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AIR-TO-GROUND GUNNERY SIMULATION COMPUTER PROGRAM-PO655

MISSILE AND GUN SYSTEM ANALYSIS BRANCH
WEAPON SYSTEMS ANALYSIS DIVISION

OCTOBER 1976

FINAL REPORT FOR PERIOD
NOVEMBER 1975-JULY 1976

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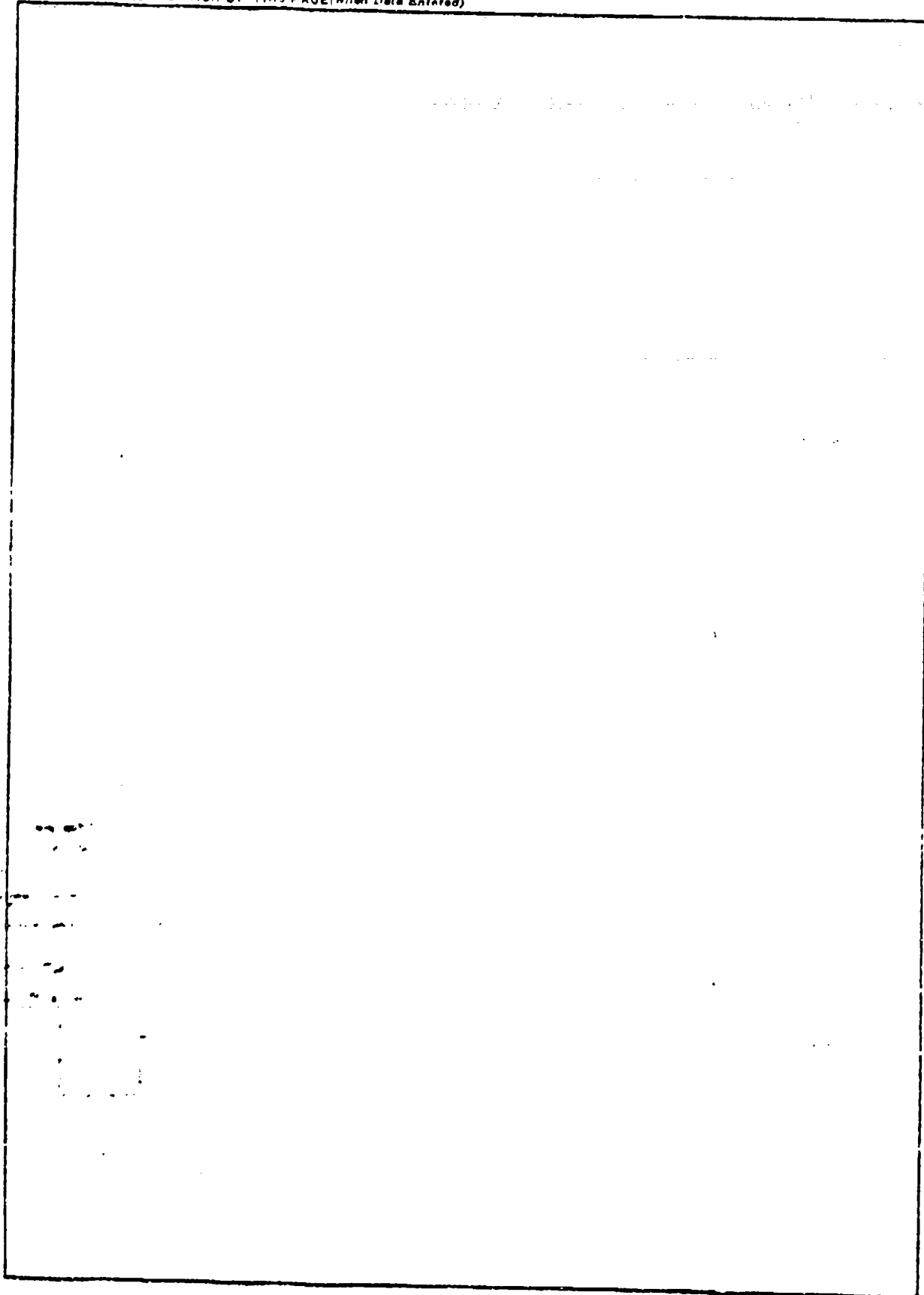
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PREFACE

This report documents an air-to-ground gunnery model accomplished during the period November 1975 to July 1976 at the Air Force Armament Laboratory, Armament Development and Test Center, Eglin Air Force Base, Florida. The work was in support of JON 2543-01-10.

The original version of this program was developed by the Operations Evaluation Group, Center for Naval Analyses, Washington, D.C., in August 1969 (Reference 1). Since this time, the program has been extensively modified and updated to include the most modern techniques available.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

J. R. Murray
J. R. MURRAY
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SECTION I

INTRODUCTION

This is a computer program which simulates air-to-ground gun effectiveness against a stationary target. The impact points of the individual rounds are correlated, and a Monte Carlo method is required to determine the probability of hitting a rectangular target with one or more rounds in a single burst. The model assumes that gunnery is a stationary Markov process and that the aiming and ballistic dispersions are independent in the range (along the flight path of the aircraft) and deflection (normal to the flight path in the horizontal plane) coordinates. The guns are assumed to be fixed (as opposed to guns turreted). The strafing aircraft flies at a constant airspeed and dive angle from a specified slant range.

SECTION II

GENERAL DESCRIPTION

This is a Monte Carlo simulation program which determines the probability of killing a ground target from an aircraft equipped with a machine gun firing a single burst of N rounds. The individual aimpoints cannot be specified in advance; therefore, the program assumes that successive aimpoints are correlated (Reference 2). The aimpoints are normally distributed about the center of the target. The program further assumes that ballistic dispersion is present. Thus, the i^{th} round impacts not at its aimpoint but at some point nearby.

The target assumed in the program is the rectangular projection of the real target on the plane normal to the line of flight of the attacking aircraft. Distances are measured with respect to a range-deflection (R, D) coordinate system. The origin is located at the center of the target, and the coordinate axes are parallel to the sides of the target (Figures 1 and 2). In real life the target will seldom or never be rectangular in shape, but the projected target can always be approximated by a rectangle. The target length, l , is measured in the range direction, and width, w , in the deflection direction. The slant range is denoted by s , c is the aircraft speed, and R is firing rate in rounds per minute. The slant range decreases for each successive round fired, thus increasing the apparent size of the target and causing a corresponding increase in hit probability. In addition to the above, the program inputs include the maximum number of rounds per pass (PN), the number of Monte Carlo iterations to be made (F), the burst length print increment (DN), the maximum standard deviation of the mean (E), the probability that the gun jams ($PJAM$), the number of gun systems ($GUNS$), and a time-to-rate table for a Gatling gun effect.

To determine aimpoint error, let (R_1, D_1) be the aimpoint of the i^{th} round, and let (r_1, d_1) be the point at which the round impacts. Further, let s_1 be the slant range at the instant the i^{th} round is fired. Then from Figure 2 it can be seen $R_1 \cong s_1 \alpha_1$ and $D_1 \cong s_1 \beta_1$; expressing the angles in mils, $R_1 \cong 0.001 s_1 \alpha_1$; and $D_1 \cong 0.001 s_1 \beta_1$. The program uses the two angles α_1 and β_1 rather than R_1 and D_1 . These angles are computed by employing a random number generator. The angle α_1 is a random normal variable with mean zero and standard deviation σ_α , and β_1 is a random normal variable with a mean zero and standard deviation σ_β . Ballistic dispersion is determined similarly. Two angles γ_1 and δ_1 are defined so that $(r_1 - R_1) \cong 0.001 s_1 \gamma_1$ and $(d_1 - D_1) \cong 0.001 s_1 \delta_1$. The angle γ_1 is a normally distributed random variable with mean zero and standard deviation σ_γ ; s_1 is a normally distributed random variable with mean zero and standard deviation σ_s . The range component of error is considered to be independent

of the deflection component. Also, for all $i, j \leq N$,

$$E(\alpha_i \alpha_j) = a |1 - j| \sigma_\alpha^2$$

and

$$E(\beta_i \beta_j) = b |1 - j| \sigma_\beta^2$$

These two relationships characterize the programs correlation feature. The numbers a and b are inputs that determine the correlation between aimpoints. The correlation in range between consecutive aimpoints is given by a , and b is the correlation deflection. The correlation in range between the i th and the j th aimpoint is $a |1 - j|$ and the correlation in deflection is $b |1 - j|$. If $a = b = 1$, then $R_i = R_j$ and $D_i = D_j$ for all $i, j \leq N$. This occurs in the salvo model where every round has the same aimpoint. If $a = b = 0$, every aimpoint is independent of every other aimpoint. The general case will be when a and b lie between 0 and 1. It should be noted that if $|1 - j|$ becomes large,

$$a |1 - j| \rightarrow 0 \text{ and } b |1 - j| \rightarrow 0$$

and the correlation damps out.

The correlation coefficient in range is a , and b is in deflection. These values can be input into the program if they are known. If the correlation coefficients are not known for the particular gun system being analyzed, the program will calculate them based on the following equations:

$$a = e^{-1.5T - 3T^2}$$

and

$$b = e^{-0.25T^4 - 5.35T^2}$$

where T is time in seconds between rounds.

In the computation of the target kill probabilities, each iteration of the Monte Carlo process represents one pass at the target. The attacking aircraft commences firing at the start of every pass and continues until one of the following occurs: (1) a killing hit has been scored, (2) the gun jams, or (3) N rounds have been fired. When a gun jams, the number of guns in the system is reduced by one. Therefore,

there is a corresponding reduction in rate of fire. If a jam occurs, the firing loop is exited and a miss is recorded for calculation purposes. Each round has a conditional kill probability (P_{HK}). This is the probability that a hit kills and it has the same value for every round in the burst if only one conditional kill value is input. A conditional kill value can be input for the beginning of the firing run and one at the end. If this option is elected, the program will do a linear interpolation between the beginning and end conditional kill values for each round based on time into the burst. The program computes an aimpoint and a point of impact for each round and assesses damage by testing to see whether the round hit the target and if so whether the hit resulted in a kill. The final probability of kill is set equal to the number of successful passes divided by the total number of passes.

SECTION III

MATHEMATICAL PROCEDURES

The final solution is obtained as shown in the flow chart and the following mathematical procedures. Before starting the first iteration for the first data set dummy passes are made through the random number generator.

For each Monte Carlo iteration there is given the standard deviation of the aim error (σ_R , σ_D) and the aimpoint of the $(n - 1)$ st round. There are also two Gaussian-distributed (mean = 0, standard deviation = 1) random numbers (α , γ) selected, and the aimpoint of the n th round (R_n , D_n) is determined by the following relations:

for the first round ($n = 1$), then

$$R_1 = \sigma_R \alpha_1 \quad (1)$$

$$D_1 = \sigma_D \gamma_1 \quad (2)$$

$$R_n = aR_{n-1} + \sigma_R(1-a^2)^{1/2} \alpha_{n, n \neq 1} \quad (3)$$

$$D_n = bD_{n-1} + \sigma_D(1-b^2)^{1/2} \gamma_{n, n \neq 1} \quad (4)$$

where a and b are the correlation coefficients in range and deflection and R_n and D_n are the respective range and deflection aimpoints for the n th round.

Equation (3) may be rewritten so that

$$R_n = \sigma_R \left[a^{n-1} \alpha_1 + (1-a^2)^{1/2} \sum_{i=2}^n a^{n-i} \alpha_i \right] \quad (5)$$

and Equation (4) may be rewritten as

$$D_n = \sigma_D \left[b^{n-1} \gamma_1 + (1-b^2)^{1/2} \sum_{i=2}^n b^{n-i} \gamma_i \right] \quad (6)$$

Then it can be seen from Equations (5) and (6) that

$$E(R_n) = E(D_n) = 0 \quad (7)$$

$$E(R_n^2) = \sigma_R^2 \quad (8)$$

$$E(D_n^2) = \sigma_D^2 \quad (9)$$

$$E(R_n R_m) = \sigma_R^2 a^{|m-n|} \quad (10)$$

$$E(D_n D_m) = \sigma_D^2 b^{|m-n|} \quad (11)$$

Therefore we have a process where each aimpoint is normally distributed with mean zero and standard deviation σ_R , σ_D . We also have a process where the correlation coefficient between the n^{th} and the m^{th} round is $a^{|n-m|}$ in the range direction and $b^{|n-m|}$ in deflection. When a and b equal zero or one the process degenerates into the independent or salvo cases, respectively.

Next, the target size must be considered. The target dimension (ℓ, ω) is given with the firing rate (R), the aircraft speed (C), and the initial slant range (S). From these the half-target size (in mils) is determined for the instant at which the n^{th} round is fired using relations:

$$1/2\ell_n = \frac{500\ell}{60} \quad (12)$$

$$S - (n-1)c(R) \quad (1.688)$$

$$1/2\omega_n = \frac{500\omega}{60} \quad (13)$$

$$S - (n-1)c(R) \quad (1.688)$$

The aimpoint for the n^{th} round is then checked to determine if it is within three standard deviations of the ballistic dispersion (β_R , β_D) measured from the target center, or stated mathematically,

$$|R_n| \leq 1/2\ell_n + 3\sigma_R \quad (14)$$

$$|D_n| \leq 1/2\omega_n + 3\sigma_D \quad (15)$$

If the aimpoint is not within three standard deviations of the ballistic dispersion from the target in either coordinate, it is assumed that the round missed the target and the aimpoint for the $(n + 1)$ st round is then computed. If the aimpoint is within three standard deviations from the target in both coordinates, a Gaussian-distributed random number (δ) is determined and checked to ascertain whether the round falls within the limits of the target in the range coordinates.

$$|R_n + \delta R| < 1/2\ell_n \quad (16)$$

If the round does not fall within the target limits a miss is assumed, and the aimpoint for the $(n + 1)$ st round is computed. However, if the n th round does fall within the target limits in the range coordinates another Gaussian-distributed random number (E) is selected and the impact point of the round in the deflection coordinate is determined. The following check is then made to see if the round hit the target.

$$|D_n + \delta_D E| < 1/2\omega_n \quad (17)$$

If the round does not hit the target, the aimpoint for the $(n + 1)$ st round is determined. But, if the n th round does hit the target, a uniformly distributed (between 0 and 1) random number (PP) is selected and compared with the conditional kill probability to determine if the hit results in a target kill. If $P_{HK} < PP$, the weapon does not destroy the target and the aimpoint for the $(n + 1)$ st round is determined. But if $P_{HK} \geq PP$, the n th weapon does kill the target. The count (N_h) of the Monte Carlo iterations for which the target is destroyed is increased by one. Also, a counter (JJ_1) for the next highest multiple (1) of the increment (ΔN) in the number of rounds for which the probability is to be determined is increased by one.

$$N_h + 1 \rightarrow N_h, \quad JJ_1 + 1 \rightarrow JJ_1$$

When a round has resulted in a kill or when the maximum number of rounds (N) has been fired without killing the target, the entire process is repeated until (F) Monte Carlo iterations have been completed.

Finally, the estimated probability of destroying the target with N rounds is determined by:

$$P(N) = \frac{Nn}{F} \quad (18)$$

The probability of destroying the target with j rounds is determined by:

$$P(j) = \sum_{i=1}^n \left[\frac{j j_i}{F} \right] \quad (19)$$

where

$$j = n\Delta N; n = \left[1, 2, \dots, \frac{N}{\Delta N} \right]$$

SECTION IV

PROGRAM UTILIZATION GUIDE

The utilization guide for the air-to-surface gun simulation computer program is contained in this section. The program variables used are discussed with input formats, limits, and units specified for each.

Throughout the utilization discussion, variables which begin with the letters I, J, K, L, M, N are integer values and are right adjusted in their specified fields with no decimal punched unless otherwise specified. The alphanumeric formats are designated in the description column of the program set-up procedure. All other variables are in decimal or real mode and may be punched anywhere in their columnar field with a decimal point.

This program has three different set-up procedures of which two will accomplish the same end result. The third set-up is a plot option only.

The first set-up is a regular run with any number of cases desired, and limited only by computer time. The second set-up shows the procedure for generating the input data when large parametric runs are needed. The third set-up describes the inputs for the plot only portion of the programs and should not be confused with the first two set-ups which also produce plots as desired.

Figure 3 is a flow chart overview of the gun simulation program with notes.

The regular computer set-up is very simple and straightforward but the generate-the-input set-up can be very ambiguous and frustrating. When the second option can be used it should yield a 10 to 1 savings in set-up time. The analyst should become familiar with this option in order to better utilize his time on large parametric computer runs and data requirement deadlines. It is hoped that the following flow chart will further simplify the generate-the-input set-up.

TIMING

The program run time is based on a number of variables in the program. It is not possible to figure the exact time required for each run. When the analyst becomes familiar with the program it will be easier to estimate the required run time based on the following equation:

$$\text{RUN TIME} = \text{MCI} * N * (\text{NO. OF CASES}) * .000159$$

where MCI is the number of Monte Carlo iterations

N is number of rounds fired on each burst.

After calculating the estimated run time for a given set-up it is recommended that more time be added to the job card if the run time is not a limiting factor on the computer system.

