


Figure 4. Four Tower Readings.

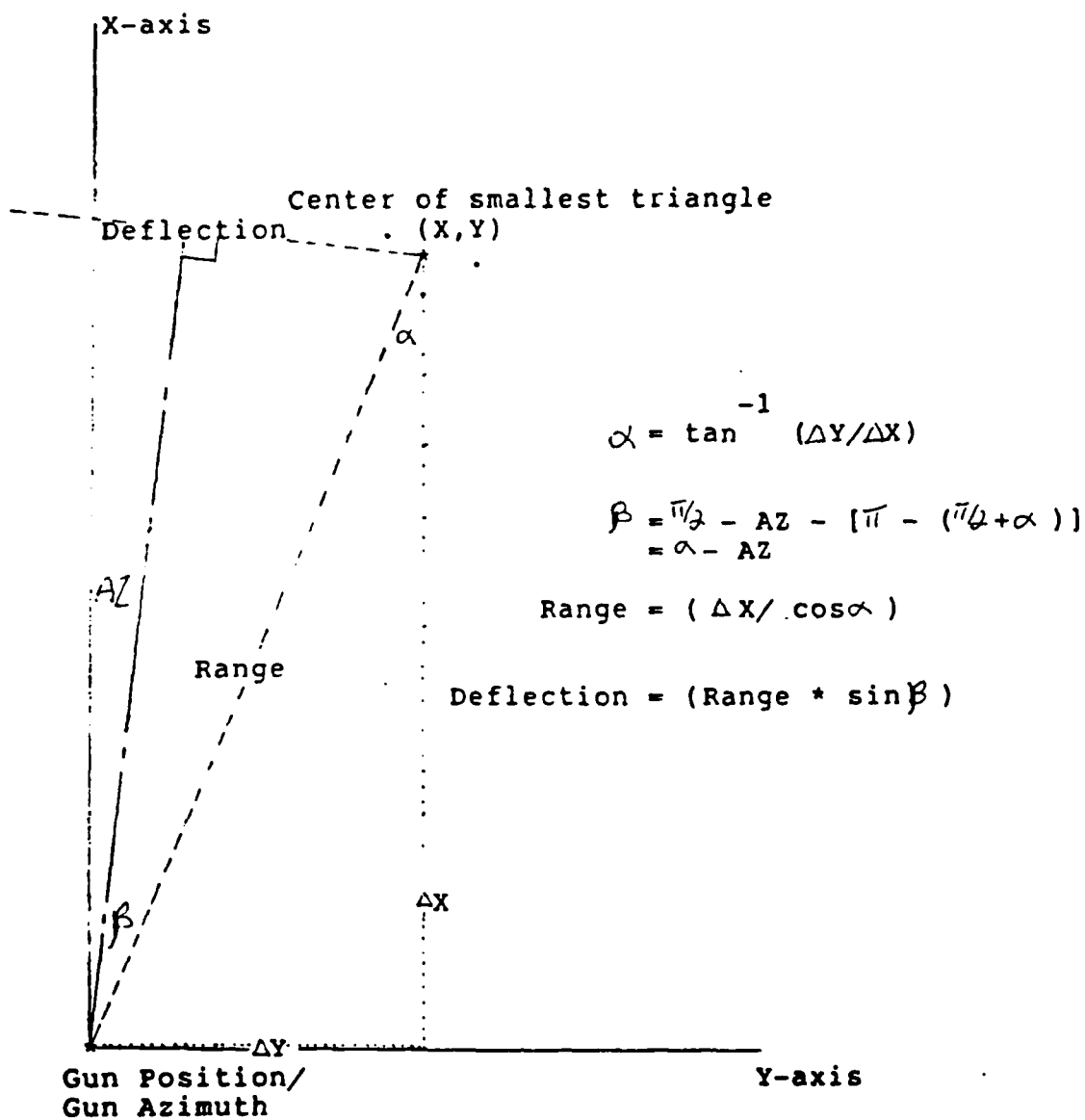


Figure 5. Illustration of How Range and Deflection are Computed.

$$HOB = HI + [R_1 * \tan(ELEV_1)]$$

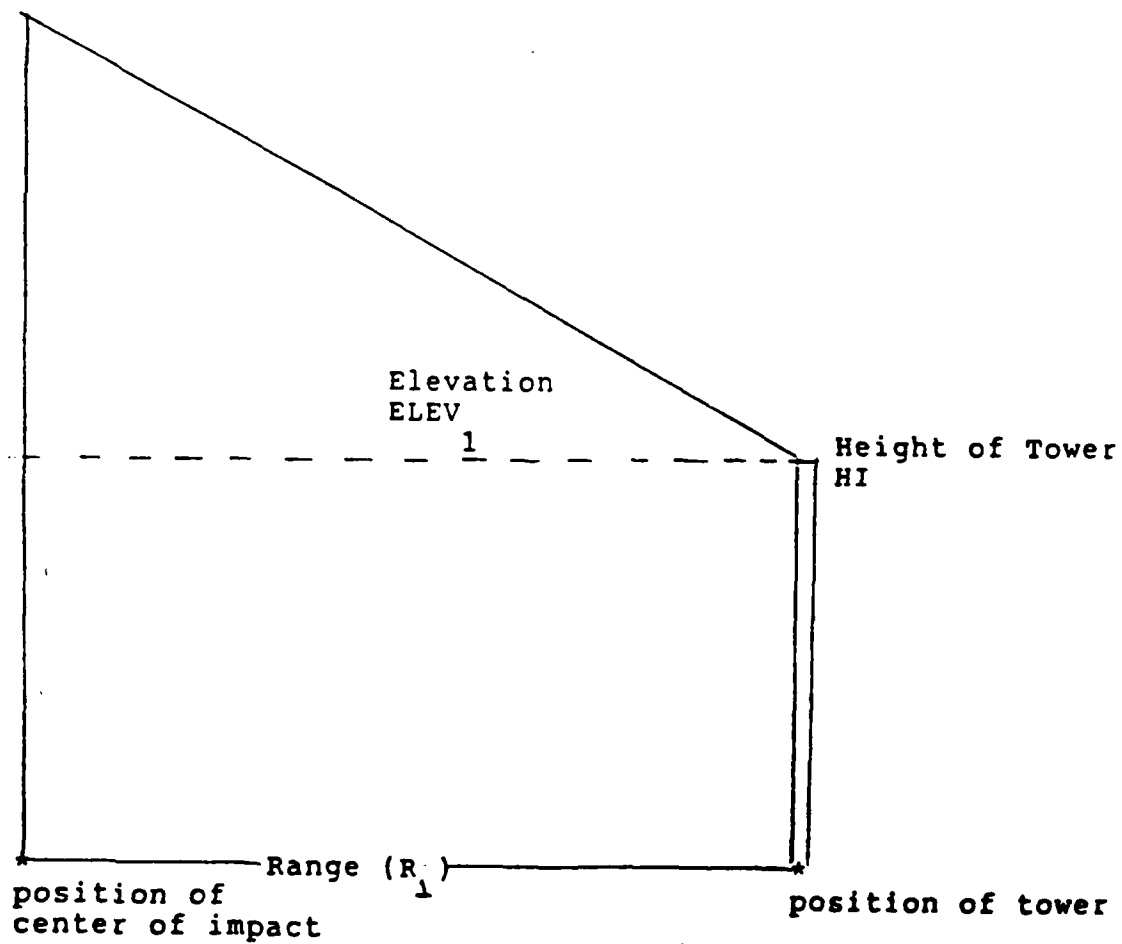


Figure 6. Illustration of How Height of Burst (HOB) is Computed.