INPUT/OUTPUT

Input and output are discussed in detail in Sections V, VI, and VII.

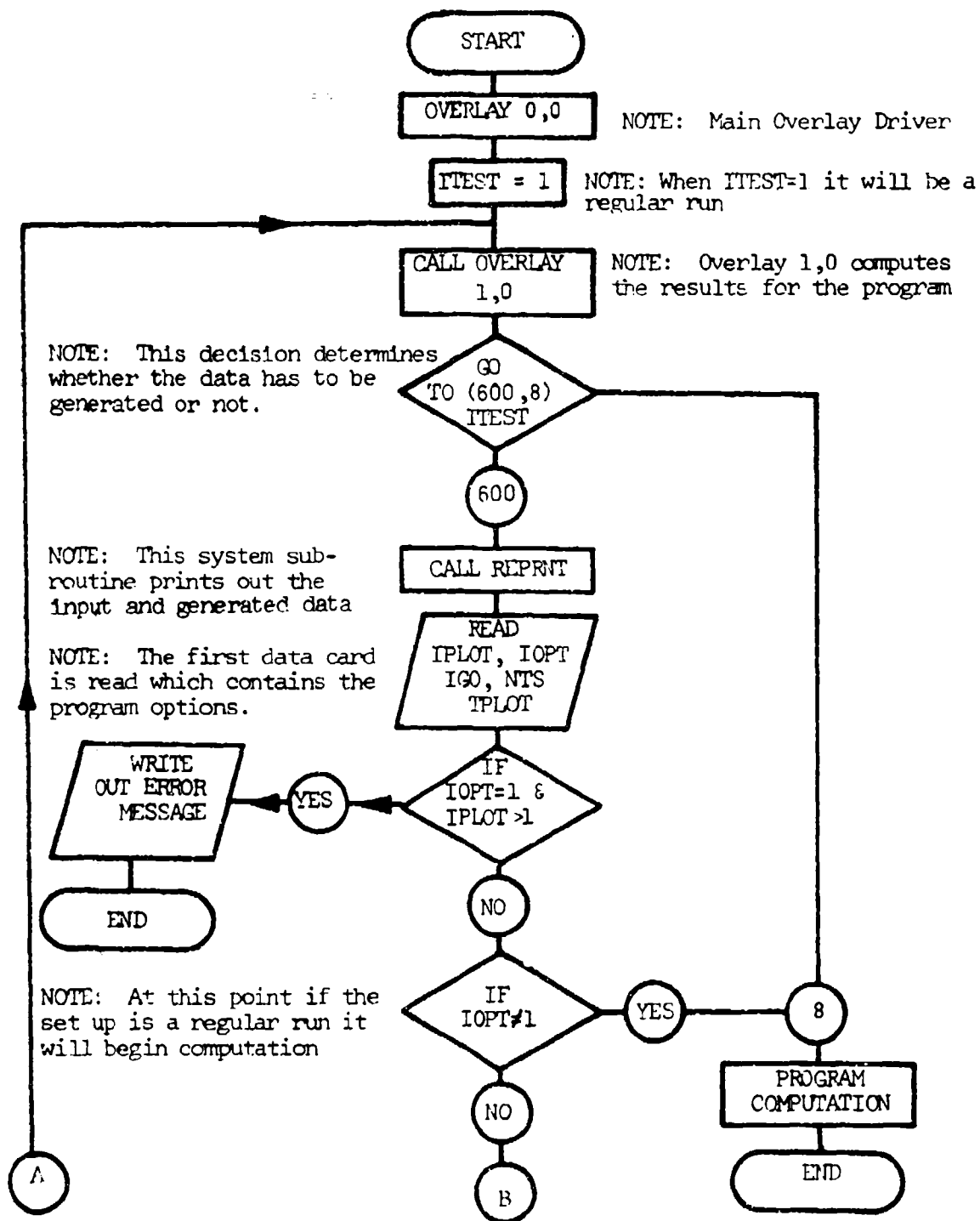


Figure 3. Overview Flow Chart for Gun Simulation Program

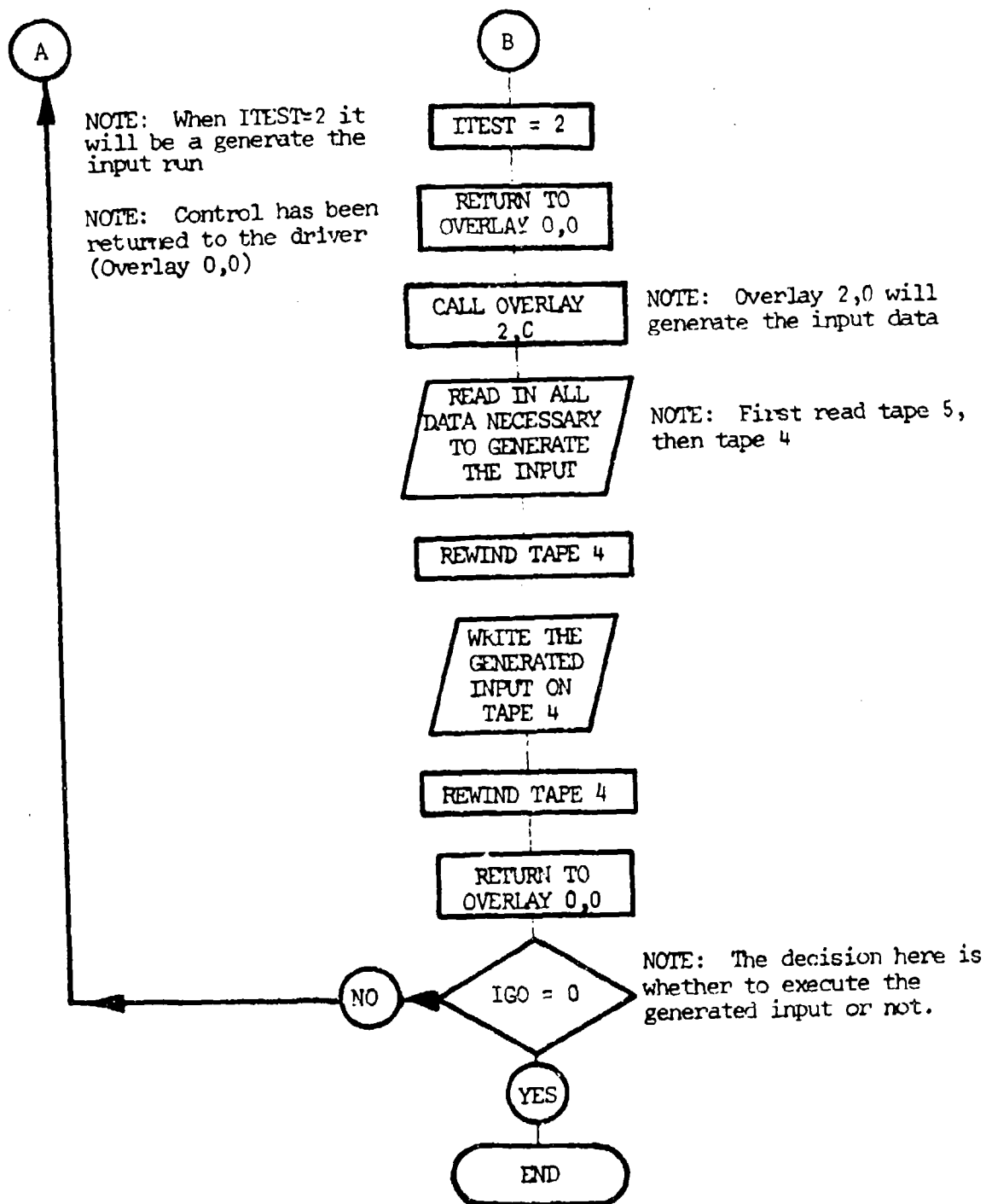


Figure 3. Overview Flow Chart for Gun Simulation Program (Concluded)

SECTION V

REGULAR COMPUTER RUN

SAMPLE PROBLEM

The effectiveness of a strafing tactic for a 150-knot aircraft with a firing rate of 4100 rounds per minute is to be analyzed. The pilot commences firing at a slant range of 1000 feet and fires a single burst of 120 rounds at an 11.74 x 11.74-foot target. The standard deviations of aiming error are 4.24 mils in range and deflection, and the standard deviations of ballistic dispersion are 1.39 mils in range and deflection. The probability of kill given a hit for the first case is a three-round mix with the ammunition belt having four rounds with a PHK of 0.012, 0.016, and two rounds with 0.020, 0.024 and one round with 0.006, 0.010. There are two probability of kill values in each case. The first value is the probability of kill given a hit for the beginning of the burst, and the second value is for the end of the burst. The computer does a linear interpolation between these two values based on time into the burst.

Table 1 contains the description for setting up any regular computer run. Table 2 is a sample set-up of the case described above. Table 3 is an output listing of the input data. Table 4 contains the final output probability of kill for only two of the cases. The first case was at 1000 feet slant range and 150 knots. The second case shown in Table 4 was for 1000 feet slant range and 350 knots air speed. The second case has been included to show the analyst what happens when the conditions become unrealistic. This feature saves paper and computer time. Figure 4 contains the probability of kill for the first six slant ranges. Card 2 in Table 1 indicates the number of cases plotted on one graph.

The required time to run any given set-up is described in Section IV.

TABLE 1. DESCRIPTION OF THE SET-UP FOR A REGULAR COMPUTER RUN

Card	Columns	Variable	Limits	Description	Units
DESCRIPTION OF THE SET-UP FOR A REGULAR COMPUTER RUN:					
1	1	IPL0T	0,1,2	0 = No plots 1 = Plot option has been turned on 2 = Stand alone plot (see PLOT ONLY SET-UP)	
	2	IOPT	0,1	0 = Regular computer run, leave IGO blank 1 = Data will be generated (see GENERATE THE INPUT SET-UP)	
	3	IGO	0,1	0 = Do not execute the generated input data 1 = Execute the generated input data (see GENERATE THE INPUT DATA SET-UP)	
	4-5	NTS	1-10	Number of burst lengths to be plotted	
	6-12 13-19	IPL0T(1) IPL0T(2)		Time which burst length should be plotted	decimal
	.	.			
	.	.			
	69-75	IPL0T(10)		Tenth burst length time	decimal
NOTE: Card 1 is necessary in the set-up even when all the options are zero.					
2	1-5	NSLANT	1-5	If IPL0T = 1, you must input the number of slant ranges to be plotted on one graph. <u>If no plots are wanted, this card must be omitted from the set-up.</u>	
3	1-60	TITLE		Title or general information (alpha-numeric data)	
	61-70	DIVE	≤90	Dive angle - for identification only	DEG
4	1-2	DX(1)	1	Address = 1	
	3-10	A	20, ≤1	Correlation coefficient in range between consecutive aimpoints.	
NOTE: A value for the correlation coefficient is computed in the program for each round. This parameter should be set to zero if JIN = 1 on card 24.					

TABLE 1. DESCRIPTION OF THE SET-UP FOR A REGULAR COMPUTER RUN (CONTINUED)

Card	Columns	Variable	Limits	Description	Units
10	1-2	D(7)	7	Address = 7	
	3-10	S		Slant range at the beginning of firing run.	feet
	1-2	D(8)	8	Address = 8	
	3-10	R		Firing rate of gun in rounds per minute.	RPM
12	1-2	D(9)	9	Address = 9	
	3-10	C		Aircraft speed	knots
13	1-2	D(10)	10	Address = 10	
	3-10	N		Number of rounds fired on a single pass per gun.	decimal
14	1-2	D(11)	11	Address = 11	
	3-10	NTYPE	1,2,3	Number of types of mixed belts. Set equal to 1 if no mixed belts.	
15	1-5	NUMR(I)	Blank-N	Number of consecutive rounds using this conditional kill probability. If left blank the program sets NUMR(I) equal to N.	
	6-15	CP1(I)		Starting value for the conditional kill probability - if CPN is left blank, CP1(I) is used for all rounds.	
	16-25	CPN(I)		End value for the conditional kill probability. If an end value is used, the program does a linear interpolation between CP1 and CPN based on time.	
NOTE: Repeat card 15 NTYPE times.					
16	1-2	D(12)	12	Address = 12	
	3-10	L		Target length	feet decimal
17	1-2	D(13)	13	Address = 13	
	3-10	W		Target width	feet

TABLE 1. DESCRIPTION OF THE SET-UP FOR A REGULAR COMPUTER RUN (CONTINUED)

Card	Columns	Variable	Limits	Description	Units	
18	1-2	D(14)	14	Address = 14	decimal	
	3-10	F	200-∞	Maximum number of Monte Carlo iterations.		
19	1-2	D(15)	15	Address = 15		
	3-10	II		Number of dummy passes through random number generator.		
20	1-2	D(16)		Address = 16		
	3-10	DI	≤1	Increment in burst length.		
NOTE: This controls the number of lines that will be printed; i.e., 1 will cause the printer to write out a data line for each round in the burst.						
21	1-2	D(17)	17	Address = 17	decimal	
	3-10	E		Desired maximum value of the standard deviation of the mean.		
22	1-2	D(18)	18	Address = 18		
	3-10	PJAM		Probability of the gun jamming.		
23	1-2	D(19)	19	Address = 19	decimal	
	3-10	GUNS		Number of gun systems to be analyzed.		
NOTE: The program computes a final probability of kill based on the total number of gun systems.						
24	1-2	D(20)	20	Address = 20		decimal
	3-10	JIM	0,1	0 = indicates that you have input some correlation value in cards 4 and 5 other than zero and omit cards 25, 26 and 27. 1 = indicates you have a zero in cards 4 and 5 and plan to input a time-to-rate table for a Gatling gun by completing cards 25, 26 and 27.		
25	1-5	NOT	≤30	Number of pairs of entries for the time-to-rate table for a Gatling gun.		

TABLE 1. DESCRIPTION OF THE SET-UP FOR A REGULAR COMPUTER RUN (CONCLUDED)

Card	Columns	Variable	Limits	Description	Units
26	1-8	RD(1)		Number of rounds fired at TIME (1)	
	9-16	RE(2)		Number of rounds fired at TIME (2)	
	.	.		.	
	.	.		.	
	.	.		.	
	3 cards	RD(NOT)		Number of rounds fired at TIME (NOT)	
NOTE: If JIM = 1 you can have 15 cards 13, typical for card 27 also.					
27	1-5	TIME(1)		Time to fire RD(1) rounds	
	6-10	TIME(2)		Time to fire RD(2) rounds	
	.	.		.	
	.	.		.	
	.	.		.	
	3 cards	TIME(NOT)		Time to fire RD(NOT) rounds	
28				BLANK CARD AT END OF EACH DATA SET	

NOTE: For multiple cases, include the title (card 4) and any parameters that may change from card 4 to 28. Cases are unlimited. If the time to rate table (cards 25, 26, 27) is changed, the conditional kill probability (cards 14, 15) must also be repeated.

[illegible]

TABLE 2. SAMPLE SET-UP FOR 'REGULAR COMPUTER RUN' (Continued)

	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
1	0254567890	0123456789	0012345678	9012345678	9012345678	9012345678	9012345678	9012345678
2	15	10.0						
3	16	1.0						
4	17	001						
5	18	001						
6	19	1.0						
7	20	1.0						
8	21	1.0						
9	22	1.0						
10	23	1.0						
11	24	1.0						
12	25	1.0						
13	26	1.0						
14	27	1.0						
15	28	1.0						
16	29	1.0						
17	30	1.0						
18	31	1.0						
19	32	1.0						
20	33	1.0						
21	34	1.0						
22	35	1.0						
23	36	1.0						
24	37	1.0						
25	38	1.0						
26	39	1.0						
27	40	1.0						
28	41	1.0						
29	42	1.0						
30	43	1.0						
31	44	1.0						
32	45	1.0						
33	46	1.0						
34	47	1.0						
35	48	1.0						
36	49	1.0						
37	50	1.0						
38	51	1.0						
39	52	1.0						
40	53	1.0						
41	54	1.0						
42	55	1.0						
43	56	1.0						
44	57	1.0						
45	58	1.0						
46	59	1.0						
47	60	1.0						
48	61	1.0						
49	62	1.0						
50	63	1.0						
51	64	1.0						
52	65	1.0						
53	66	1.0						
54	67	1.0						
55	68	1.0						
56	69	1.0						
57	70	1.0						
58	71	1.0						
59	72	1.0						
60	73	1.0						
61	74	1.0						
62	75	1.0						
63	76	1.0						
64	77	1.0						
65	78	1.0						
66	79	1.0						
67	80	1.0						
68	81	1.0						
69	82	1.0						
70	83	1.0						
71	84	1.0						
72	85	1.0						
73	86	1.0						
74	87	1.0						
75	88	1.0						
76	89	1.0						
77	90	1.0						
78	91	1.0						
79	92	1.0						
80	93	1.0						
81	94	1.0						
82	95	1.0						
83	96	1.0						
84	97	1.0						
85	98	1.0						
86	99	1.0						
87	100	1.0						
88	101	1.0						
89	102	1.0						
90	103	1.0						
91	104	1.0						
92	105	1.0						
93	106	1.0						
94	107	1.0						
95	108	1.0						
96	109	1.0						
97	110	1.0						
98	111	1.0						
99	112	1.0						
100	113	1.0						
101	114	1.0						
102	115	1.0						
103	116	1.0						
104	117	1.0						
105	118	1.0						
106	119	1.0						
107	120	1.0						
108	121	1.0						
109	122	1.0						
110	123	1.0						
111	124	1.0						
112	125	1.0						
113	126	1.0						
114	127	1.0						
115	128	1.0						
116	129	1.0						
117	130	1.0						
118	131	1.0						
119	132	1.0						
120	133	1.0						
121	134	1.0						
122	135	1.0						
123	136	1.0						
124	137	1.0						
125	138	1.0						
126	139	1.0						
127	140	1.0						
128	141	1.0						
129	142	1.0						
130	143	1.0						
131	144	1.0						
132	145	1.0						
133	146	1.0						
134	147	1.0						
135	148	1.0						
136	149	1.0						
137	150	1.0						
138	151	1.0						
139	152	1.0						
140	153	1.0						
141	154	1.0						
142	155	1.0						
143	156	1.0						
144	157	1.0						
145	158	1.0						
146	159	1.0						
147	160	1.0						
148	161	1.0						
149	162	1.0						
150	163	1.0						
151	164	1.0						
152	165	1.0						
153	166	1.0						
154	167	1.0						
155	168	1.0						
156	169	1.0						
157	170	1.0						
158	171	1.0						
159	172	1.0						
160	173	1.0						
161	174	1.0						
162	175	1.0						
163	176	1.0						
164	177	1.0						
165	178	1.0						
166	179	1.0						
167	180	1.0						
168	181	1.0						
169	182	1.0						
170	183	1.0						
171	184	1.0						
172	185	1.0						
173	186	1.0						
174	187	1.0						
175	188	1.0						
176	189	1.0						
177	190	1.0						
178	191	1.0						
179	192	1.0						
180	193	1.0						
181	194	1.0						
182	195	1.0						
183	196	1.0						
184	197	1.0						
185	198	1.0						
186	199	1.0						
187	200	1.0						
188	201	1.0						
189	202	1.0						
190	203	1.0						
191	204	1.0						
192	205	1.0						
193	206	1.0						
194	207	1.0						
195	208	1.0						
196	209	1.0						
197	210	1.0						
198	211	1.0						
199	212	1.0						
200	213	1.0						
201	214	1.0						
202	215	1.0						
203	216	1.0						
204	217	1.0						
205	218	1.0						
206	219	1.0						
207	220	1.0						
208	221	1.0						
209	222	1.0						
210	223	1.0						
211	224	1.0						
212	225	1.0						
213	226	1.0						
214	227	1.0						
215	228	1.0						
216	229	1.0						
217	230	1.0						
218	231	1.0						
219	232	1.0						
220	233	1.0						
221	234	1.0						
222	235	1.0						
223	236	1.0						
224	237	1.0						
225	238	1.0						
226	239	1.0						
227	240	1.0						
228	241	1.0						
229								

TABLE 2. SAMPLE SET-UP FOR 'REGULAR COMPUTER RUN' (Continued)

1	10	11	20	21	30	31	40	41	50	51	60	61	70	71	80
1	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
2	4	000	012												
3	2	016	020												
4	1	004	008												
5		BLANK CARD													
6	7	5000.0													
7	1	3													
8	4	006	010												
9	3	014	018												
10	1	003	007												
11		BLANK CARD													
12	7	5000.0													
13	1	3													
14	4	004	008												
15	2	012	016												
16	1	002	006												
17		BLANK CARD													
18	6														
19	7	5000.0													
20	1	3													

TABLE 2. SAMPLE SET-UP FOR 'REGULAR COMPUTER RUN' (Concluded)

[illegible]

TABLE 3. REPRINT LISTING OF INPUT DATA FOR A REGULAR COMPUTER RUN

EVENT DATA CARD NO.	1	10	20	30	40	50	60	70
10	4	.5	1.0	1.5	2.0			
6	SAMPLE * REGULAR COMPUTER RUN *							15
1	0.0							
2	0.0							
3	4.24							
4	4.24							
5	1.33							
6	1.33							
7	1000.0							
8	4180.0							
9	150.0							
10	120.0							
11	3	.012		.016				
	2	.020		.024				
	1	.006		.010				
12	11.74							
13	11.74							
14	500.0							
15	10.0							
16	1.0							
17	.801							
18	.001							
19	1.0							
20	1.8							
	4	0.0	1.0	51.0	120.0			
	0.0	.16	1.0	2.0				
TITLE - 2000 FT SLANT RANGE								
7	2000.0							
11	3							
	4	.011		.015				
	2	.019		.023				
	1	.005		.009				
TITLE - 3000 FT SLANT RANGE								
7	3000.0							
11	3							
	2	.008		.012				
	1	.016		.020				
	1	.004		.008				
TITLE - 4000 FT SLANT RANGE								
7	4000.0							
11	3							
	4	.036		.010				
	2	.014		.018				
	1	.003		.007				
TITLE - 5000 FT SLANT RANGE								
7	5000.0							
11	3							
	2	.004		.008				
	1	.012		.016				
	1	.002		.006				
TITLE - 6000 FT SLANT RANGE								
7	6000.0							
11	3							
	4	.003		.007				
	2	.011		.015				
	1	.001		.005				
TITLE - 1000 FT SLANT RANGE								
7	1000.0							
9	250.0							
11	3							
	4	.014		.018				

TABLE 3. REPRINT LISTING OF INPUT DATA FOR A REGULAR COMPUTER RUN (CONTINUED)

INPUT DATA CARD NO.	1	10	20	30	40	50	60	70
72	2	.022	.026					
73	1	.008	.012					
74								
75	TITLE - 2000 FT SLANT RANGE							
76	7	2000.0						
77	11	3						
78	4	.013	.017					
79	2	.021	.025					
80	1	.007	.011					
81								
82	TITLE - 3000 FT SLANT RANGE							
83	7	3000.0						
84	11	3						
85	4	.010	.014					
86	2	.018	.022					
87	1	.006	.010					
88								
89	TITLE - 4000 FT SLANT RANGE							
90	7	4000.0						
91	11	3						
92	4	.008	.012					
93	2	.016	.020					
94	1	.005	.009					
95								
96	TITLE - 5000 FT SLANT RANGE							
97	7	5000.0						
98	11	3						
99	4	.006	.010					
100	2	.014	.018					
101	1	.004	.008					
102								
103	TITLE - 5000 FT SLANT RANGE							
104	7	6000.0						
105	11	3						
106	4	.005	.009					
107	2	.013	.017					
108	1	.003	.007					
109								
110	TITLE - 1000 FT SLANT RANGE							
111	7	1000.0						
112	9	358.0						
113	11	3						
114	4	.016	.020					
115	2	.024	.028					
116	1	.010	.014					
117								
118	TITLE - 2000 FT SLANT RANGE							
119	7	2000.0						
120	11	3						
121	4	.015	.019					
122	2	.023	.027					
123	1	.009	.013					
124								
125	TITLE - 3000 FT SLANT RANGE							
126	7	3000.0						
127	11	3						
128	4	.012	.016					
129	2	.020	.024					
130	1	.008	.012					
131								
132	TITLE - 4000 FT SLANT RANGE							
133	7	4000.0						
134	11	3						
135	4	.010	.014					
136	2	.018	.022					
137	1	.007	.011					
138								
139	TITLE - 5000 FT SLANT RANGE							
140	7	5000.0						
141	11	3						

TABLE 3. REPRINT LISTING OF INPUT DATA FOR A REGULAR COMPUTER RUN (CONCLUDED)

INPUT DATA CARD NO.	1	10	20	30	40	50	60	70
143								
144	4	.008	.012					
145	2	.016	.020					
146	1	.006	.010					
147	TITLE - 6000 FT SLANT RANGE							
148	7	6000.0						
149	11	3						
150	4	.007	.011					
151	2	.015	.019					
152	1	.005	.009					
153								
154	6							
155	TITLE - 1000 FT SLANT RANGE							
156	7	1000.0						
157	9	450.0						
158	11	3						
159	4	.018	.022					
160	2	.025	.030					
161	1	.012	.016					
162								
163	TITLE - 2000 FT SLANT RANGE							
164	7	2000.0						
165	11	3						
166	4	.017	.021					
167	2	.025	.029					
168	1	.011	.015					
169								
170	TITLE - 3000 FT SLANT RANGE							
171	7	3000.0						
172	11	3						
173	4	.014	.018					
174	2	.022	.026					
175	1	.010	.014					
176								
177	TITLE - 4000 FT SLANT RANGE							
178	7	4000.0						
179	11	3						
180	4	.012	.016					
181	2	.020	.024					
182	1	.009	.013					
183								
184	TITLE - 5000 FT SLANT RANGE							
185	7	5000.0						
186	11	3						
187	4	.010	.014					
188	2	.018	.022					
189	1	.008	.012					
190								
191	TITLE - 6000 FT SLANT RANGE							
192	7	6000.0						
193	11	3						
194	4	.009	.013					
195	2	.017	.021					
196	1	.007	.011					
197								

TABLE 4. OUTPUT

SAMPLE * REGULAR COMPUTER RUN *

COORDINATE	AIM ERROR (MILS)	BALLISTIC DISPERSION (MILS)
RANGE	4.2	1.4
DEFLECTION	4.2	1.4

AIRCRAFT SPEED (KTAS) = 150.
 STEADY STATE FIRING RATE PER GUN (RDS/MIN) = 4100.
 SLANT RANGE AT COMMENCEMENT OF FIRING RUN (FT) = 1000.
 NO. OF ROUNDS PER PASS PER GUN = 120
 PROBABILITY OF JAMMING = .00100

TARGET LENGTH (FEET) = 11.7
 TARGET WIDTH (FEET) = 11.7

NUMBER OF MONTE CARLO ITERATIONS = 500
 NUMBER OF EMPTY PASSES THROUGH RANDOM NO. GENERATORS = 10
 NUMBER OF GUN SYSTEMS CONSIDERED = 1

PROBABILITY OF TARGET KILL = .786
 STANDARD DEVIATION OF THE MEAN = .0183

NO. OF RDS/GUN	CONDITIONAL KILL PROBABILITY	TIME	CORRELATION CONSTANTS RANGE	DEFL	SLANT RANGE	KILL PROBABILITY
1	.012	.1800	0.000	0.000	954.	.000
2	.012	.1964	.975	.951	950.	.012
3	.012	.2128	.975	.951	946.	.016
4	.012	.2292	.975	.951	942.	.022
5	.012	.2456	.975	.951	938.	.034
6	.012	.2620	.975	.951	934.	.042
7	.012	.2784	.975	.951	930.	.044
8	.013	.2948	.975	.951	925.	.064
9	.013	.3112	.975	.951	921.	.074
10	.013	.3276	.975	.951	917.	.082
11	.013	.3440	.975	.951	913.	.086
12	.021	.3604	.975	.951	909.	.114
13	.021	.3768	.975	.951	905.	.116
14	.021	.3932	.975	.951	900.	.116
15	.013	.4096	.975	.951	896.	.116
16	.013	.4260	.975	.951	892.	.116
17	.013	.4424	.975	.951	888.	.116
18	.013	.4588	.975	.951	884.	.116
19	.021	.4752	.975	.951	880.	.116
20	.021	.4916	.975	.951	876.	.116
21	.007	.5080	.975	.951	871.	.116
22	.013	.5244	.975	.951	867.	.116
23	.013	.5408	.975	.951	863.	.116
24	.013	.5572	.975	.951	859.	.116
25	.013	.5736	.975	.951	855.	.116
26	.013	.5900	.975	.951	851.	.116
27	.013	.6064	.975	.951	846.	.116
28	.013	.6228	.975	.951	842.	.116
29	.013	.6392	.975	.951	838.	.116
30	.013	.6556	.975	.951	834.	.116
31	.013	.6720	.975	.951	830.	.116
32	.013	.6884	.975	.951	826.	.116
33	.021	.7048	.975	.951	822.	.116
34	.021	.7212	.975	.951	817.	.116
35	.014	.7376	.975	.951	813.	.116
36	.014	.7540	.975	.951	809.	.116
37	.014	.7704	.975	.951	805.	.116
38	.014	.7868	.975	.951	801.	.116
39	.014	.8032	.975	.951	797.	.116
40	.014	.8196	.975	.951	792.	.116
41	.014	.8360	.975	.951	788.	.116
42	.014	.8524	.975	.951	784.	.116
43	.014	.8688	.975	.951	780.	.116
44	.014	.8852	.975	.951	776.	.116
45	.014	.9016	.975	.951	772.	.116
46	.014	.9180	.975	.951	768.	.116
47	.022	.9344	.975	.951	763.	.116
48	.022	.9508	.975	.951	759.	.116
49	.022	.9672	.975	.951	755.	.116
50	.022	.9836	.975	.951	751.	.116
51	.011	.0000	.975	.951	747.	.116
52	.011	.0164	.975	.951	743.	.116
53	.011	.0328	.975	.951	739.	.116

TABLE 4. OUTPUT (CONTINUED)

NO. OF RDS/GUN	CONDITIONAL KILL PROBABILITY	TIME	CORRELATION CONSTANTS	SLANT RANGE	KILL PROBABILITY
54	.0222	1.0435	.978	736.	.448
55	.0222	1.0580	.978	732.	.428
56	.008	1.0725	.978	728.	.462
57	.014	1.0870	.978	725.	.464
58	.014	1.1014	.978	721.	.472
59	.014	1.1159	.978	717.	.476
60	.014	1.1304	.978	714.	.478
61	.0222	1.1449	.978	710.	.486
62	.0222	1.1594	.978	706.	.502
63	.008	1.1739	.978	703.	.504
64	.014	1.1884	.978	699.	.506
65	.014	1.2029	.978	695.	.518
66	.014	1.2174	.978	692.	.524
67	.014	1.2319	.978	688.	.532
68	.0222	1.2464	.978	684.	.538
69	.023	1.2609	.978	681.	.550
70	.009	1.2754	.978	677.	.554
71	.015	1.2899	.978	673.	.556
72	.015	1.3043	.978	670.	.566
73	.015	1.3188	.978	666.	.566
74	.015	1.3333	.978	662.	.572
75	.023	1.3478	.978	659.	.580
76	.023	1.3623	.978	655.	.592
77	.009	1.3768	.978	651.	.598
78	.015	1.3913	.978	648.	.598
79	.015	1.4058	.978	644.	.598
80	.015	1.4203	.978	640.	.604
81	.015	1.4348	.978	637.	.612
82	.023	1.4493	.978	633.	.616
83	.023	1.4638	.978	629.	.618
84	.000	1.4783	.978	626.	.618
85	.015	1.4928	.978	622.	.624
86	.015	1.5072	.978	618.	.628
87	.015	1.5217	.978	615.	.634
88	.015	1.5362	.978	611.	.638
89	.023	1.5507	.978	607.	.644
90	.023	1.5652	.978	604.	.650
91	.003	1.5797	.978	600.	.652
92	.015	1.5942	.978	596.	.654
93	.015	1.6087	.978	593.	.658
94	.015	1.6232	.978	589.	.662
95	.015	1.6377	.978	585.	.668
96	.023	1.6522	.978	582.	.684
97	.023	1.6667	.978	578.	.690
98	.009	1.6812	.978	574.	.690
99	.015	1.6957	.978	571.	.692
100	.015	1.7101	.978	567.	.692
101	.015	1.7246	.978	563.	.698
102	.015	1.7391	.978	560.	.702
103	.024	1.7536	.978	556.	.710
104	.024	1.7681	.978	552.	.716
105	.010	1.7826	.978	549.	.716
106	.016	1.7971	.978	545.	.726
107	.016	1.8116	.978	541.	.734
108	.016	1.8261	.978	538.	.738
109	.016	1.8406	.978	534.	.748
110	.024	1.8551	.978	530.	.758
111	.024	1.8696	.978	527.	.754
112	.010	1.8841	.978	523.	.756
113	.015	1.8986	.978	519.	.768
114	.016	1.9130	.978	516.	.766
115	.016	1.9275	.978	512.	.770
116	.016	1.9420	.978	508.	.774
117	.024	1.9565	.978	505.	.778
118	.024	1.9710	.978	501.	.780
119	.010	1.9855	.978	497.	.780
120	.016	2.0000	.978	494.	.786

TABLE 4. OUTPUT (CONTINUED)

TITLE - 1000 FT SLANT RANGE

COORDINATE	AIM ERROR (MILS)	BALLISTIC DISPERSION (MILS)
RANGE	4.2	1.4
DEFLECTION	4.2	1.4

AIRCRAFT SPEED (KTAS) = 350.
 STEADY STATE FIRING RATE PER GUN (ROS/MIN) = 4180.
 SLANT RANGE AT COMMENCEMENT OF FIRING RUN (FT) = 1000.
 NO. OF ROUNDS PER PASS PER GUN = 120
 PROBABILITY OF JAMMING = .00100