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APPENDIX A:
LISTING OF INPUT TO TRIANGULATION PROGRAM;
DEFINITIONS OF INPUT TO TRIANGULATION PROGRAM;
DESCRIPTION OF OUTPUT TO TRIANGULATION PROGRAM

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LISTING OF INPUT TO TRIANGULATION PROGRAM

All input is punched into a file, using the following format.

For IRX = 01 or 02

Items	Format
IRX (01 or 02)	I2
GUN	14A4
XLOC (location)	13A4
DATE	14A4
PRENG (Project Engineer)	11A4
ELEV (Elevation - ft.), ABOVE	F6.2, 1X, 6A4
KRD, N, NSTEP, A	3I4, F20.0
X Y	2F11.3
1 1	
	N < 4
· ·	
X Y	
n n	
X , Y , AZD, AZM	4F11.3
5 5	

For N of Towers:

AZD, AZM, ALX, BEX, ALPHA, TIME, SID 2F7.2, 2F7.2, A8, F6.2, A4
 If blank data use -999 for both AZD and ALX
 If blank data for time, leave TIME blank on input card

·
 ·
 AZD
 n
 +999.

For IRX = 03 or 04

IRX	I2
*U, V, HI, HCOR	4F11.3
*For each tower	
IRX	
999999.	
05 Termination	

Note: Maximum number of tower readings 199.

Note: When using IRX of 03 be sure to use specified point coordinate for gun coordinates if no gun coordinates are given.

DEFINITIONS OF INPUT TO TRIANGULATION PROGRAM

IRX An integer equal to 1,2,3, or 4 - it specifies the type of run.
 1 - Compute range and deflection
 2 - Computes impact coordinates in APG grid system
 3 - Computes distance from specified point (e.g. tower or
 weapon) to impact point
 4 - Computes altitude

GUN 56 character alphanumeric field weapon identification
 XLOC 56 character alphanumeric field weapon location
 DATE 56 character alphanumeric field date
 PRENG 44 character alphanumeric field project engineer
 ELEV Height of weapon (feet)
 ABOVE 24 character alphanumeric field - specifies reference level
 for weapon elevation
 KRD sequence number of first round
 N number of towers
 NSTEP Increment for round number
 A Limiting area (used with 3 or 4 towers)
 X Y Position coordinates of i-th tower (i 4) in APG grid system
 i i
 X Y Position coordinates of weapon, APG system
 5 5
 AZD, AZM Line of fire measured from south, in degrees and minutes
 AZD, AZM (second set) Tower readings measured south in degrees and
 minutes
 ALX, BEX Tower elevation readings of burst height, in degrees and
 minutes
 ALPHA 8 character alphanumeric field used to label a tower reading
 TIME Observed time of flight from a given tower, in seconds
 SID 4 character alphanumeric character S to be used to identify
 a spotter round as opposed to a numbered round
 U, V Position coordinates of tower (used for IRX = 03 or 04) in
 APG system (meters)
 HI Elevation correction, in meters (used for IRX=04)
 HCOR* Elevation correction, in minutes (used for IRX=04)

*As of 26 June 75, there will no longer be a requirement of HCOR for APG firings.

DESCRIPTION OF OUTPUT TO TRIANGULATION PROGRAM

Taking the various conditions in order, the output formats are as follows:

I. IRX = 1

Output is stored until the completion of the processing run. If any error rounds are encountered, the checking routine prints out the corrections as follows:

RANGE FIRING SUMMARY ERROR CORRECTIONS

Round No.	AREA (I6, D16.9) The area has been calculated as larger than the standard value given on input	
Tower X	Azimuth X (2I4, 1X, F7.3)	
Tower Y	Azimuth Y	
Tower Z	Azimuth Z	

To correct such an error one of the tower readings is changed to the azimuth given or the standard area is increased to be greater than the calculated area.

The azimuths are given in integral degrees, and minutes to three decimal places.

If no errors are encountered during the processing run the normal type output process is reached. A page would resemble the following:

RANGE FIRING SUMMARY

COPY 1 OF 3

GUN 175 MM GUN	LOCATION X RANGE
DATE 28 MAY 1969	PROJECT ENGINEER MR. SMITH
ELEVATION OF TRUNNION 6.73 FT ABOVE MLW	

AZIMUTH LINE OF FIRE

RDS 1 to 20 AZ 35D 3.72 M

Rd No.	Deflection		Range meters	Ord of Det	Times of Flight				Mean
	mils	meters			1	2	3	4	
I6	F6.1	F6.1	F8.1	A8	F6.2	F6.2	F6.2	F6.2	F6.2

Three copies are printed for each run.

II. IRX = 2

The error checking procedure and output are the same as for IRX = 1.
The standard output is as follows.

RANGE FIRING SUMMARY

COPY 1 of 3

GUN 175 MM

DATE 28 MAY 1969

ELEVATION OF TRUNNION 6.73 ft above MLW

LOCATION X - RANGE

PROJECT ENGINEER MR. SMITH

AZIMUTH LINE OF FIRE

Rds 1 to 20 AZ 350D 3.72 M

GRID COORDINATES OF POINT OF IMPACT

ROUND	X	Y
I6	F17.2	F17.2

Again three copies are provided.

III. IRX = 3

RANGE FIRING SUMMARY

COPY 1 of 3

ROUND	N* (RANGE, TANGENT BHT)	AV BHT	DIFF
I6	N (1X, F8.1, 1X, F9.5, 1X, F5.1)	F5.1	F5.1

N represents the number of towers or other reference taking readings
1 N 4

ROUND	AVBHT	DIFF	
I6	F5.1	F5.1	These are copies of the respective columns above. Only one copy of this set is provided. There are three for the above.