TARGET LENGTH (FEET) = 11.7
 TARGET WIDTH (FEET) = 11.7

NUMBER OF MONTE CARLO ITERATIONS = 200
 NUMBER OF EMPTY PASSES THROUGH RANDOM NO. GENERATORS = 10
 NUMBER OF GUN SYSTEMS CONSIDERED = 1

PROBABILITY OF TARGET KILL = 1.000
 STANDARD DEVIATION OF THE MEAN = 0.0000

NO. OF ROS/GUN	CONDITIONAL KILL PROBABILITY	TIME	CORRELATION CONSTANTS RANGE DEFL	SLANT RANGE	KILL PROBABILITY
1	.016	.1800	0.000	0.000	.010
1	.016	.1964	.975	.951	.025
1	.016	.2128	.975	.951	.030
1	.016	.2292	.975	.951	.035
1	.016	.2456	.975	.951	.040
1	.025	.2620	.975	.951	.045
1	.011	.2784	.975	.951	.050
1	.017	.2948	.975	.951	.055
1	.017	.3112	.975	.951	.060
1	.017	.3276	.975	.951	.065
1	.017	.3440	.975	.951	.070
1	.025	.3604	.975	.951	.075
1	.025	.3768	.975	.951	.080
1	.014	.3932	.975	.951	.085
1	.017	.4096	.975	.951	.090
1	.017	.4260	.975	.951	.095
1	.017	.4424	.975	.951	.100
1	.017	.4588	.975	.951	.105
1	.025	.4752	.975	.951	.110
1	.025	.4916	.975	.951	.115
1	.011	.5080	.975	.951	.120
1	.017	.5244	.975	.951	.125
1	.017	.5408	.975	.951	.130
1	.017	.5572	.975	.951	.135
1	.017	.5736	.975	.951	.140
1	.025	.5900	.975	.951	.145
1	.025	.6064	.975	.951	.150
1	.011	.6228	.975	.951	.155
1	.017	.6392	.975	.951	.160
1	.017	.6556	.975	.951	.165
1	.017	.6720	.975	.951	.170
1	.017	.6884	.975	.951	.175
1	.025	.7048	.975	.951	.180
1	.025	.7212	.975	.951	.185
1	.011	.7376	.975	.951	.190
1	.018	.7540	.975	.951	.195
1	.018	.7704	.975	.951	.200
1	.018	.7868	.975	.951	.205
1	.018	.8032	.975	.951	.210
1	.026	.8196	.975	.951	.215
1	.026	.8360	.975	.951	.220
1	.012	.8524	.975	.951	.225
1	.018	.8688	.975	.951	.230
1	.018	.8852	.975	.951	.235
1	.018	.9016	.975	.951	.240
1	.018	.9180	.975	.951	.245
1	.026	.9344	.975	.951	.250
1	.026	.9508	.975	.951	.255
1	.012	.9672	.975	.951	.260
1	.018	.9836	.975	.951	.265
1	.018	1.0000	.975	.951	.270
1	.018	1.0164	.978	.954	.275
1	.018	1.0328	.978	.954	.280

TABLE 4. OUTPUT (CONCLUDED)

NO. OF RDS/GUN	CONDITIONAL KILL PROBABILITY	TIME	CORRELATION CONSTANTS RANGE	DEFL	SLANT RANGE	KILL PROBABILITY
54	.026	1.0435	.978	.954	394.	.555
55	.026	1.0580	.978	.954	375.	.565
56	.012	1.0725	.978	.954	366.	.575
57	.018	1.0870	.978	.954	358.	.580
58	.018	1.1014	.978	.954	349.	.585
59	.018	1.1159	.978	.954	341.	.590
60	.018	1.1304	.978	.954	332.	.595
61	.026	1.1449	.978	.954	324.	.595
62	.026	1.1594	.978	.954	315.	.605
63	.012	1.1739	.978	.954	306.	.615
64	.018	1.1884	.978	.954	298.	.625
65	.018	1.2029	.978	.954	289.	.635
66	.018	1.2174	.978	.954	281.	.650
67	.018	1.2319	.978	.954	272.	.655
68	.026	1.2464	.978	.954	264.	.660
69	.027	1.2609	.978	.954	255.	.675
70	.013	1.2754	.978	.954	247.	.685
71	.019	1.2899	.978	.954	238.	.695
72	.019	1.3043	.978	.954	229.	.695
73	.019	1.3188	.978	.954	221.	.705
74	.019	1.3333	.978	.954	212.	.715
75	.027	1.3478	.978	.954	204.	.715
76	.027	1.3623	.978	.954	195.	.730
77	.013	1.3768	.978	.954	187.	.735
78	.019	1.3913	.978	.954	178.	.740
79	.019	1.4058	.978	.954	169.	.745
80	.019	1.4203	.978	.954	161.	.760
81	.019	1.4348	.978	.954	152.	.780
82	.027	1.4493	.978	.954	144.	.770
83	.027	1.4638	.978	.954	135.	.780
84	.013	1.4783	.978	.954	127.	.785
85	.019	1.4928	.978	.954	118.	.785
86	.019	1.5072	.978	.954	110.	.795
87	.019	1.5217	.978	.954	101.	.800
88	.019	1.5362	.978	.954	92.	.800
89	.027	1.5507	.978	.954	84.	.810
90	.027	1.5652	.978	.954	75.	.815
91	.013	1.5797	.978	.954	67.	.815
92	.019	1.5942	.978	.954	58.	.815
93	.019	1.6087	.978	.954	50.	.815
94	.019	1.6232	.978	.954	41.	.815
95	.019	1.6377	.978	.954	32.	.825
96	.027	1.6522	.978	.954	24.	.825
97	.027	1.6667	.978	.954	15.	.825
98	.013	1.6812	.978	.954	7.	.825
99	.019	1.6957	.978	.954	-2.	.800
THE AIRCRAFT FLEW INTO THE TARGET AFTER FIRING					98	ROUNDS

ROUNDS FIRED IN 1 SEC. 31. AIR SPEED 150. KNOTS
 STEADY FIRE RATE 4100.0 ROUNDS/MIN DIVE ANGLE -0.0
 BALLISTIC DISP. 1.39 RANGE. 1.39 DEFLECTION
 AIM ERROR 4.24 RANGE. 4.24 DEFLECTION

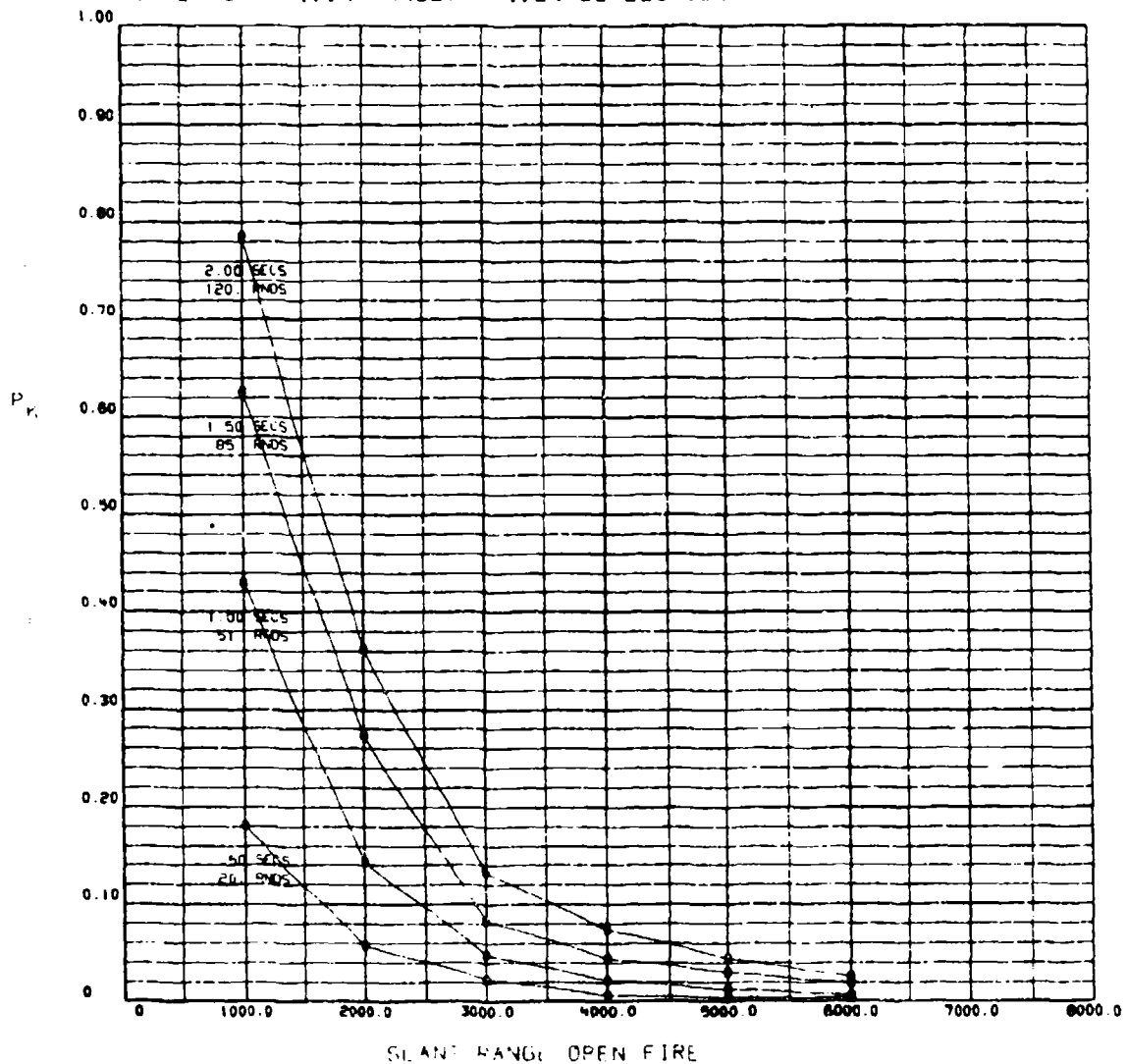


Figure 4. Filmplot Output Sample for Regular Computer Run

SECTION VI

GENERATE THE INPUT RUN

SAMPLE PROBLEM

The sample for Generate the Input Run uses the same data as the Regular Computer Run in order to demonstrate the flexibility, time savings and less chance for errors that can be realized through the use of this technique (see sample problem in Section V for details of problem).

There are five parameters that change more frequently than the other inputs. They are listed in Figure 5 with their hierarchy. Table 5 describes how to set the job up. Table 6 is a sample coding for the problem. Table 7 is a REPRINT listing (a computer system routine) of the input data. Table 8 contains a list of the data generated from the input from Table 7. The final output listing is given in Table 9 with most of the input values included. After the columnar titles each round is analyzed for the entire burst. This output is the same as the Regular Computer Run. Also when the slant range goes negative the computation stops and prints out a message that the aircraft flew into the target. Figure 6 is the filmplot output for the first six slant range values with their respective probability of kill values plotted.

The time required for any given computer run can be calculated by the equation described in Section IV.

AIM
ERROR (S)
IAIM $\geq 1, \leq 3$

BALLISTIC
DISPERSION (S)
IBALE $\geq 1, \leq 6$

AIRCRAFT
VELOCITY (IES)
IVEL $\geq 1, \leq 12$

TARGET (S)
LENGTH & WIDTH
ITGTL
ITGTW

SLANT
RANGES
NSLANT $\geq 1, \leq 6$

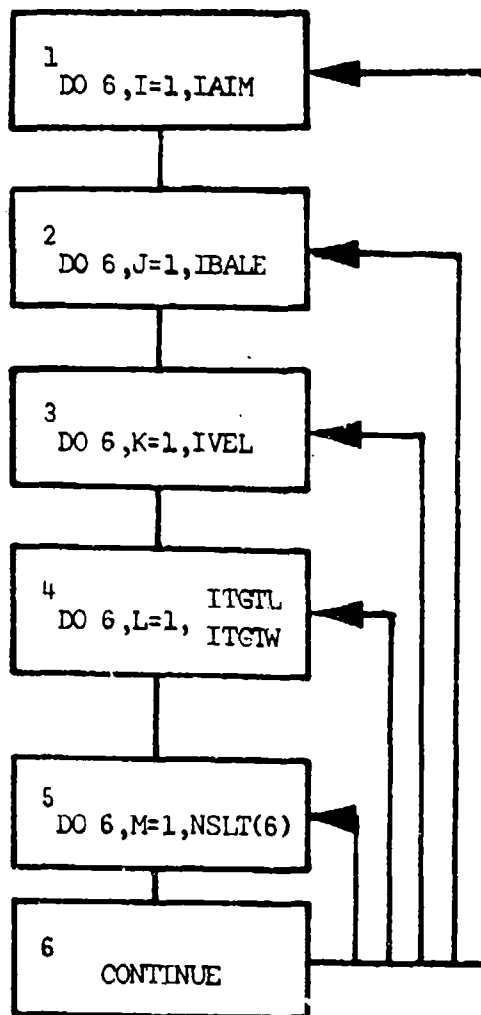


Figure 5. Flow Chart for Generate the Input Run

TABLE 5. DESCRIPTION OF THE SET-UP FOR A GENERATE THE INPUT RUN

Card	Columns	Variable	Limits	Description	Units
1	1	IPLOT	0,1,2	0 = No plots. 1 = Plot option has been turned on. 2 = Stand alone plot.	
	2	IPLOT	0,1	0 = Regular computer run. 1 = Data will be generated.	
	3	IGL	0,1	0 = Do not execute the generated input data. This is used for checking the set-up before executing it. 1 = execute the generated input data.	
	4-5	IBUR	1-10	Number of burst lengths to be plotted.	
	6-12 13-19 .	IPLOT(1) IPLOT(2) .		Time which burst length should be plotted.	secs decimal
	69-75	IPLOT(10)		TIME (secs).	
	1-2	D(1)	1	Address = 1.	
	3-10	A	20, ≤1	Correlation coefficient in range between consecutive airpoints.	
NOTE: If a value for the correlation coefficient is computed in the program for each round, this parameter should be set to zero if JEM = 1 on card 12.					
2	1-2	D(2)	1	Address = 2.	
	3-10	B	20, ≤1	Correlation coefficient in deflection between consecutive airpoints.	
NOTE: If a value for the correlation coefficient is computed in the program for each round, this parameter should be set to zero if JEM = 1 on card 12.					

TABLE 5. DESCRIPTION OF THE SET-UP FOR A GENERATE THE INPUT RUN (CONTINUED)

Card	Columns	Variable	Limits	Description	Units	
4	1-2	D(8)	8	Address = 8.	decimal	
	3-10	R		Firing rate of gun in rounds per minute.		
5	1-2	D(10)	10	Address = 10.		decimal
	3-10	N		Number of rounds fired on a single pass per gun.		
6	1-2	D(14)	14	Address = 14.	decimal	
	3-10	P	200-∞	Maximum number of Monte Carlo iterations.		
7	1-2	D(15)	15	Address = 15.		decimal
	3-10	II		Number of dummy passes through random number generator.		
8	1-2	D(16)	16	Address = 16.		
	3-10	DN	21	Increment in burst length.		
NOTE: This controls the number of lines that will be printed, i.e., 1 will cause the printer to write out a data line for each round in the burst.						
9	1-2	D(17)	17	Address = 17.		
	3-10	E		Desired maximum value of the standard deviation of the mean.		
10	1-2	D(18)	18	Address = 18.		
	3-10	PJAM		Probability of the gun jamming.		
11	1-2	D(19)	19	Address = 19.		
	3-10	GUNS		Number of gun systems to be analyzed.		

NOTE: The program computes a final probability of kill based on the total number of gun systems.

TABLE 5. DESCRIPTION OF THE SET-UP FOR A GENERATE THE INPUT RUN (CONTINUED)

Card	Columns	Variable	Limits	Description	Units
12	1-2	D(20)	20	Address = 20	
	3-10	JDM	0,1	0 indicates that you have input some correlation value in cards 2 and 3 other than zero and omit cards 13, 14, and 15. 1 indicates you have a zero in cards 2 and 3 for the correlation values and plan to input a time-to-rate table for a Gatling gun by completing cards 13, 14, and 15.	
13	1-5	NOT	≤30	Number of pairs of entries for the time-to-rate table for 1 Gatling gun.	
14	1-8	RD(1)		Number of rounds fired at TIME (1)	
	9-16	RD(2)		Number of rounds fired at TIME (2)	
	.	.		.	
	.	.		.	
	3 cards	RD(NOT)		Number of rounds fired at TIME (NOT)	
NOTE: You can have from 1 to 3 cards for a maximum of 30 entries.					
15	1-5	TIME(1)		Time to fire RD(1) rounds	
	6-10	TIME(2)		Time to fire RD(2) rounds	
	.	.		.	
	.	.		.	
	3 cards	TIME(NOT)		Time to fire RD(NOT) rounds	
16				Blank card	
17				End of record card	
18	1-2	IAIM	1,2,3	Number of sets of aiming errors	
	6-10	SIGMA (ALPHA)/1		Beginning value for the first standard deviation of the aim error in range	mils c
	11-15	SGRM(1)		End value for standard deviation aim error in range	mils c

NOTE: If no end value is used, the beginning value will be used for the entire burst length. If an end value is used, the program will do a linear interpolation between the beginning and end value for the aim error based on the slanting range of the aircraft.

TABLE 5. DESCRIPTION OF THE SET-UP FOR A GENERATE THE INPUT RUN (CONTINUED)

CARD	COLUMNS	VARIABLE	LIMITS	DESCRIPTION	UNITS
	16-20	SIGMA (BETA)(1)		Beginning value for the first standard deviation of the aim error in deflection.	mils o
	21-25	SGDI(1)		End value for standard deviation aim error in deflection. (See SGRI(1) Note)	mils o
	26-30	SIGMA (ALPHA)(2)		Beginning value for the second standard deviation of the aim error in range	
	31-35	SGRI(2)		End value for the second standard deviation aim error in range. (See SGDI(1) Note)	
	36-40	SIGMA (BETA)(2)		Beginning value for the second standard deviation aim error in deflection.	
	41-45	SGDI(2)		End value for the second standard deviation aim error in deflection. (See SGRI(1) Note)	
	46-50	SIGMA		Beginning value for the third standard deviation aim error in range	
	51-55	SGRI(3)		End value for the third standard deviation aim error in range. (See SGDI(1) Note)	
	56-60	SIGMA (BETA)(3)		Beginning value for the third standard deviation aim error in deflection.	
	61-65	SGDI(3)		End value for the third standard deviation aim error in deflection. (See SGRI(1) Note)	
19	1-2	IBALE	1-6	Number of sets of ballistic errors	
	6-10	BALE(1)		First ballistic error standard deviation in range	mils o
	11-15	BALE(2)		First ballistic error standard deviation in deflection. Repeat the above step and this step for a maximum of 6 sets.	mils o
20	1-2	IWEL	1-12	Number of aircraft velocities following	

TABLE 5. DESCRIPTION OF THE SET-UP FOR A GENERATE THE INPUT RUN (CONTINUED)

Card	Columns	Variable	Limits	Description	Units
21	6-10	VEL(1)	1-12	First aircraft velocity	knots
	.	.		.	.
	61-65	VEL(12)		Twelfth aircraft velocity	knots
	1-2	ITOTL		Number of different target lengths following	
22	6-10	TOTL(1)	1-12	First target length in range	feet
	.	.		.	.
	61-65	TOTL(12)		Twelfth target length in range	feet
	1-2	ITGTW		Number of target widths following	
23	6-10	ITGTW(1)	1-12	First target width in deflection	feet seconds
	.	.		.	.
	61-65	ITGTW(12)		Twelfth target width in deflection	feet
	1-2	IKILL		2-6	Number of conditional kill cards in this set - must equal NSLT(1), Card 24
NOTE: This value is used on the first card of each set of conditional kill ratio tables, i.e., when card 23 is repeated second through the sixth time this parameter is omitted. See sample set up.					
6-10	NTYPE(1)	1,2,3	1,2, or 3 different arm types analyzed in burst	decimal	
11-15	NUMR(1)		Number of consecutive rounds using the first conditional kill ratio	decimal	
NOTE: If NUMR(1) = 0 the program sets NUMR(1) equal to N if NTYPE(1) = 1. This card type is the same as card 14 in the REGULAR COMPUTER run set-up.					
16-20	CHI(1)			Value of the conditional kill ratio at the beginning of the burst	
21-25	CEH(1)			Value of the conditional kill ratio at the end of the burst. The program does a linear interpolation between the beginning and end values. If no end conditional kill value is input, the beginning value will be used NUMR(1) times.	

TABLE 5. DESCRIPTION OF THE SET-UP FOR A GENERATE THE INPUT RUN (CONCLUDED)

Card	Columns	Variable	Limits	Description	Units
	26-30	NUMR(2)		Number of consecutive rounds using the second conditional kill ratio. This option will be used if NTYPE(1) is 2 or 3.	decimal
	31-35	CP1(2)		Beginning value for second conditional kill ratio in the mixed round ammo belt.	
	36-40	CPN(2)		End value for the second conditional kill ratio in the mixed round ammo belt. When the end value is input, the program does a linear interpolation between the beginning and end values. If no end conditional kill value is input the beginning value will be used NUMR(2) times.	
	41-45	NUMR(3)		Number of consecutive rounds using the third conditional kill ratio. This option will be used if NTYPE(1) is equal to 3.	decimal
	46-50	CP1(3)		Beginning value for the third conditional kill ratio in the mixed round ammo belt.	
	51-55	CPN(3)		End value for the third conditional kill ratio in the mixed round ammo belt. When the end value is input, the program does a linear interpolation between the beginning and end values.	
NOTE: Repeat Card 23 NSLT(1) times for each additional set of conditional kill tables (Sets range from 2 to 244). A set is = NSLT(1) or IKILL. No. of sets required = IADM*IBALE*IVEI*ITGTL.					
24	1-5	ISLRG	1	Number of unique slant range tables; see sample set up.	
	6-10	NSLT(1)	2-6	Number of slant ranges on this card.	
NOTE: NSLT(1) should equal IKILL.					
	11-20	SLRNG(1)		First slant range	feet
	.	.			
	.	.			
	61-70	SLRNG (IKILL)		(IKILL) slant range	feet
25	1-60	TITLE(1)		Hollerith information	
	61-70			Omit this parameter on GENERATE-THE-INPUT data set-up.	

Table 6. SAMPLE SET-UP FOR 'GENERATE THE INPUT'

	1 10	11 20	21 30	31 40	41 50	51 60	61 70	71 80
1	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
2	111.4	5	1.0	1.5	2.0			
3	1.0	0.0						
4	2	0.0						
5	8	4100.0						
6	10	120.0						
7	14	1000.0						
8	15	10.0						
9	16	1.0						
10	17	0.001						
11	18	0.001						
12	19	1.0						
13	20	1.0						
14	4							
15	10.0	1.0	51.0	120.0				
16	0.0	18	1.0	2.0				
17	BLANK CARD							
18	- END OF RECORD CARD -							
19	1	4.24	4.24					
20	1	1.39	1.39					
21	4	150.0250.0350.0450.0						

Table 6. SAMPLE SET-UP FOR 'GENERATE THE INPUT' (Continued)

	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
1	3234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
2	111174							
3	6	3.0	4.0	.012	.016	2.0	.020	.024
4		3.0	4.0	.011	.015	2.0	.019	.023
5		3.0	4.0	.008	.012	2.0	.016	.020
6		3.0	4.0	.006	.010	2.0	.014	.018
7		3.0	4.0	.004	.008	2.0	.012	.016
8		3.0	4.0	.003	.007	2.0	.011	.015
9	6	1000.0	2000.0	3000.0	4000.0	5000.0	6000.0	
10	SAMPLE - GENERATE THE INPUT							
11	6	3.0	4.0	.014	.018	2.0	.022	.026
12		3.0	4.0	.013	.017	2.0	.021	.025
13		3.0	4.0	.010	.014	2.0	.018	.022
14		3.0	4.0	.008	.012	2.0	.016	.020
15		3.0	4.0	.006	.010	2.0	.014	.018
16		3.0	4.0	.005	.009	2.0	.013	.017
17	6	3.0	4.0	.016	.020	2.0	.024	.028
18		3.0	4.0	.015	.019	2.0	.023	.027
19		3.0	4.0	.013	.017	2.0	.021	.025
20		3.0	4.0	.010	.014	2.0	.018	.022

Table 6. SAMPLE SET-UP FOR 'GENERATE THE INPUT' (Concluded)

[illegible]

[illegible]

	111	4	.5	1.1	1.5	2.1
1						
2		6.0				
3		6.0				
4		6.0				
5	11	10.0				
6	11	10.0				
7	11	10.0				
8	11	10.0				
9	11	10.0				
10	11	10.0				
11	11	10.0				
12	11	10.0				
13	11	10.0				
14	11	10.0				
15	11	10.0				
16	11	10.0				

AIM STANDARD DEVIATION OF AIMING ERROR TABLE

IBALE STANCAHO DEVIATION OF THE BALLISTIC ERROR TABLE
1 1.39 1.39-1.0(-1.)))-1.00-0.00-(-0.00-0.00-1.0)-0.00-(-0.00-0.00

ITSTL TARGET LENGTH TABLE
1 11.74

IKILL CONDITIONAL KILL TABLE

ISLNG HSLT		SLANT PANGF TABLE					
1	6	1000.	2000.	3000.	4000.	5000.	6000.
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9
10	10	10	10	10	10	10	10
11	11	11	11	11	11	11	11
12	12	12	12	12	12	12	12
13	13	13	13	13	13	13	13
14	14	14	14	14	14	14	14
15	15	15	15	15	15	15	15
16	16	16	16	16	16	16	16
17	17	17	17	17	17	17	17
18	18	18	18	18	18	18	18
19	19	19	19	19	19	19	19
20	20	20	20	20	20	20	20
21	21	21	21	21	21	21	21
22	22	22	22	22	22	22	22
23	23	23	23	23	23	23	23
24	24	24	24	24	24	24	24
25	25	25	25	25	25	25	25
26	26	26	26	26	26	26	26
27	27	27	27	27	27	27	27
28	28	28	28	28	28	28	28
29	29	29	29	29	29	29	29
30	30	30	30	30	30	30	30
31	31	31	31	31	31	31	31
32	32	32	32	32	32	32	32
33	33	33	33	33	33	33	33
34	34	34	34	34	34	34	34
35	35	35	35	35	35	35	35
36	36	36	36	36	36	36	36
37	37	37	37	37	37	37	37
38	38	38	38	38	38	38	38
39	39	39	39	39	39	39	39
40	40	40	40	40	40	40	40
41	41	41	41	41	41	41	41
42	42	42	42	42	42	42	42
43	43	43	43	43	43	43	43
44	44	44	44	44	44	44	44
45	45	45	45	45	45	45	45
46	46	46	46	46	46	46	46
47	47	47	47	47	47	47	47
48	48	48	48	48	48	48	48
49	49	49	49	49	49	49	49
50	50	50	50	50	50	50	50
51	51	51	51	51	51	51	51
52	52	52	52	52	52	52	52
53	53	53	53	53	53	53	53
54	54	54	54	54	54	54	54
55	55	55	55	55	55	55	55
56	56	56	56	56	56	56	56
57	57	57	57	5			

ADDITIONAL I/P GENERATED WITH PREVIOUS TABLES BEING REPLACED BY THESE TABLES

IKILL CONDITIONAL KILL TABLE

IKILL CONDITIONAL KILL IABLE

IKILL CONDITIONAL KILL TABLE

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TABLE 8. LISTING OF GENERATED DATA

GENERATED 1/10

6	SAMPLE	•	GENERATE THE INPUT RUN	•	-C.
11	1.00	1.00	1.00	1.00	
12	1.00	1.00	1.00	1.00	
13	1.00	1.00	1.00	1.00	
14	1.00	1.00	1.00	1.00	
15	1.00	1.00	1.00	1.00	
16	1.00	1.00	1.00	1.00	
17	1.00	1.00	1.00	1.00	
18	1.00	1.00	1.00	1.00	
19	1.00	1.00	1.00	1.00	
20	1.00	1.00	1.00	1.00	
21	1.00	1.00	1.00	1.00	
22	1.00	1.00	1.00	1.00	
23	1.00	1.00	1.00	1.00	
24	1.00	1.00	1.00	1.00	
25	1.00	1.00	1.00	1.00	
26	1.00	1.00	1.00	1.00	
27	1.00	1.00	1.00	1.00	
28	1.00	1.00	1.00	1.00	
29	1.00	1.00	1.00	1.00	
30	1.00	1.00	1.00	1.00	
31	1.00	1.00	1.00	1.00	
32	1.00	1.00	1.00	1.00	
33	1.00	1.00	1.00	1.00	
34	1.00	1.00	1.00	1.00	
35	1.00	1.00	1.00	1.00	
36	1.00	1.00	1.00	1.00	
37	1.00	1.00	1.00	1.00	
38	1.00	1.00	1.00	1.00	
39	1.00	1.00	1.00	1.00	
40	1.00	1.00	1.00	1.00	
41	1.00	1.00	1.00	1.00	
42	1.00	1.00	1.00	1.00	
43	1.00	1.00	1.00	1.00	
44	1.00	1.00	1.00	1.00	
45	1.00	1.00	1.00	1.00	
46	1.00	1.00	1.00	1.00	
47	1.00	1.00	1.00	1.00	
48	1.00	1.00	1.00	1.00	
49	1.00	1.00	1.00	1.00	
50	1.00	1.00	1.00	1.00	
51	1.00	1.00	1.00	1.00	
52	1.00	1.00	1.00	1.00	
53	1.00	1.00	1.00	1.00	
54	1.00	1.00	1.00	1.00	
55	1.00	1.00	1.00	1.00	
56	1.00	1.00	1.00	1.00	
57	1.00	1.00	1.00	1.00	
58	1.00	1.00	1.00	1.00	
59	1.00	1.00	1.00	1.00	
60	1.00	1.00	1.00	1.00	
61	1.00	1.00	1.00	1.00	
62	1.00	1.00	1.00	1.00	
63	1.00	1.00	1.00	1.00	
64	1.00	1.00	1.00	1.00	
65	1.00	1.00	1.00	1.00	
66	1.00	1.00	1.00	1.00	
67	1.00	1.00	1.00	1.00	
68	1.00	1.00	1.00	1.00	
69	1.00	1.00	1.00	1.00	
70	1.00	1.00	1.00	1.00	
71	1.00	1.00	1.00	1.00	
72	1.00	1.00	1.00	1.00	
73	1.00	1.00	1.00	1.00	
74	1.00	1.00	1.00	1.00	
75	1.00	1.00	1.00	1.00	
76	1.00	1.00	1.00	1.00	
77	1.00	1.00	1.00	1.00	
78	1.00	1.00	1.00	1.00	
79	1.00	1.00	1.00	1.00	
80	1.00	1.00	1.00	1.00	
81	1.00	1.00	1.00	1.00	
82	1.00	1.00	1.00	1.00	
83	1.00	1.00	1.00	1.00	
84	1.00	1.00	1.00	1.00	
85	1.00	1.00	1.00	1.00	
86	1.00	1.00	1.00	1.00	
87	1.00	1.00	1.00	1.00	
88	1.00	1.00	1.00	1.00	
89	1.00	1.00	1.00	1.00	
90	1.00	1.00	1.00	1.00	
91	1.00	1.00	1.00	1.00	
92	1.00	1.00	1.00	1.00	
93	1.00	1.00	1.00	1.00	
94	1.00	1.00	1.00	1.00	
95	1.00	1.00	1.00	1.00	
96	1.00	1.00	1.00	1.00	
97	1.00	1.00	1.00	1.00	
98	1.00	1.00	1.00	1.00	
99	1.00	1.00	1.00	1.00	
100	1.00	1.00	1.00	1.00	

TABLE 8. LISTING OF GENERATED DATA (CONTINUED)

7	500.00	SAMPLE * GENERATE THE INPUT RUN *		-0.
11	3.00			
	4	.028	.010	
	2	.014	.013	
	1	.012	.014	
7	600.00	SAMPLE * GENERATE THE INPUT RUN *		-0.
11	3.00			
	4	.025	.010	
	2	.017	.017	
	1	.013	.017	
6		SAMPLE * GENERATE THE INPUT RUN *		-0.
7	1000.00			
9	350.00			
11	3.00			
	4	.018	.020	
	2	.024	.028	
	1	.010	.014	
12	11.74			
13	11.74			
7	2000.00	SAMPLE * GENERATE THE INPUT RUN *		-0.
11	3.00			
	4	.015	.019	
	2	.037	.017	
	1	.009	.017	
7	3000.00	SAMPLE * GENERATE THE INPUT RUN *		-0.
11	3.00			
	4	.012	.016	
	2	.025	.034	
	1	.008	.012	
7	4000.00	SAMPLE * GENERATE THE INPUT RUN *		-0.
11	3.00			
	4	.010	.014	
	2	.018	.022	
	1	.007	.011	
7	5000.00	SAMPLE * GENERATE THE INPUT RUN *		-0.
11	3.00			
	4	.008	.012	
	2	.016	.025	
	1	.006	.010	
7	6000.00	SAMPLE * GENERATE THE INPUT RUN *		-0.
11	3.00			
	4	.007	.011	
	2	.015	.019	
	1	.005	.009	
6		SAMPLE * GENERATE THE INPUT RUN *		-0.
7	1000.00			
9	450.00			
11	3.00			
	4	.018	.022	
	2	.026	.033	
	1	.012	.016	
12	11.74			
13	11.74			

TABLE 8. LISTING OF GENERATED DATA (CONCLUDED)