APPENDIX B:
LISTING OF TRIANGULATION COMPUTER PROGRAM
WRITTEN FOR THE ABERDEEN PROVING GROUND, MARYLAND,
BY DENNIS FLAHERTY

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C	PROGRAM = 52.00	0001
C	IMPACT LOCATION FROM TOWER OBSERVATIONS 1, 2, 3, OR 4 TOWERS	0002
C	FORTTRAN IV	0003
C	APRIL 1966	0004
C	PROGRAM REVISED MARCH 1971	0005
	IMPLICIT REAL*8(A-H,O-Z)	0006
	REAL*4 GUN,XLOC,DATE,PRENG,ELEV,ABOVE	0007
	INTEGER * 4 SID,S,SPOTZ	0008
	COMMON KPOINT,KRDN,DEFLM,DEF,RN,ALP,BET,BHMAX,BHMIN,BHBAR,RNG,TANK	0009
	1,BH,NNTUV	0010
	DIMENSION X(5),Y(5),AZ(201,5),ISB(4),PT(12,2),ISC(3),CNT(2)	0011
	DIMENSION KPOINT(201),KRDN(201),DEFLM(201),DEF(201),RN(201)	0012
	DIMENSION GUN(14),XLOC(13),DATE(14),PRENG(11),ABOVE(6)	0013
	DIMENSION TIME(4,200),ALPHA(4,200),DIV(200)	0014
	DIMENSION ALP(200),BET(200),BBH(3)	0015
	DIMENSION BHMAX(200),BHMIN(200),BHBAR(200)	0016
	DIMENSION RNG(4,200),TANK(4,200),BH(4,200)	0017
	DIMENSION NNTUV(200),IRND(5)	0018
	DIMENSION ALX(5,200),BEX(5,200),SID(4,200),S(50)	0019
	DATA SPOTZ/'S' '/'	0020
10	READ(5,1040)IRX	0021
	GO TO (11,11,12,12,600),IRX	0022
12	READ(5,1011)U,V,HI,HCOR	0023
	IF(U .EQ. 999999.D0) GO TO 450	0024
121	KNTUV=KNTUV+1	0025
	IF(KNTUV .GT. 1) GO TO 122	0026
	DO 1200 MN=1,200	0027
1200	NNTUV(MN)=0	0028
122	IF(IRX .EQ. 3) GO TO 17	0029
123	ICNT=ICNT+1	0030
	M=ICNT	0031
	L=IRND(1)	0032
	DO 15 K=1,L	0033
	IF(ALX(M,K).EQ.-999.D0) GO TO 815	0034
	NNTUV(K)=NNTUV(K)+1	0035
	ALX(M,K)=(ALX(M,K)+(BEX(M,K)+HCOR)/60.D0)*.017453293	0036
815	BET(K)=BEX(M,K)	0037
	ALP(K)=ALX(M,K)	0038
15	CONTINUE	0039
17	GO TO (71,10),IERR	0040
11	READ(5,3100)GUN	0041
	II=1	0042
	DO 1 IQZ=1,50	0043
1	S(IQZ)=SPOTZ	0044
	READ(5,3150)XLOC,DATE,PRENG,ELEV,ABOVE	0045
	READ(5,1000) KRDN,N,NSTEP,A	0046
	KNTUV=0	0047
	DO 13 J=1,200	0048
	BHMAX(J)=0.D0	0049
	BHMIN(J)=999999.D0	0050
	BHBAR(J)=0.D0	0051
13	DIV(J)=N	0052
	IERR=1	0053
	DO 20 I=1,N	0054
20	READ(5,1010)X(I),Y(I)	0055
	READ(5,1011)X(5),Y(5),AZD,AZM	0056
	KDEG=AZD+.5	0057
	DKMIN=AZM	0058
	AZ(1,5)=((AZD+AZM/60.D0)-35.D0)*.017453293	0059
	IRDG=0	0060

	ICNT=0	0061
	DO 70 J=1,N	0062
	K=1	0063
	DO 70 I=1,200	0064
	GO TO (30,60),K	0065
30	READ(5,1030)AZD,AZM,ALX(J,I),BEX(J,I),ALPHA(J,I),TIME(J,I),SID(J,I)	0066
	1)	0067
	AZ(I,5)=AZ(1,5)	0068
32	IF(AZD.EQ.-999.D0) GO TO 60	0069
33	IF(AZD.NE.999.D0) GO TO 50	0070
34	IF (IRDG-I)35,40,40	0071
35	IRDG=I	0072
40	K=2	0073
	IRND(J)=I-1	0074
	GO TO 60	0075
50	AZ(I,J)={(AZD+AZM/60.D0)-35.D0)*.017453293	0076
	GO TO 65	0077
60	AZ(I,J)=99999.D0	0078
65	IF(TIME(J,I))70,66,70	0079
66	DIV(I)=DIV(I)-1.	0080
70	CONTINUE	0081
	IRDG=IRDG-1	0082
	LL=1	0083
71	DO 280 I=1,IRDG	0084
	IF(SID(1,I).EQ.S(II)) II=II+1	0085
	IF(SID(1,I).EQ.S(II)) GO TO 772	0086
	KRDNO=KRD+NSTEP*(LL-1)	0087
	LL=LL+1	0088
772	NHR=1	0089
	J=1	0090
	DO 90 K=1,N	0091
	IF(AZ(I,K).EQ.99999.D0) GO TO 90	0092
80	NHR=NHR+1	0093
	ISB(J)=K	0094
	J=J+1	0095
90	CONTINUE	0096
	GO TO (274,110,120,130,140),NHR	0097
110	ISB(2)=5	0098
120	LSV=1	0099
	CALL POINT(AZ,I,ISB,1,2,X,Y,PT,LSV)	0100
	CNT(1)=PT(1,1)	0101
	CNT(2)=PT(1,2)	0102
	GO TO 254	0103
130	LST=4	0104
	GO TO 150	0105
140	LST=1	0106
150	ARSV=1.D20	0107
	DO 240 L=LST,4	0108
	CALL ISCR(L,ISC)	0109
	IF (NHR-4)160,160,200	0110
160	DO 170 IBC=1,3	0111
170	ISC(IBC)=ISB(IBC)	0112
200	DO 210 J=1,2	0113
	KST=J+1	0114
	DO 210 K=KST,3	0115
210	CALL POINT(AZ,I,ISC,J,K,X,Y,PT,L)	0116
220	CALL AREA(PT,L,AR)	0117
	IF (ARSV-AR)240,230,230	0118
230	ARSV=AR	0119
	LSV=L	0120

240	CONTINUE	0121
	IF (ARSV-A)250,250,300	0122
250	CALL CNTR(PT,LSV,CNT)	0123
254	GO TO (255,280),IERR	0124
255	GO TO (260,270,400,400),IRX	0125
260	CALL RANGE(X(5),Y(5),AZ(1,5),CNT,RN(I),DEFL,DEFLML)	0126
	KPOINT(I)=1	0127
	KRDN(I)=KRDNO	0128
	DEFLM(I)=DEFLML	0129
	DEF(I)=DEFL	0130
	GO TO 280	0131
270	KPOINT(I)=2	0132
	KRDN(I)=KRDNO	0133
	DEFLM(I)=CNT(1)	0134
	DEF(I)=CNT(2)	0135
	GO TO 280	0136
274	GO TO (275,280),IERR	0137
275	KPOINT(I)=3	0138
	IF(IRX .GT. 2) GO TO 280	0139
	KRDN(I)=KRDNO	0140
280	CONTINUE	0141
	GO TO (285,10),IERR	0142
285	GO TO (500,500,10,10,600),IRX	0143
300	GO TO (310,320),IERR	0144
310	IERR=2	0145
	WRITE(6,4000)	0146
320	IF(NHR-4)340,340,330	0147
330	CALL ISCR(LSV,ISC)	0148
	M=3*LSV+1	0149
	GO TO 350	0150
340	M=13	0151
350	IF(SID(1,I).EQ.S(II)) GO TO 352	0152
	WRITE(6,2031)KRDNO,ARSV	0153
	GO TO 353	0154
352	IQ=II-1	0155
	WRITE(6,2033)IQ,ARSV	0156
353	DO 390 J=1,3	0157
	JISC=ISC(J)	0158
	ANUM=PT(M-J,2)-Y(JISC)	0159
	ADEN=PT(M-J,1)-X(JISC)	0160
	CALL ATNSR(ANUM,ADEN,CORR,1)	0161
	CORR=CORR/.017453293+35.D0	0162
360	IF(CORR .LT. 360.D0) GO TO 380	0163
370	CORR=CORR-360.D0	0164
380	ICORR=CORR	0165
	CORR=(CORR-DFLOAT(ICORR))*60.D0	0166
	CORRA=CORR/60.	0167
	CORRH=FLOAT(ICORR)+CORRA	0168
390	WRITE(6,2032)ISC(J),ICORR,CORR,CORRH	0169
	GO TO 280	0170
400	CALL RANGE(U,V,AZ(1,5),CNT,RNG(KNTUV,I),DEFL,DEFLML)	0171
	IF(ALP(I) .EQ. -999.D0) RNG(KNTUV,I)=0.D0	0172
	IF(IRX .EQ. 3) GO TO 425	0173
	KONTRL=1	0174
	IF(ALP(I) .NE. -999.D0) GO TO 420	0175
401	TANK(KNTUV,I)=0.	0176
	BH(KNTUV,I)=0.	0177
	GO TO 280	0178
420	TANK(KNTUV,I)=DTAN(ALP(I))	0179
	BH(KNTUV,I)=RNG(KNTUV,I)*TANK(KNTUV,I)+HI	0180

	BHMAX(I)=DMAX1(BHMAX(I),BH(KNTUV,I))	0181
	BHMIN(I)=DMIN1(BHMIN(I),BH(KNTUV,I))	0182
	BHBAR(I)=BHBAR(I)+BH(KNTUV,I)	0183
	GO TO 280	0184
425	KONTRL=2	0185
	GO TO 280	0186
450	IF(IERR .EQ. 2) GO TO 10	0187
	DO 470 KOPY=1,3	0188
	WRITE(6,3200)KOPY	0189
	GO TO (460,451),KONTRL	0190
451	DO 453 J=1,KNTUV	0191
	WRITE(6,1014)J	0192
	DO 452 I=1,IRDG	0193
	IF(KPOINT(I).EQ.3) GO TO 4530	0194
	IF(SID(J,I).EQ.S(II)) GO TO 4522	0195
	WRITE(6,1016)KRDN(I),RNG(J,I)	0196
	GO TO 452	0197
4530	IF(SID(J,I).EQ.S(II)) WRITE(6,1216)	0198
	IF(SID(J,I).NE.S(II)) WRITE(6,1316)KRDN(I)	0199
1316	FORMAT(1H ,I6)	0200
1216	FORMAT(1H , ' SPOT')	0201
	GO TO 452	0202
4522	WRITE(6,1116)RNG(J,I)	0203
452	CONTINUE	0204
453	CONTINUE	0205
	GO TO 470	0206
460	DO 462 I=1,IRDG	0207
	IF(KOPY .GT. 1) GO TO 461	0208
	IF(NNTUV(I) .EQ. 0) NNTUV(I)=1	0209
	BHMAX(I)=BHMAX(I)-BHMIN(I)	0210
	BHBAR(I)=BHBAR(I)/DFLOAT(NNTUV(I))	0211
461	GO TO (4611,4612,4613,4614),KNTUV	0212
4611	IF(I .EQ. 1) WRITE(6,1021)	0213
	IF(SID(1,I).EQ.S(II)) GO TO 4711	0214
	WRITE(6,1061) KRDN(I),((RNG(J,I),TANK(J,I),BH(J,I)),J=1,KNTUV),	0215
	1BHBAR(I),BHMAX(I)	0216
	GO TO 462	0217
4711	WRITE(6,1161)((RNG(J,I),TANK(J,I),BH(J,I)),J=1,KNTUV),BHBAR(I),	0218
	1BHMAX(I)	0219
	GO TO 462	0220
4612	IF(I .EQ. 1) WRITE(6,1022)	0221
	IF(SID(1,I).EQ.S(II)) GO TO 4712	0222
	WRITE(6,1062) KRDN(I),((RNG(J,I),TANK(J,I),BH(J,I)),J=1,KNTUV),	0223
	1BHBAR(I),BHMAX(I)	0224
	GO TO 462	0225
4712	WRITE(6,1162)((RNG(J,I),TANK(J,I),BH(J,I)),J=1,KNTUV),BHBAR(I),	0226
	1BHMAX(I)	0227
	GO TO 462	0228
4613	IF(I .EQ. 1) WRITE(6,1023)	0229
	IF(SID(1,I).EQ.S(II)) GO TO 4713	0230
	WRITE(6,1063) KRDN(I),((RNG(J,I),TANK(J,I),BH(J,I)),J=1,KNTUV),	0231
	1BHBAR(I),BHMAX(I)	0232
	GO TO 462	0233
4713	WRITE(6,1163)((RNG(J,I),TANK(J,I),BH(J,I)),J=1,KNTUV),BHBAR(I),	0234
	1BHMAX(I)	0235
	GO TO 462	0236
4614	IF(I .EQ. 1) WRITE(6,1024)	0237
	IF(SID(1,I).EQ.S(II)) GO TO 4714	0238
	WRITE(6,1064) KRDN(I),((RNG(J,I),TANK(J,I),BH(J,I)),J=1,KNTUV),	0239
	1BHBAR(I),BHMAX(I)	0240