7	2000.00	SAMPLE	•	GENERATE THE INPUT RUN	•	-0.
11	3.00					
	4					
	2	.017		.021		
	1	.025		.023		
	1	.011		.015		
7	3000.00	SAMPLE	•	GENERATE THE INPUT RUN	•	-0.
11	3.00					
	4					
	2	.014		.018		
	1	.022		.026		
	1	.010		.014		
7	4000.00	SAMPLE	•	GENERATE THE INPUT RUN	•	-0.
11	3.00					
	4					
	2	.012		.016		
	1	.023		.024		
	1	.030		.013		
7	5000.00	SAMPLE	•	GENERATE THE INPUT RUN	•	-0.
11	3.00					
	4					
	2	.017		.014		
	1	.018		.033		
	1	.008		.012		
7	6000.00	SAMPLE	•	GENERATE THE INPUT RUN	•	-0.
11	3.00					
	4					
	2	.070		.013		
	1	.017		.021		
	1	.007		.011		

TABLE 9. OUTPUT SAMPLE * GENERATE THE INPUT RUN *

COORDINATE AIM ERROR BALLISTIC
(MILS) (DISPERSION (MILS))

RANGE 4.2 1.4
DEFLECTION 4.2 1.4

AIRCRAFT SPEED (KTAS) = 150.
STEADY STATE FIRING RATE PER GUN (ROS/MIN) = 4100.
SLANT RANGE AT COMMENCEMENT OF FIRING RUN (FT) = 1000.
NO. OF ROUNDS PER PASS PER GUN = 120
PROBABILITY OF JAMMING = .0010

TARGET LENGTH (FEET) = 11.7
TARGET WIDTH (FEET) = 11.7

NUMBER OF MONTE CARLO ITERATIONS = 500
NUMBER OF EMPTY PASSES THROUGH RANDOM NO. GENERATORS = 17
NUMBER OF GUN SYSTEMS CONSIDERED = 1

PROBABILITY OF TARGET KILL = .726
STANDARD DEVIATION OF THE MEAN = .0183

NO. OF ROS/GUN	CONDITIONAL KILL PROBABILITY	TIME	CORRELATION CONSTANTS RANGE DEFL	SLANT RANGE	KILL PROBABILITY
1	.012	.1820	.975	.951	.0008
1	.012	.1864	.975	.951	.0012
1	.012	.2128	.975	.951	.0016
1	.012	.2252	.975	.951	.0022
1	.020	.2456	.975	.951	.0034
1	.021	.2620	.975	.951	.0042
1	.007	.2784	.975	.951	.0044
1	.013	.2948	.975	.951	.0064
1	.013	.3112	.975	.951	.0070
1	.013	.3276	.975	.951	.0074
1	.013	.3440	.975	.951	.0082
1	.021	.3604	.975	.951	.0096
1	.013	.3768	.975	.951	.0116
1	.013	.3932	.975	.951	.0116
1	.013	.4096	.975	.951	.0116
1	.013	.4260	.975	.951	.0116
1	.013	.4424	.975	.951	.0134
1	.013	.4588	.975	.951	.0136
1	.021	.4752	.975	.951	.0144
1	.021	.4916	.975	.951	.0144
1	.007	.5080	.975	.951	.0144
1	.013	.5244	.975	.951	.0144
1	.013	.5408	.975	.951	.0144
1	.013	.5572	.975	.951	.0144
1	.013	.5736	.975	.951	.0144
1	.021	.5900	.975	.951	.0144
1	.021	.6064	.975	.951	.0144
1	.013	.6228	.975	.951	.0144
1	.013	.6392	.975	.951	.0144
1	.013	.6556	.975	.951	.0144
1	.013	.6720	.975	.951	.0144
1	.013	.6884	.975	.951	.0144
1	.021	.7048	.975	.951	.0144
1	.021	.7212	.975	.951	.0144
1	.021	.7376	.975	.951	.0144
1	.014	.7540	.975	.951	.0144
1	.014	.7704	.975	.951	.0144
1	.014	.7868	.975	.951	.0144
1	.014	.8032	.975	.951	.0144
1	.022	.8196	.975	.951	.0144
1	.022	.8360	.975	.951	.0144
1	.014	.8524	.975	.951	.0144
1	.014	.8688	.975	.951	.0144
1	.014	.8852	.975	.951	.0144
1	.014	.9016	.975	.951	.0144
1	.014	.9180	.975	.951	.0144
1	.022	.9344	.975	.951	.0144
1	.022	.9508	.975	.951	.0144
1	.014	.9672	.975	.951	.0144
1	.014	.9836	.975	.951	.0144
1	.014	1.0000	.975	.951	.0144
1	.014	1.0164	.975	.951	.0144
1	.014	1.0328	.975	.951	.0144

TABLE 9. OUTPUT SAMPLE * GENERATE THE INPUT RUN * (CONCLUDED)

NO. OF RDS/G LN	CONDITIONAL KILL PROBABILITY	TIME	CORRELATION CONSTANTS RANGE DEFL	SLANT RANGE	KILL PROBABILITY
54	.J22	1.0435	.978 .954	736.	.448
55	.022	1.0589	.978 .954	732.	.458
56	.J08	1.0725	.978 .954	728.	.462
57	.J14	1.0870	.978 .954	725.	.464
58	.014	1.1014	.978 .954	721.	.472
59	.014	1.1159	.978 .954	717.	.476
60	.014	1.1304	.978 .954	714.	.478
61	.022	1.1449	.978 .954	710.	.486
62	.022	1.1594	.978 .954	706.	.512
63	.008	1.1739	.978 .954	703.	.514
64	.014	1.1884	.978 .954	699.	.506
65	.J14	1.2029	.978 .954	695.	.518
66	.014	1.2174	.978 .954	692.	.524
67	.J14	1.2319	.978 .954	688.	.532
68	.J22	1.2464	.978 .954	684.	.538
69	.023	1.2609	.978 .954	681.	.550
70	.J09	1.2754	.978 .954	677.	.554
71	.015	1.2899	.978 .954	673.	.556
72	.J15	1.3044	.978 .954	670.	.566
73	.015	1.3188	.978 .954	666.	.566
74	.J15	1.3333	.978 .954	662.	.572
75	.023	1.3478	.978 .954	659.	.590
76	.023	1.3623	.978 .954	655.	.592
77	.J09	1.3768	.978 .954	651.	.598
78	.015	1.3913	.978 .954	648.	.598
79	.015	1.4058	.978 .954	644.	.598
80	.015	1.4203	.978 .954	640.	.594
81	.015	1.4348	.978 .954	637.	.612
82	.023	1.4493	.978 .954	633.	.616
83	.023	1.4638	.978 .954	629.	.618
84	.J09	1.4783	.978 .954	626.	.618
85	.015	1.4928	.978 .954	622.	.624
86	.J15	1.5072	.978 .954	618.	.638
87	.015	1.5217	.978 .954	615.	.634
88	.015	1.5362	.978 .954	611.	.638
89	.023	1.5507	.978 .954	607.	.644
90	.023	1.5652	.978 .954	604.	.650
91	.J09	1.5797	.978 .954	600.	.652
92	.015	1.5942	.978 .954	596.	.654
93	.015	1.6087	.978 .954	593.	.658
94	.J15	1.6232	.978 .954	589.	.662
95	.015	1.6377	.978 .954	585.	.668
96	.023	1.6522	.978 .954	582.	.684
97	.J23	1.6667	.978 .954	578.	.690
98	.J09	1.6812	.978 .954	574.	.690
99	.015	1.6957	.978 .954	571.	.692
100	.015	1.7101	.978 .954	567.	.698
101	.015	1.7246	.978 .954	563.	.698
102	.015	1.7391	.978 .954	560.	.712
103	.J24	1.7536	.978 .954	556.	.710
104	.J24	1.7681	.978 .954	552.	.716
105	.010	1.7826	.978 .954	549.	.716
106	.J16	1.7971	.978 .954	545.	.726
107	.015	1.8116	.978 .954	541.	.734
108	.015	1.8261	.978 .954	538.	.738
109	.016	1.8406	.978 .954	534.	.748
110	.024	1.8551	.978 .954	530.	.750
111	.024	1.8696	.978 .954	527.	.754
112	.010	1.8841	.978 .954	523.	.756
113	.010	1.8986	.978 .954	519.	.760
114	.J16	1.9130	.978 .954	516.	.766
115	.016	1.9275	.978 .954	512.	.770
116	.J16	1.9420	.978 .954	508.	.774
117	.024	1.9565	.978 .954	505.	.778
118	.J24	1.9710	.978 .954	501.	.778
119	.010	1.9855	.978 .954	497.	.780
120	.016	2.0000	.978 .954	494.	.786

AIR SPEED 100 KNOTS
 RPM 4100.0 ROUNDS/MIN DIVE ANGLE 40.0
 RM 10.00 DISC. 1.39 RANGE. 1.39 DEFLECTION
 RM ERROR 4.24 RANGE. 4.24 DEFLECTION

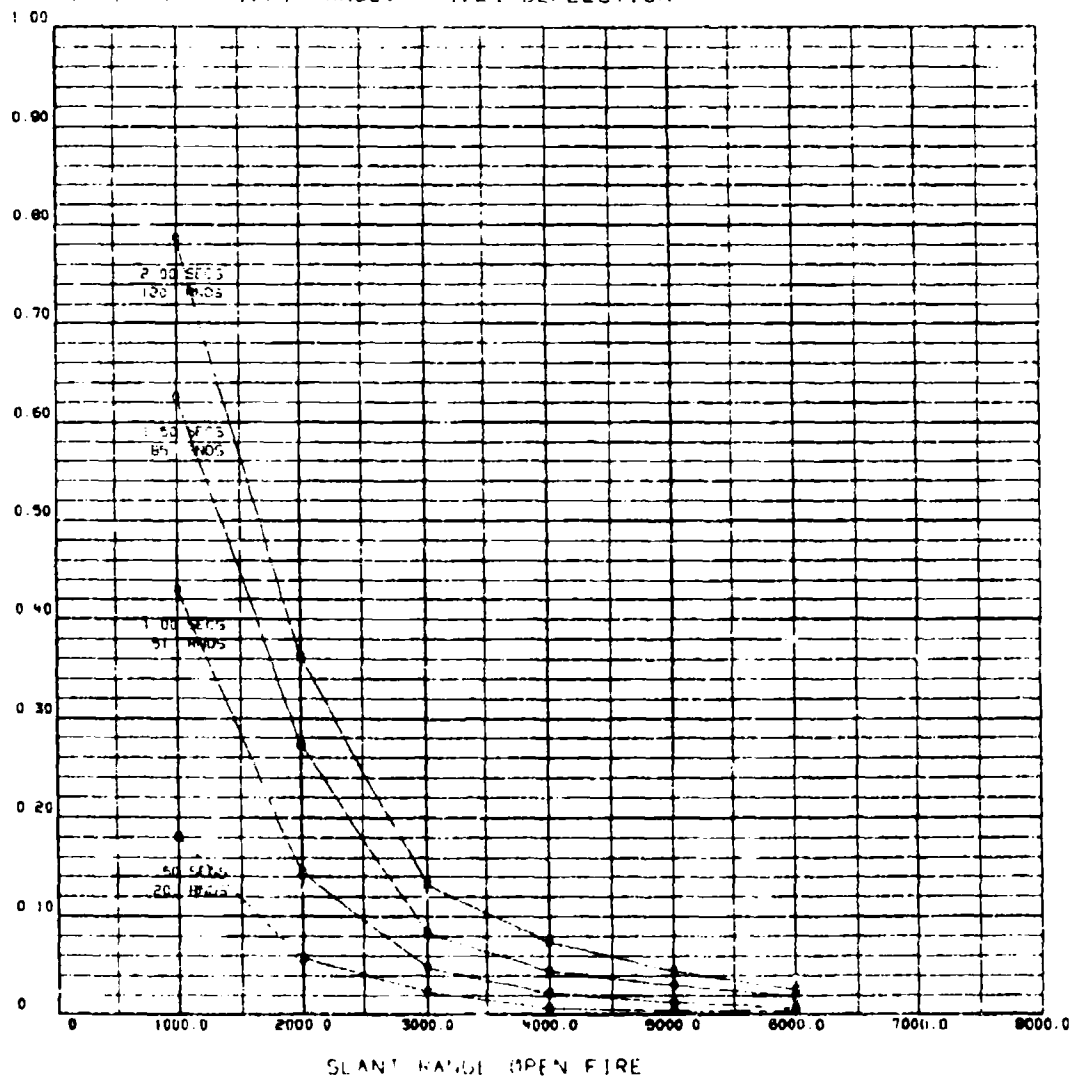


Figure 6. Filmplot Output Sample for Generate the Input Run

SECTION VII

STAND ALONE PLOT

There may be times when the probability of kill values are known but no plots were made. This section becomes a back-up plot option when this occurs. The P_k 's can be keypunched and plotted with a minimum computer and turn around times. Without this option the analyst would have to resubmit the computer run with the plot option turned on or plot the P_k 's by hand. Table 10 describes the set-up and Table 11 is a sample set-up. Figure 7 is the filmplot output for the stand alone plot.

TABLE 10. DESCRIPTION OF THE SET-UP FOR A STAND ALONE PLOT

Card	Columns	Variable	Limits	Description	Units
1	1	IPLOT	2	2 = Stand alone plot	
2	1-5	TCODE		Description of the target	
	6-10	WCODE		Description of the weapon	
	11-20	RPS		Number of rounds fired in one second	
	21-30	C		Aircraft speed	knots
	31-40	R		Steady state firing rate of gun	rnds/ min
	41-50	DIVE		Aircraft dive angle	degrees
	51-60	BURSTL		Burst length	secs
	61-70	RNDSTL		Total rounds fired	
3	1-10	SIGR		Standard deviation of aim error in range	mils
	11-20	SIGD		Standard deviation of aim error in deflection	mils
	21-30	BETAR		Standard deviation of ballistic error in range	mils
	31-40	BETAD		Standard deviation of ballistic error in deflection	mils
4	1-10	CPK(1)		Probability of target kill for 1000 ft slant range	
	11-20	CPK(2)		Probability of target kill for 2000 ft slant range	
	21-30	CPK(3)		Probability of target kill for 3000 ft slant range	
	31-40	CPK(4)		Probability of target kill for 4000 ft slant range	
	41-50	CPK(5)		Probability of target kill for 5000 ft slant range	
	51-60	CPK(6)		Probability of target kill for 6000 ft slant range	
	61-70	PTITLE		Label for this curve on graph	
NOTE: Repeat card 4 for additional curves on same graph.					
5				Blank card	

NOTE: A blank card follows the last curve card on graph - for additional graphs repeat card 2 thru 4. The number of plots are unlimited.

Table 11. SAMPLE SET-UP FOR 'STAND ALONE PLOT'

	1 10	11 20	21 30	31 40	41 50	51 60	61 70	71 80
1	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
2	APC 30MM	51	350	4100	30	2	120	
3	4.24	4.24	2.0	2.0				
4	1.00	06	56	19	13	08 A		
5	90	77	45	17	10	05 B		
6	80	65	30	12	08	04 C		
7	70	50	20	08	06	03 D		
8	60	40	15	05	03	02 E		
9	50	32	10	03	02	01 F		
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

ROUNDS FIRED 1.1 SEC. 01 AIR SPEED 350. KNOTS
 STEADY FIRE RATE 4100.0 ROUNDS/MIN DIVE ANGLE 30.0
 BALLISTIC DISP. 2.00 RANGE. 2.00 DEFLECTION
 AIM ERROR 4.24 RANGE. 4.24 DEFLECTION
 TARGET CODE APC WEAPON CODE 30 MM
 BURST LENGTH 2.00 TOTAL POUNDS FIRED 120.