	GO TO 462	0241
4714	WRITE(6,1164)((RNG(J,I),TANK(J,I),BH(J,I)),J=1,KNTUV),BHBAR(I),	0242
	1BHMAX(I)	0243
462	CONTINUE	0244
	WRITE(6,1017)	0245
	DO 469 J=1,IRDG	0246
	IF(SID(1,J).EQ.S(II)) GO TO 468	0247
465	WRITE(6,1019)KRDN(J),BHBAR(J),BHMAX(J)	0248
	GO TO 469	0249
468	WRITE(6,1119)BHBAR(J),BHMAX(J)	0250
469	CONTINUE	0251
470	CONTINUE	0252
	GO TO 10	0253
500	LAST=KRD+NSTEP*(IRDG-1)	0254
	DO 560 KOPY=1,3	0255
	WRITE(6,3200)KOPY	0256
	WRITE(6,3300)GUN,XLOC,DATE,PRENG,ELEV,ABOVE	0257
	WRITE(6,3400)KRD,LAST,KDEG,DKMIN	0258
	IF(1RX-2)503,501,503	0259
501	WRITE(6,3700)	0260
	GO TO 504	0261
503	WRITE(6,3500)	0262
	WRITE(6,3600)	0263
504	DO 560 M=1,IRDG	0264
	IBRNCH=KPOINT(M)	0265
	GO TO (510,520,530,510,510),IBRNCH	0266
510	PMEAN=0.D0	0267
	DO 515 K=1,N	0268
	IF(DIV(M))515,514,515	0269
514	DIV(M)=1.	0270
515	PMEAN=PMEAN+TIME(K,M)/DIV(M)	0271
	KK=0	0272
	DO 5999 MM=1,N	0273
	IF(AZ(M,MM).EQ.99999.D0) KK=KK+1	0274
5999	CONTINUE	0275
	GO TO (5151,5152,5153,5154),N	0276
5151	IF(SID(1,M).EQ.S(II)) GO TO 5551	0277
	WRITE(6,2001)KRDN(M),RN(M),ALPHA(1,M),TIME(1,M),PMEAN	0278
	GO TO 560	0279
5551	WRITE(6,2101)RN(M),ALPHA(1,M),TIME(1,M),PMEAN	0280
	GO TO 560	0281
5152	IF(KK.EQ.1) GO TO 5252	0282
	IF(SID(1,M).EQ.S(II)) GO TO 5352	0283
	WRITE(6,2002)KRDN(M),DEFLM(M),DEF(M),RN(M),ALPHA(1,M),TIME(1,M)	0284
	1,TIME(2,M),PMEAN	0285
	GO TO 560	0286
5352	WRITE(6,2102)DEFLM(M),DEF(M),RN(M),ALPHA(1,M),TIME(1,M),TIME(2,M),	0287
	1PMEAN	0288
	GO TO 560	0289
5252	IF(SID(1,M).EQ.S(II)) GO TO 5452	0290
	WRITE(6,2012)KRDN(M),RN(M),ALPHA(1,M),TIME(1,M),TIME(2,M),PMEAN	0291
	GO TO 560	0292
5452	WRITE(6,2112)RN(M),ALPHA(1,M),TIME(1,M),TIME(2,M),PMEAN	0293
	GO TO 560	0294
5153	IF(KK.EQ.2) GO TO 5253	0295
	IF(SID(1,M).EQ.S(II)) GO TO 5353	0296
	WRITE(6,2003)KRDN(M),DEFLM(M),DEF(M),RN(M),ALPHA(1,M),TIME(1,M)	0297
	1,TIME(2,M),TIME(3,M),PMEAN	0298
	GO TO 560	0299
5353	WRITE(6,2103)DEFLM(M),DEF(M),RN(M),ALPHA(1,M),TIME(1,M),TIME(2,M),	0300
	1TIME(3,M),PMEAN	0301

GO TO 560	0302
5253 IF(SID(1,M).EQ.S(11)) GO TO 5453	0303
WRITE(6,2013)KRDN(M),RN(M),ALPHA(1,M),TIME(1,M),TIME(2,M),TIME(3,M)	0304
1),PMEAN	0305
GO TO 560	0306
5453 WRITE(6,2113)RN(M),ALPHA(1,M),TIME(1,M),TIME(2,M),TIME(3,M),PMEAN	0307
GO TO 560	0308
5154 IF(KK.EQ.3) GO TO 5254	0309
IF(SID(1,M).EQ.S(11)) GO TO 5354	0310
WRITE(6,2000)KRDN(M),DEFLM(M),DEF(M),RN(M),ALPHA(1,M),TIME(1,M)	0311
1),TIME(2,M),TIME(3,M),TIME(4,M),PMEAN	0312
GO TO 560	0313
5354 WRITE(6,2100)DEFLM(M),DEF(M),RN(M),ALPHA(1,M),TIME(1,M),TIME(2,M),	0314
1TIME(3,M),TIME(4,M),PMEAN	0315
GO TO 560	0316
5254 IF(SID(1,M).EQ.S(11)) GO TO 5454	0317
WRITE(6,2014)KRDN(M),RN(M),ALPHA(1,M),TIME(1,M),TIME(2,M),TIME(3,M)	0318
1),TIME(4,M),PMEAN	0319
GO TO 560	0320
5454 WRITE(6,2114)RN(M),ALPHA(1,M),TIME(1,M),TIME(2,M),TIME(3,M),TIME(4	0321
1,M),PMEAN	0322
GO TO 560	0323
520 IF(SID(1,M).EQ.S(11)) GO TO 5201	0324
WRITE(6,2010)KRDN(M),DEFLM(M),DEF(M)	0325
GO TO 560	0326
5201 WRITE(6,2110)DEFLM(M),DEF(M)	0327
GO TO 560	0328
530 IF(SID(1,M).EQ.S(11)) GO TO 5301	0329
WRITE(6,2020)KRDN(M)	0330
GO TO 560	0331
5301 WRITE(6,2120)	0332
560 CONTINUE	0333
GO TO 10	0334
600 CALL EXIT	0335
2110 FORMAT(1H0,' SPOT',1X,F17.2,1X,F13.2/)	0336
2114 FORMAT(1H,' SPOT',T14,'-----',T29,'-----',T42,F8.1,4X,A8,3X,4(	0337
1F6.2,4X),F6.2)	0338
2014 FORMAT(1H,'16,T14,'-----',T29,'-----',T42,F8.1,4X,A8,3X,4(F6.2,4	0339
1X),F6.2)	0340
2102 FORMAT(1H,' SPOT',T14,F6.1,T29,F6.1,T42,F8.1,4X,A8,3X,2(F6.2,4X)	0341
1,20X,F6.2)	0342
2002 FORMAT(1H,'16,T14,F6.1,T29,F6.1,T42,F8.1,4X,A8,3X,2(F6.2,4X),20X,F	0343
16.2)	0344
2100 FORMAT(1H,' SPOT',T14,F6.1,T29,F6.1,T42,F8.1,4X,A8,3X,5(F6.2,4X)	0345
1)	0346
2000 FORMAT(1H,'16,T14,F6.1,T29,F6.1,T42,F8.1,4X,A8,3X,5(F6.2,4X))	0347
2010 FORMAT(1H0,16,1X,F17.2,1X,F13.2/)	0348
1000 FORMAT(3I4,F20.0)	0349
1010 FORMAT(2F11.3)	0350
1011 FORMAT(4F11.3)	0351
1015 FORMAT(F4.0,1X,F3.0)	0352
1016 FORMAT(1H,'16,F17.1,1X,F9.5,1X,F5.1)	0353
1116 FORMAT(1H,' SPOT',F17.1,1X,F9.5,1X,F5.1)	0354
1017 FORMAT(1H1,1X,'ROUND',9X,'AVBHT',6X,'DIFF',/,',15X,'METERS',/)	0355
1119 FORMAT(1H,' SPOT',8X,F6.1,6X,F5.1)	0356
1019 FORMAT(1H,'16,8X,F6.1,6X,F5.1)	0357
1014 FORMAT(1H,'TOWER',11/)	0358
1021 FORMAT(1H0,T24,'1'/	0359
11H,' ROUND',1(' RANGE TANGENT BHT'),' AVBHT DIFF')	0360