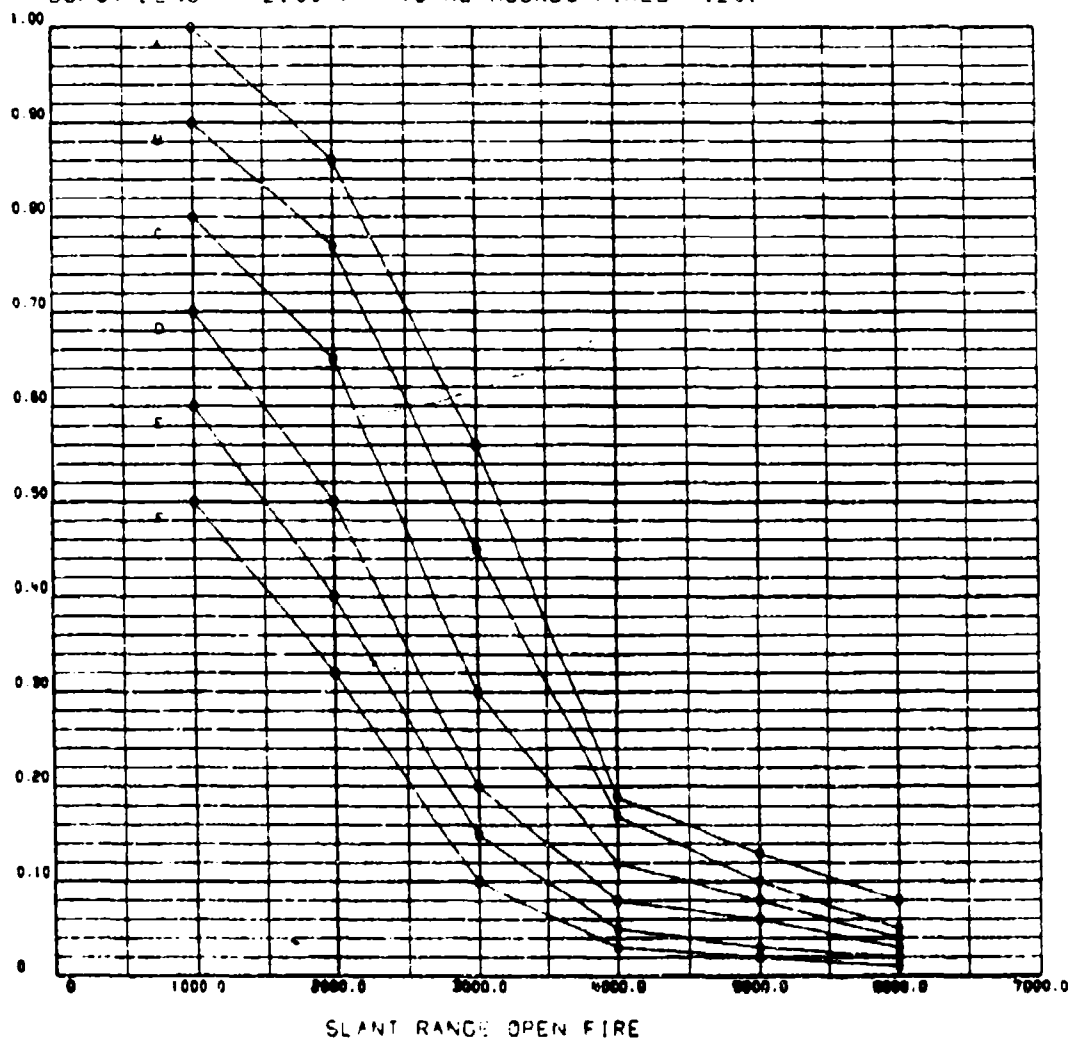


Figure 7. Filmplot Output Sample for Stand Alone Plot

REFERENCES

1. Operations Evaluation Group Research Contribution No. 43, "Air-to-Ground Gunnery Simulation; OEG Computer Program 18-63P," OEG Center for Naval Analyses, Washington, D.C., 5 August 1963, Unclassified.
2. Aim Wander Correlation in Air-to-Ground Gunnery, R. V. Ridings, OEG-RC 63, Operation Evaluations Group, Center for Naval Analyses, Washington, D.C., 3 December 1964, Unclassified.

APPENDIX A

FORTRAN VARIABLE LIST

This appendix contains a list of input, output, and intermediate FORTRAN variables used in the mathematical computation overlay 1,0.

<u>FORTTRAN Variable</u>	<u>Description</u>
A,D(1)	Correlation coefficient in range - input variable.
AI	An intermediate variable used to check to see if the time-to-rate table is correct.
ALPHA	A random normal number used to determine the aim point in range.
AM	Intermediate aim error value in range.
AMI	Intermediate aim error value in deflection.
B,D(2),PD(J)	Correlation coefficient in deflection - input variable.
BBB,TEMP	Intermediate aim error value in range.
BBC	Intermediate aim error value in deflection.
BETAD,D(6)	Standard deviation of ballistic error in deflection - input variable.
BETAR,D(5)	Standard deviation of ballistic error in range - input variable.
BURSTL	Burst length input variable for plot only option.
C,D(9)	Input and output variable for the aircraft speed in knots.
CPK(I)	Conditional kill probability, or probability that a hit kills - output variable.
COUNT,I2	The number of times the program goes through the Monte Carlo loop.
CPK1(I)	1st conditional kill value using a mixed ammo belt.
CPK2(I)	2nd conditional kill value using a mixed ammo belt.
CPK3(I)	3rd conditional kill value using a mixed ammo belt.
CP1(I)	Starting conditional kill value at the beginning of firing run.
CPN(I)	End conditional kill value at the end of firing run.
DC	Aim point of the first round in deflection.
DELTA	Random normal number used to check the ballistic error in range.

<u>FORTTRAN Variable</u>	<u>Description</u>
DIVE	Dive angle (for information only), input, and output variable.
DN,D(16)	Output print increment in burst length - input variable.
DQ	An intermediate value used to calculate time into burst for each round.
DT	Time increment between rounds in a burst.
DUMMY	Acts as a return variable to mix the random number generator not used in computation.
E,D(17)	Maximum allowable error for standard deviation of the mean-input variable.
EPS	Random normal number used to check the ballistic error in deflection.
F,D(14)	Maximum number of Monte Carlo iterations - input and output variable.
FF(I)	Output probability of kill for each round (AN).
FI D(12)	Target length in feet-input and output variable.
FLN2,FLR2(I)	Half of target length in mils.
FLR2(I)=TEMF	Half of target length in mils.
FN,D(10)	Attempted number of rounds fired on a single pass - input variable.
GAMMA	Random normal number used to determine the aimpoint in deflection.
GUNN	Intermediate variable used to increment gun systems.
GUNS,D(19)	Number of gun systems considered - input variable.
IAIM	Number of sets of aiming errors - input variable.
I1	Initial value of the index for the Monte Carlo loop.
I2,Q	Test value of the index for the Monte Carlo loop (>200). Each iteration represents one pass at the target.
IDN,DN	Intermediate variable for burst length increment.

FORTRAN Variable	Description
JSTR,JSTP	The initial and index values for the DO loop that deals with the 3 belt mix, or 3 conditional kill values for 1 pass.
K	An integer value calculated for each round in the burst.
KN	Integer value of rounds per pass per gun - output variable.
L	Integer value of the address on the input cards.
LINE	Integer value used to determine the number of lines to be printed on a page.
LS	Integer used in an intermediate calculation of the conditional kill probabilities of a mixed belt set up.
LST,INC	Intermediate integer used with a mixed belt conditional kill probability set up.
N	Attempted number of rounds fired on a single pass.
NCASES	Number of cases to be plotted.
NEMP,D(15)	Number of empty passes through random number generator - input and output variable.
NKILLS	Number of kills or successful passes.
NOT	Number of pairs of entries in the time-to-rate table.
NSLANT	The number of slant ranges to be plotted on one graph.
NTS	Number of burst lengths to be plotted.
NTYPE	The number of types of mixed belts.
NUMR(I)	The number of consecutive rounds using this conditional kill probability.
P,D(11)	Input conditional kill probability
PD(I)	Correlation coefficient array in deflection.
PJAM,D(18)	Probability that the gun jams - input variable.
PK	Probability of target kill - output variable.
PKPLOT(I)	An intermediate value used to plot the PK's.

FORTRAN Variable	Description
PM2	The end parameter on the input data card if it has one.
PRMTR	The parameter after the address on each input data card.
PP	A random number used to test against the conditional kill value to see if the target was killed.
PR(I)	Correlation coefficient array in range.
PTITLE	Title for the plots for the plot only option in the program.
Q	The updated value for the index of the Monte Carlo loop.
R,D(8)	Steady state firing rate per gun in rounds per min - input and output variable.
RC	Aim point of the first round in range.
RD(I),RPS	Rounds per second for stand alone plot.
RNSTL	Total rounds fired - used on plot only option - input and output variable.
RPS	Rounds fired in one second - input and output variable for plot option.
RPS1(J),IR	The round number array for plotting.
S,D(7)	Slant range - input and output
SDPK	Output variable for the standard deviation of the mean - used to test accuracy of probability of kill.
SGD1	End input value for the standard deviation aim error in deflection.
SGR1	End input value for the standard deviation aim error in range.
SIGD,D(4)	Standard deviation of aim error in deflection - input and output variable.
SIGD1(I)	An intermediate array variable for the standard deviation aim error in deflection.
SIGR,D(3)	Standard deviation of aim error in range - input and output
SIGR1(I)	An intermediate array variable for the standard deviation aim error in range.

FORTRAN Variable	Description
SLR(I)	Output array variable for slant range at the time each round is fired.
T(1)	Intermediate time array variable.
TCODE	Target code for the plot option only - input and output variable.
TD(I)	Delta time array between rounds.
TD2	TD(I) squared - this variable is used to find the range and deflection correlation coefficients.
TEMF	Intermediate variable which converts 1/2 the target length to mils.
TEMW	Intermediate variable which converts 1/2 the target width to mils.
TEST	An intermediate variable used in the look-up table.
TIME(I)	Time value array for the time-to-rate table.
TITLE	Description of the output in 60 characters or less.
TPLOT	An array that contains the burst lengths to be plotted.
V	The variable where knots are converted to feet per second.
VR	An intermediate variable that determines the distance plane traveled between rounds fired.
W,D(13)	Target width in feet - input and output variable.
WCODE	Weapon code used as an input - output variable in the stand alone plot.
WN2,WR2(I)	Half of target width in mils.
X	Probability that the gun jams.
XX	Random number used to test against X to see if the gun jammed.

APPENDIX

FLOW CHART FOR OVERLAY 1,0

This appendix contains the flow chart for the mathematical computation section of the gun simulation program.