1022	FORMAT(1H0,T24,'1',T49,'2'/	0361
21H	, 'ROUND', 2(' RANGE TANGENT BHT'), ' AVBHT DIFF')	0362
1023	FORMAT(1H0,T24,'1',T49,'2',T74,'3'/	0363
31H	, 'ROUND', 3(' RANGE TANGENT BHT'), ' AVBHT DIFF')	0364
1024	FORMAT(1H0,T24,'1',T49,'2',T74,'3',T99,'4'/	0365
41H	, 'ROUND', 4(' RANGE TANGENT BHT'), ' AVBHT DIFF')	0366
1030	FORMAT(2F7.2,2F7.2,A8,F6.2,A4)	0367
1040	FORMAT(12)	0368
1050	FORMAT(1H 16,D16.9)	0369
1061	FORMAT(1H ,16,1(1X,F8.1,1X,F9.5,1X,F6.1),1X,F6.1,1X,F5.1)	0370
1161	FORMAT(1H , ' SPOT', 1(1X,F8.1,1X,F9.5,1X,F6.1),1X,F6.1,1X,F5.1)	0371
1062	FORMAT(1H ,16,2(1X,F8.1,1X,F9.5,1X,F6.1),1X,F6.1,1X,F5.1)	0372
1162	FORMAT(1H , ' SPOT', 2(1X,F8.1,1X,F9.5,1X,F6.1),1X,F6.1,1X,F5.1)	0373
1063	FORMAT(1H ,16,3(1X,F8.1,1X,F9.5,1X,F6.1),1X,F6.1,1X,F5.1)	0374
1163	FORMAT(1H , ' SPOT', 3(1X,F8.1,1X,F9.5,1X,F6.1),1X,F6.1,1X,F5.1)	0375
1064	FORMAT(1H ,16,4(1X,F8.1,1X,F9.5,1X,F6.1),1X,F6.1,1X,F5.1)	0376
2001	FORMAT(1H ,16,T14,'-----',T29,'-----',T42,F8.1,4X,A8,3X,F6.2,34X	0377
	1,F6.2)	0378
1164	FORMAT(1H , ' SPOT', 4(1X,F8.1,1X,F9.5,1X,F6.1),1X,F6.1,1X,F5.1)	0379
2101	FORMAT(1H , ' SPOT', T14,'-----',T29,'-----',T42,F8.1,4X,A8,3X,F6	0380
	1.1,34X,F6.2)	0381
2012	FORMAT(1H ,16,T14,'-----',T29,'-----',T42,F8.1,4X,A8,3X,2(F6.2,4	0382
	1X),20X,F6.2)	0383
2112	FORMAT(1H , ' SPOT', T14,'-----',T29,'-----',T42,F8.1,4X,A8,3X,2(	0384
	1F6.2,4X),20X,F6.2)	0385
2013	FORMAT(1H ,16,T14,'-----',T29,'-----',T42,F8.1,4X,A8,3X,3(F6.2,4	0386
	1X),10X,F6.2)	0387
2113	FORMAT(1H , ' SPOT', T14,'-----',T29,'-----',T42,F8.1,4X,A8,3X,3(	0388
	1F6.2,4X),10X,F6.2)	0389
2103	FORMAT(1H , ' SPOT', T14,F6.1,T29,F6.1,T42,F8.1,4X,A8,3X,3(F6.2,4X)	0390
	1,10X,F6.2)	0391
2003	FORMAT(1H ,16,T14,F6.1,T29,F6.1,T42,F8.1,4X,A8,3X,3(F6.2,4X),10X,F	0392
	16.2)	0393
2120	FORMAT(1H0,' SPOT')	0394
2020	FORMAT(1H0,16/)	0395
2031	FORMAT(1H0,16,1X,D16.9)	0396
2032	FORMAT(1H ,214,1X,F7.3,1X,F8.3)	0397
2033	FORMAT(1H0,' SPOT',12,1X,D16.9)	0398
3100	FORMAT(14A4)	0399
3150	FORMAT(13A4/14A4/11A4/F6.2,1X,6A4)	0400
3200	FORMAT(1H1,50X,'RANGE FIRING SUMMARY',T110,'COPY ',11,'OF 3')	0401
3300	FORMAT(1H0,'GUN ',14A4,' LOCATION ',13A4/1H , 'DATE ',14A4,'PROJECT	0402
	1 ENGINEER ',11A4/1H , 'ELEVATION OF TRUNNIONS ',F6.2,' FT. ABOVE ',	0403
	26A4)	0404
3400	FORMAT(1H0,T51,'AZIMUTH LINE OF FIRE'/1H ,T44,'RDS. ',16,' TO ',16	0405
	1,' AZ. ',13,' D ',F5.2,' M ')	0406
3500	FORMAT(1H0,'RD.NO.',T18,'DEFLECTIONS',T43,'RANGE',T53,'ORD OF DET'	0407
	1,T85,'TIMES OF FLIGHT')	0408
3600	FORMAT(1H ,T15,'MILS',T29,'METERS',T43,'METERS',T68,'1',T78,'2',	0409
	1T88,'3',T98,'4',T106,'MEAN'/)	0410
3700	FORMAT(1H0,T43,'GRID COORDINATES OF POINT OF IMPACT'/1H0,	0411
	1' ROUND',11X,' X ',8X,' Y ')/)	0412
4000	FORMAT(1H1,'RANGE FIRING SUMMARY ERROR CORRECTIONS')	0413
	END	0414

	SUBROUTINE ISCR(L,I)	0415
	IMPLICIT REAL*8(A-H,O-Z)	0416
	DIMENSION I(3)	0417
	K=1	0418
	DO 20 J=1,4	0419
	IF (J-L)10,20,10	0420
10	I(K)=J	0421
	K=K+1	0422
20	CONTINUE	0423
	RETURN	0424
	END	0425

SUBROUTINE POINT(AZ,I,ISC,J,K,X,Y,PT,L)	0426
IMPLICIT REAL*8(A-H,O-Z)	0427
DIMENSION AZ(201,5),ISC(3),X(5),Y(5),PT(12,2)	0428
M=3*L+J+K-5	0429
JISC=ISC(J)	0430
KISC=ISC(K)	0431
A=DTAN(AZ(I,JISC))	0432
B=DTAN(AZ(I,KISC))	0433
PT(M,1)=(X(JISC)*A-Y(JISC)+Y(KISC)-X(KISC)*B)/(A-B)	0434
PT(M,2)=(PT(M,1)-X(KISC))*B+Y(KISC)	0435
RETURN	0436
END	0437

SUBROUTINE AREA(P,L,A)	0438
IMPLICIT REAL*8(A-H,O-Z)	0439
DIMENSION P(12,2)	0440
I=3*L-2	0441
J=I+1	0442
K=I+2	0443
A=DABS(.5D0*((P(I,2)-P(J,2))*P(K,1)+(P(J,2)-P(K,2))*P(I,1)+	0444
1(P(K,2)-P(I,2))*P(J,1)))	0445
RETURN	0446
END	0447


```

SUBROUTINE CNTR(P,L,C)
IMPLICIT REAL*8(A-H,O-Z)
DIMENSION P(12,2),C(2)
M=3*L-2
DO 10 I=1,2
10 C(I)=(P(M,1)+P(M+1,I)+P(M+2,I))/3.D0
RETURN
END

```

```

0448
0449
0450
0451
0452
0453
0454
0455

```

	SUBROUTINE RANGE(X,Y,AZ,CNT,RNG,DEFL,DEFLM)	0456
	IMPLICIT REAL*8(A-H,O-Z)	0457
	DIMENSION CNT(2)	0458
	RNG=CNT(1)-X	0459
	DEFL=CNT(2)-Y	0460
	CALL ATNSR(DEFL,RNG,BETA,1)	0461
	DEFLM=BETA-AZ	0462
10	IF (DEFLM+3.14159265)30,30,20	0463
20	IF (DEFLM-3.14159265)50,40,40	0464
30	DEFLM=DEFLM+6.28318531	0465
	GO TO 10	0466
40	DEFLM=DEFLM-6.28318531	0467
	GO TO 10	0468
50	RNG=RNG/DCOS(BETA)	0469
	DEFL=RNG*DSIN(DEFLM)	0470
	DEFLM=1018.59164*DEFLM	0471
	RETURN	0472
	END	0473

	SUBROUTINE ATNSR(A,B,C,L)	0474
	IMPLICIT REAL*8(A-H,O-Z)	0475
	P=3.14159265	0476
	C=DATAN(A/B)	0477
	IF (A)10,40,40	0478
10	IF (B)20,30,30	0479
20	GO TO (21,22),L	0480
21	C=P+C	0481
	GO TO 50	0482
22	C=C-2.D0*P	0483
	GO TO 50	0484
30	GO TO (31,50),L	0485
31	C=2.D0*P+C	0486
	GO TO 50	0487
40	IF (B)20,50,50	0488
50	RETURN	0489
	END	0490

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APPENDIX C:
SAMPLE INPUT TO TRIANGULATION COMPUTER PROGRAM

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01
 105MM
 BALL PG.
 22 MAY 85
 SCHNELL
 13.89 MLW
 11 4 1 50.
 3657.607 12801.626
 3868.530 13870.487
 3754.335 13094.383
 2883.79 11998.31
 3812.273 12475.803 41. 26.
 34. 22. 18. 51. HOAB 15.67
 34. 23. 17. 45. ILLUM 16.11
 34. 25. 18. 46. HOAB 15.77
 34. 18. 17. 41. ILLUM 15.94
 34. 11. 5. 35. HOAB 12.28
 34. 17. 5. 09. GREN 12.02
 34. 05. 5. 35. GREN 11.46
 34. 17. 5. 08. GREN 11.72
 +999.
 11. 08. 19. 07. 16.03
 9. 54. 18. 01. 16.39
 11. 13. 19. 05. 15.80
 9. 42. 17. 42.
 10. 52. 6. 09. 11.55
 11. 19. 6. 37. 11.63
 10. 36. 6. 01. 11.69
 11. 03. 5. 32. 11.99
 +999.
 26. 57. 20. 04.
 27. 28. 18. 50.
 27. 52. 19. 45.
 27. 24. 18. 40.
 27. 42. 6. 45.
 27. 57. 5. 55.
 27. 32. 6. 35.
 27. 45. 5. 50.
 +999.
 47. 37. 14. 48. 15.70
 47. 55. 13. 38. 17.40
 47. 35. 14. 56. 15.73
 48. 03. 13. 41. 17.90
 47. 26. 4. 35. 11.52
 47. 24. 4. 19. 12.07
 47. 33. 4. 39. 11.40
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 04
 3657.607 12801.626 32.13
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 3868.530 13870.487 13.3
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 3754.335 13094.383 4.77
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 2883.79 11998.31 12.13
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APPENDIX D:
SAMPLE OUTPUT FROM TRIANGULATION COMPUTER PROGRAM

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RANGE FIRING SUMMARY

CLA 105PM
 DATE 22 MAY 65
 ELEVATION OF TRUNNIONS 13.84 FT. ABOVE PLA
 LOCATION BALL PG.
 PROJECT ENGINEER SCHELL

RD.MC.	DEFLECTIONS		RANGE METERS	KDS. 11 TG 18 AZ. 41 U 26.00 M	AZIMUTH LINE OF FIRE		TIMES OF FLIGHT				MEAN
	PILS	METERS			URD OF DET	1	2	3	4		
11	4.3	10.9	2551.5	HCAB	15.67	16.03	0.00	15.70	15.80		
12	7.7	18.3	2433.0	ILLUM	16.11	16.39	0.00	17.40	16.63		
13	4.4	11.1	2562.7	HUAB	15.77	15.80	0.00	15.73	15.77		
14	9.4	22.3	2407.5	ILLUM	15.94	0.00	0.00	17.90	16.92		
15	1.0	2.6	2543.3	HCAB	12.28	11.55	0.00	11.52	11.78		
16	0.8	1.9	2587.1	GRN	12.02	11.63	0.00	12.07	11.91		
17	0.2	0.5	2520.9	GRN	11.46	11.69	0.00	11.40	11.52		
18	3.5	8.6	2530.4	GRN	11.72	11.99	0.00	11.76	11.82		

RANGE FIRING SUMMARY

LOCATION BALL PG.
PROJECT ENGINEER SCHNELL

CLA 105MM
DATE 22 MAY 85
ELEVATION OF TRUNIONS 13.89 FT. ABOVE PLN

RD.NC.	DEFLECTIONS		RANGE METERS	ORD OF DET	TIMES OF FLIGHT				MEAN
	MILS	METERS			1	2	3	4	
AZIMUTH LINE OF FIRE 11 TO 18 AZ. 41 D 26.00 M									
KDS.									
RANGE									
METERS									
MILS									
DEFLECTIONS									
METERS									
11	4.3	10.5	2551.5	PCAB	15.67	16.03	0.00	15.70	15.80
12	7.7	18.3	2433.0	ILLUM	16.11	16.39	0.00	17.40	16.63
13	4.4	11.1	2562.7	HDAB	15.80	15.80	0.00	15.73	15.77
14	9.4	22.3	2407.5	ILLUM	15.94	0.00	0.00	17.90	16.92
15	1.0	2.6	2542.3	PCAB	12.28	11.55	0.00	11.52	11.78
16	0.8	1.9	2567.1	GREEN	12.02	11.63	0.00	12.07	11.91
17	0.2	0.5	2520.9	GREEN	11.46	11.69	0.00	11.40	11.52
18	3.5	8.6	2530.4	GREEN	11.72	11.59	0.00	11.76	11.82

RANGE FIRING SUMMARY

COPY 10F 3

BCIND	1			2			3			4			COPY 10F 3		
	RANGE	TANGENT	BHT	RANGE	TANGENT	BHT	RANGE	TANGENT	BHT	RANGE	TANGENT	BHT	AVBHT	DIFF	
11	2689.1	0.24140	950.2	2710.3	C.34661	952.7	2612.1	0.36529	958.9	3548.2	0.26421	949.6	952.9	9.3	
12	2570.4	0.32010	854.9	2604.8	0.32524	860.5	2495.1	0.34108	855.8	3431.2	0.24254	844.3	853.9	16.1	
13	2700.1	0.33978	949.6	2719.5	0.34596	954.3	2622.9	0.35904	946.5	3559.4	0.26670	961.4	952.9	14.9	
14	2544.6	0.31882	843.4	2581.0	C.31914	837.0	2464.4	0.33783	839.0	3406.3	0.24347	841.4	840.2	6.4	
15	2681.9	0.39776	294.3	2707.4	C.10775	305.0	2606.0	0.11836	313.2	3539.1	0.08017	295.8	302.1	18.9	
16	2725.4	0.39013	277.8	2745.6	0.11600	311.8	2648.7	0.10363	279.3	3582.6	0.07548	282.6	292.8	54.0	
17	2660.0	0.3776	292.2	2684.3	0.10540	296.7	2584.8	0.11541	303.1	3516.7	0.08134	298.2	297.5	10.9	
18	2668.4	0.38983	271.8	2693.3	C.09888	274.2	2592.1	0.10216	269.6	3526.9	0.07490	276.3	273.0	6.7	

RCUAC	AVHPT METERS	DIFF
11	952.9	9.3
12	853.9	16.1
13	952.9	14.9
14	840.2	6.4
15	302.1	18.9
16	292.8	54.0
17	257.5	10.9
18	273.0	6.7

COPY 2DF 3

RANGE FIRING SUMMARY

ICLAD	1				2				3				4			
	RANGE	TANGENT	BHT	RANGE	TANGENT	BHT	RANGE	TANGENT	BHT	RANGE	TANGENT	BHT	RANGE	TANGENT	BHT	AVBHT
11	2689.1	0.34140	950.2	2710.2	0.34661	952.7	2612.1	0.36529	458.9	3548.2	0.26421	949.6	3548.2	0.26421	949.6	952.9
12	2570.4	0.32010	854.9	2604.6	0.32524	860.5	2495.1	0.34108	855.8	3431.2	0.24254	844.3	3431.2	0.24254	844.3	853.9
13	2700.1	0.33978	949.6	2714.5	0.34596	954.3	2622.9	0.35904	946.5	3559.4	0.26670	961.4	3559.4	0.26670	961.4	952.9
14	2544.6	0.31882	843.4	2581.0	0.31914	837.0	2464.4	0.33783	839.0	3406.3	0.24347	841.4	3406.3	0.24347	841.4	840.2
15	2681.9	0.34776	294.3	2707.4	0.34775	305.0	2606.0	0.11836	313.2	3539.1	0.08017	295.8	3539.1	0.08017	295.8	302.1
16	2725.4	0.05013	277.8	2745.6	0.11600	331.8	2648.7	0.10362	279.3	3582.6	0.07548	282.6	3582.6	0.07548	282.6	292.8
17	2660.0	0.05776	292.2	2684.3	0.10540	296.7	2584.8	0.11541	303.1	3516.7	0.08134	298.2	3516.7	0.08134	298.2	297.5
18	2668.4	0.08983	271.8	2693.3	0.09688	274.2	2592.1	0.10216	269.6	3526.9	0.07490	276.3	3526.9	0.07490	276.3	273.0
																6.7

SCUC	AVBLT METERS	DIFF
11	952.9	9.3
12	853.9	16.1
13	952.9	14.9
14	840.2	6.4
15	302.1	18.9
16	292.8	54.0
17	257.5	10.9
18	273.0	6.7

RANGE FIRING SUMMARY

COPY 30F 3

SLAC	1			2			3			4			DIFF
	RANGE	TANGENT	BHT	RANGE	TANGENT	BHT	RANGE	TANGENT	BHT	RANGE	TANGENT	BHT	
11	2689.1	0.24140	950.2	2710.2	0.34661	952.7	2612.1	0.36529	958.9	3548.2	0.26421	949.6	9.3
12	2570.4	0.32010	854.9	2604.6	0.32524	860.5	2495.1	0.34108	855.8	3431.2	0.24254	844.3	16.1
13	2700.1	0.33678	949.6	2719.5	0.34546	954.3	2622.4	0.35904	946.5	3539.4	0.26670	961.4	14.9
14	2545.6	0.31882	843.4	2581.0	0.31914	837.0	2465.4	0.33783	839.0	3406.3	0.24347	841.4	6.4
15	2681.9	0.35776	244.3	2707.4	0.10775	305.0	2606.0	0.11836	313.2	3539.1	0.08017	295.8	302.1
16	2725.4	0.35013	277.8	2745.8	0.11600	331.8	2648.7	0.10363	279.3	3582.6	0.07548	282.6	292.8
17	2660.0	0.35776	292.2	2689.3	0.10540	296.7	2584.8	0.11541	303.1	3516.7	0.08134	298.2	297.5
18	2668.4	0.08983	271.8	2653.3	0.09688	274.2	2592.1	0.10210	269.6	3526.9	0.07490	276.3	273.0

ACUAC	AVBHT METERS	DIFF
11	952.9	9.3
12	853.9	16.1
13	952.9	14.9
14	846.2	6.4
15	302.1	18.9
16	292.8	54.0
17	297.5	10.9
18	273.0	6.7

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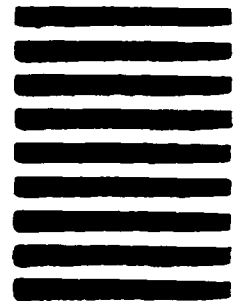


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