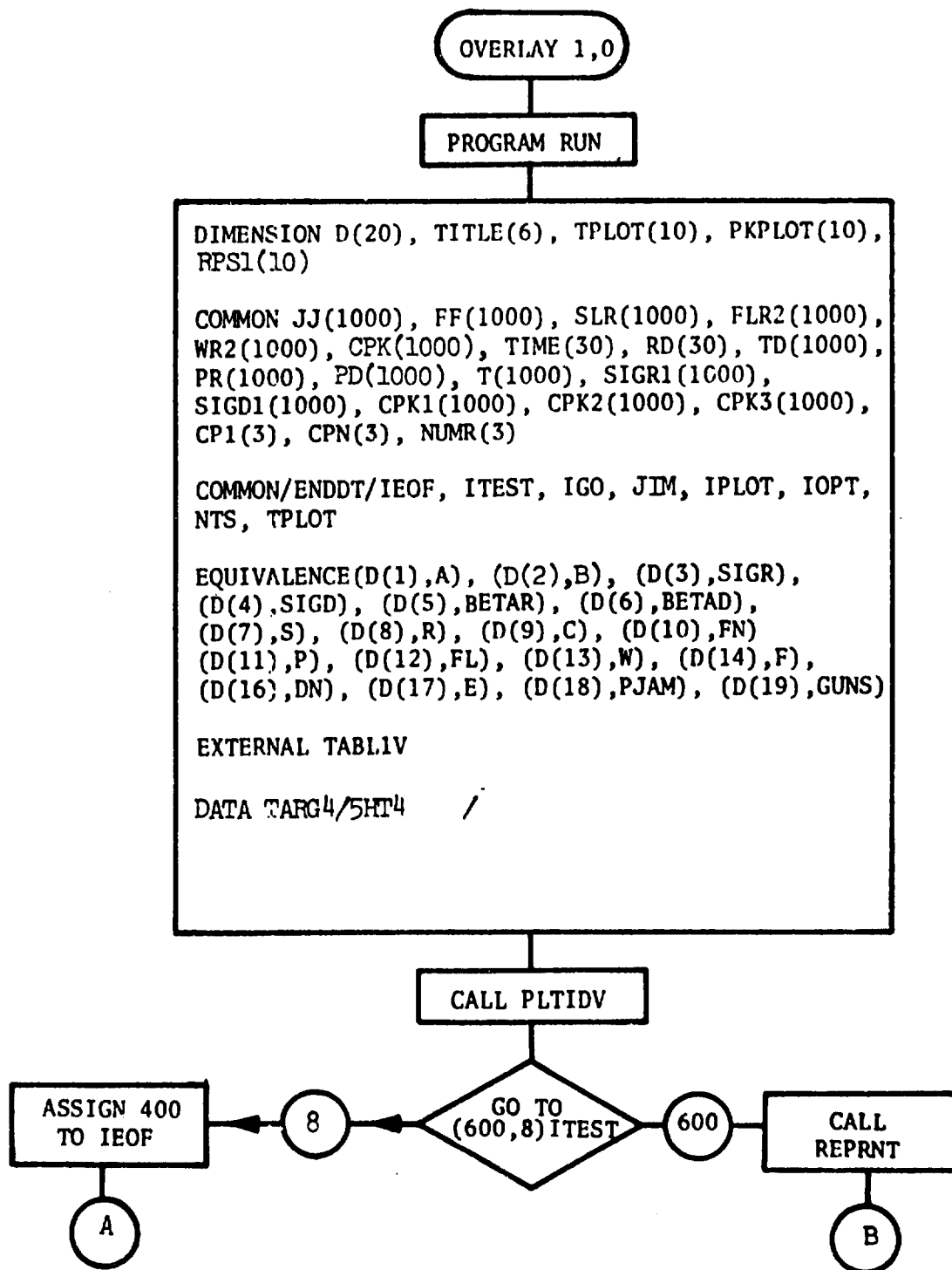


Figure 8. Flow Chart of Overlay 1,0

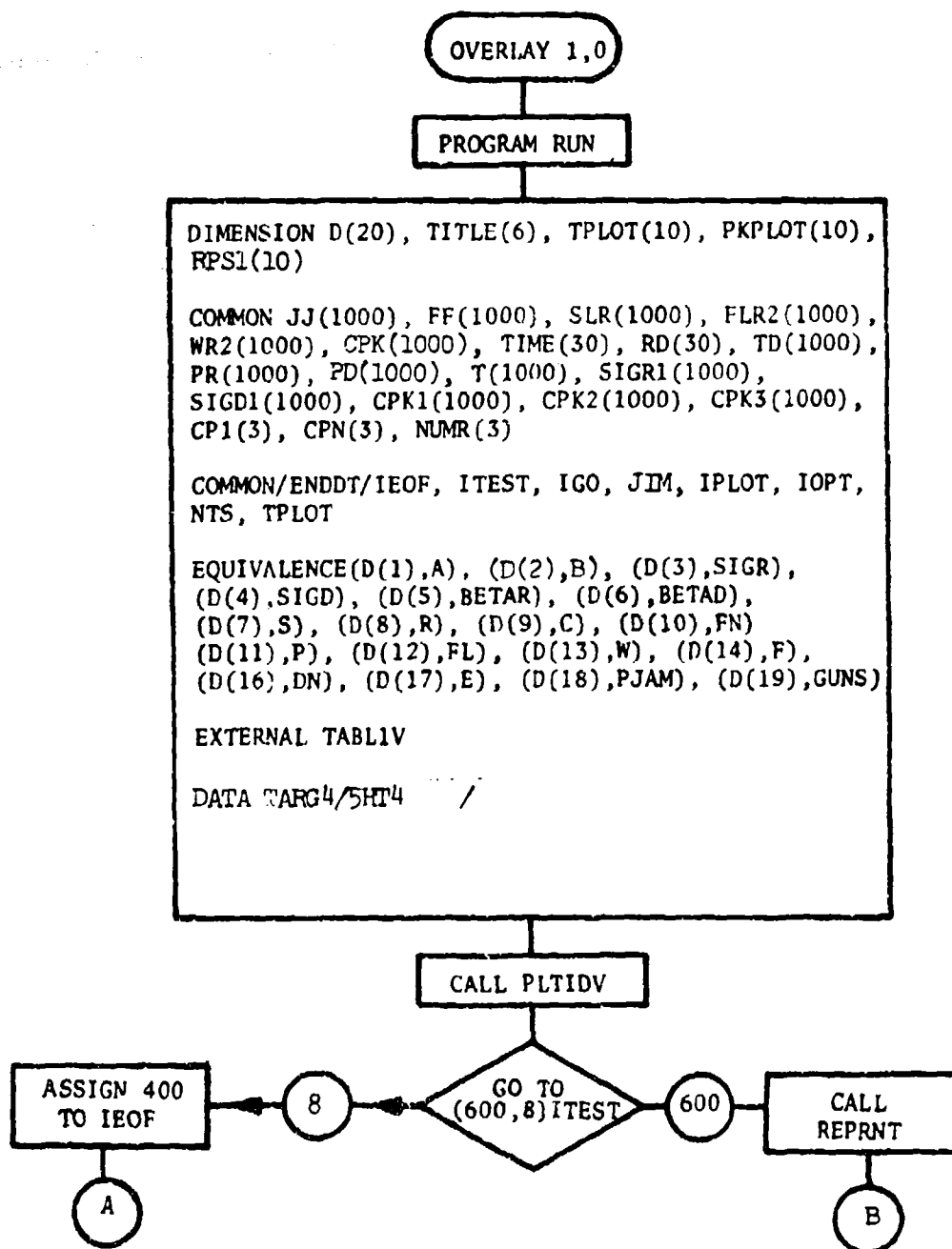


Figure 8. Flow Chart of Overlay 1,0

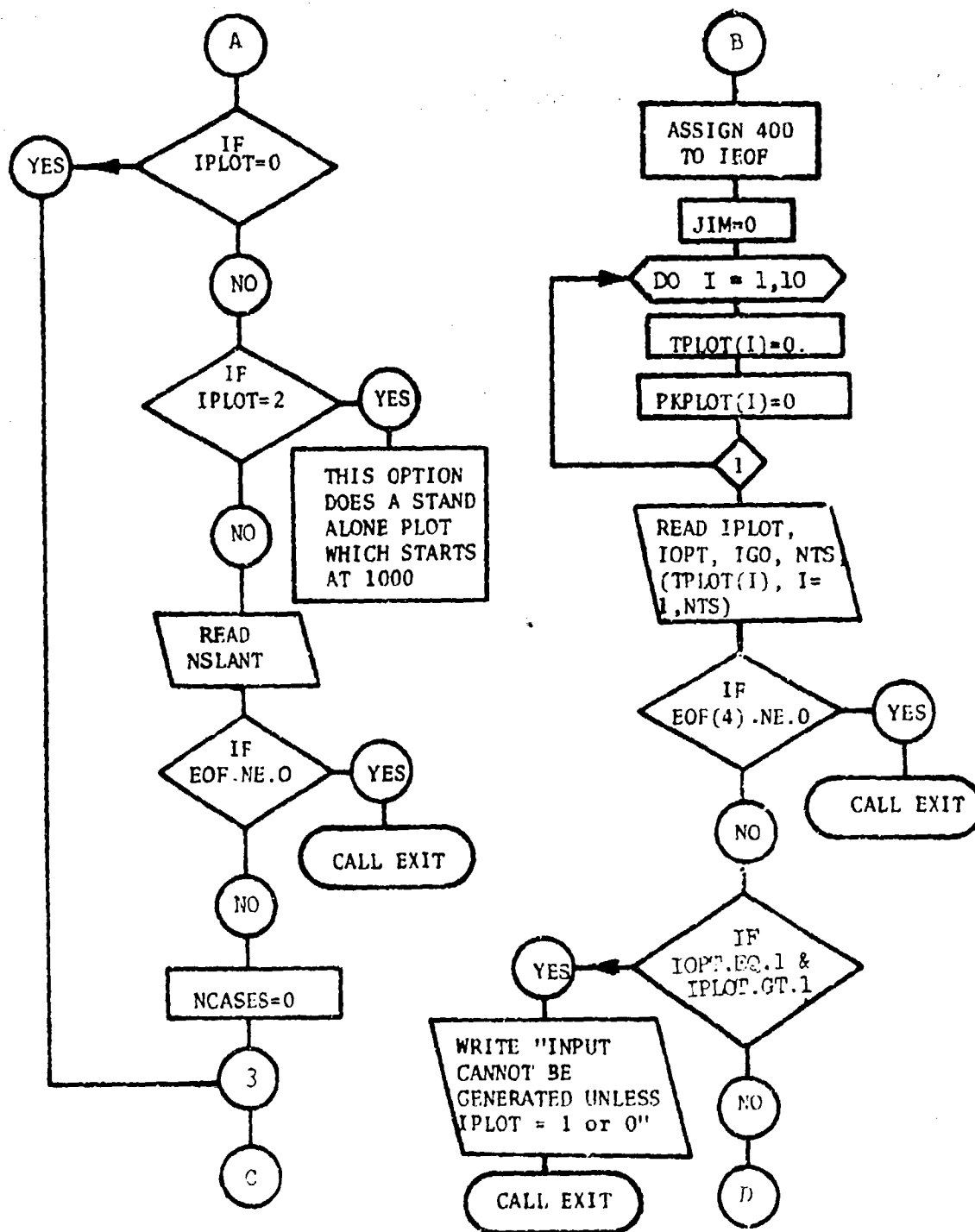


Figure 8. Flow Chart of Overlay 1,0 (Continued)

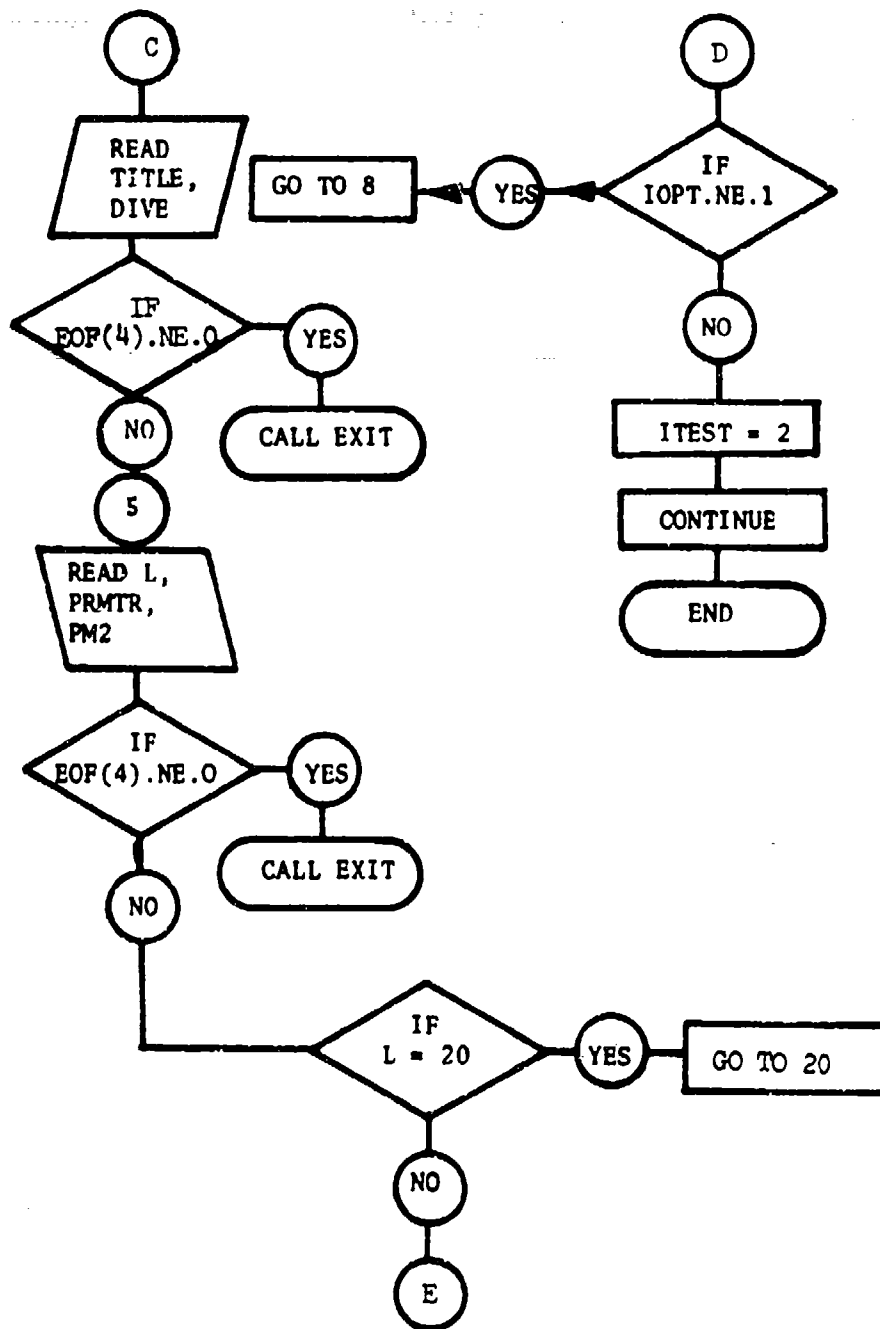


Figure 8. Flow Chart of Overlay 1,0 (Continued)

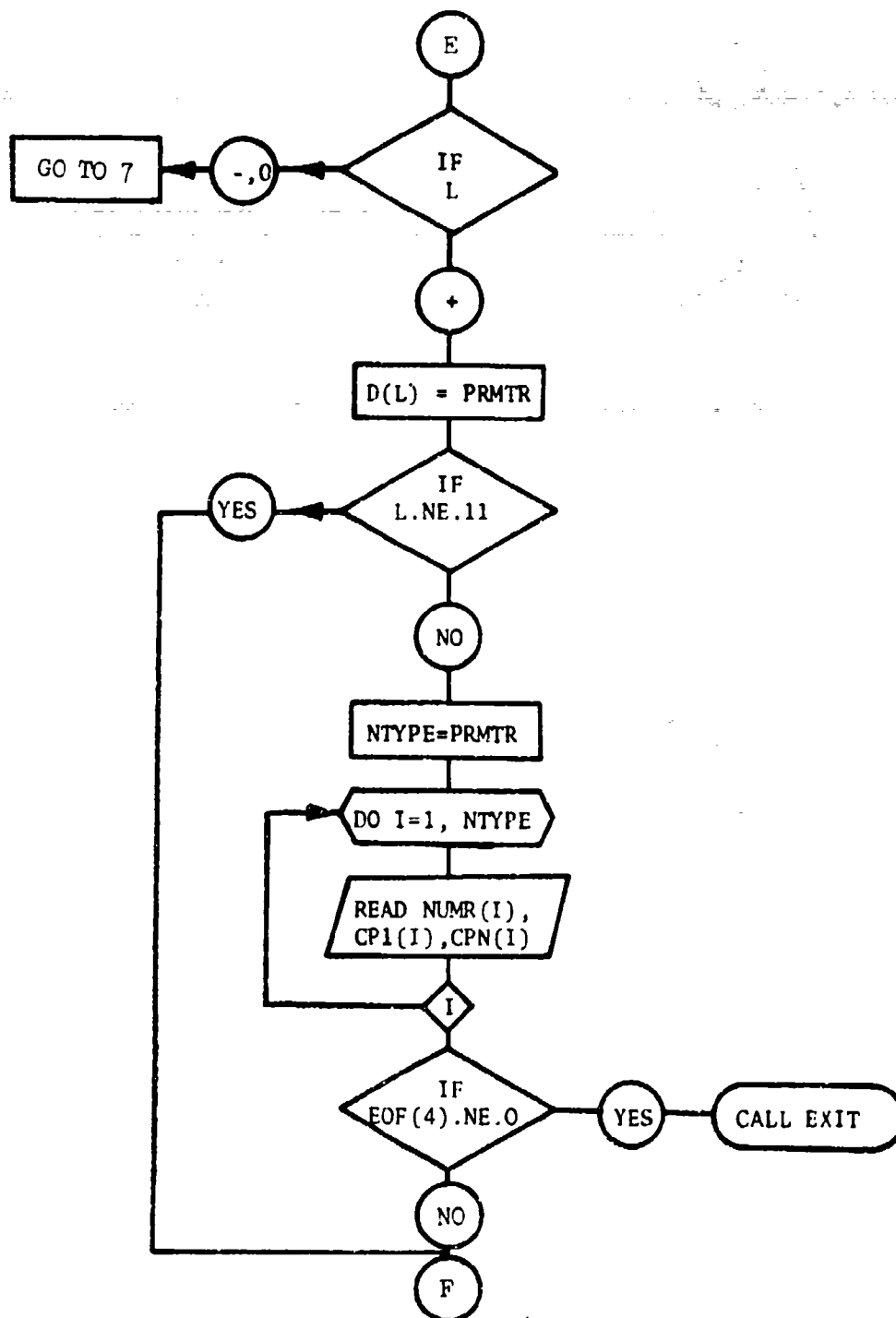


Figure 8. Flow Chart of Overlay 1,0 (Continued)

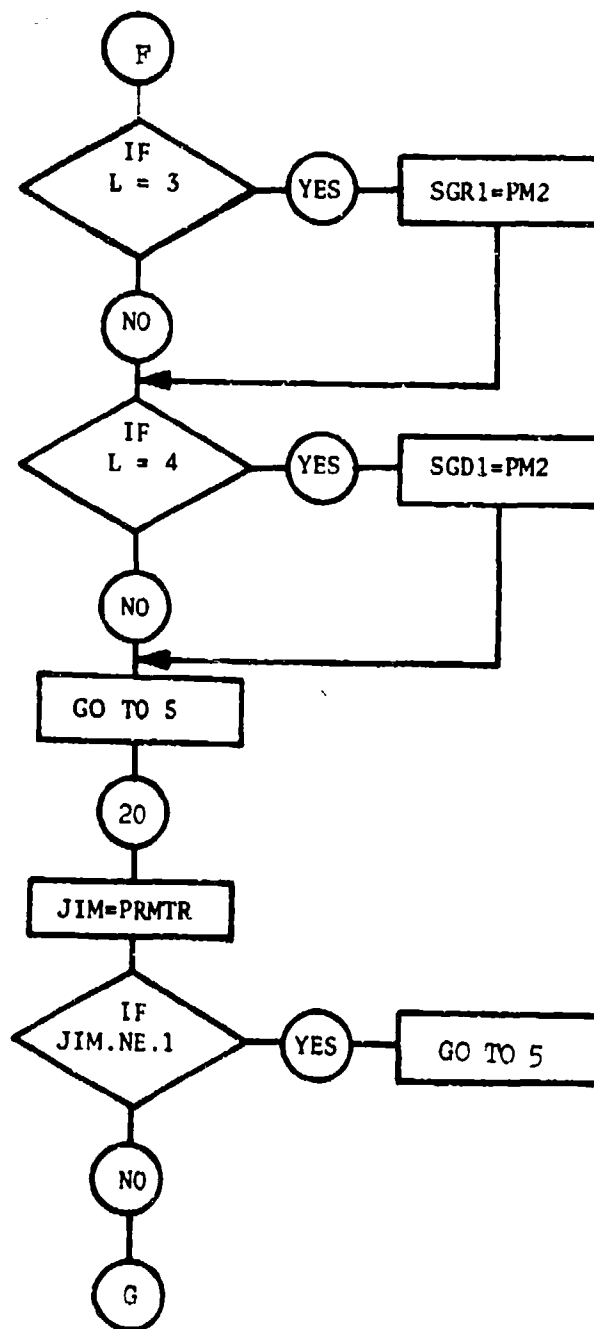


Figure 8. Flow Chart of Overlay 1,0 (Continued)

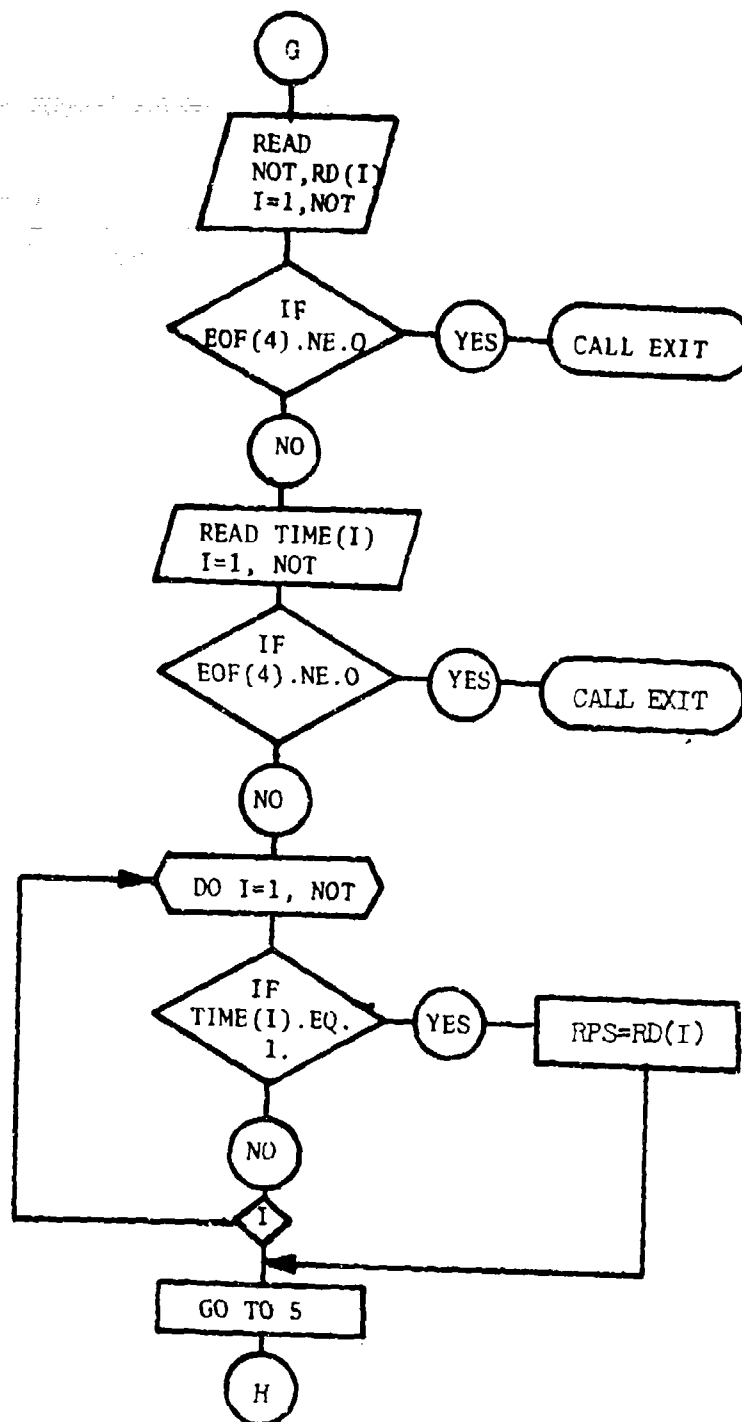


Figure 8. Flow Chart of Overlay 1,0 (Continued)

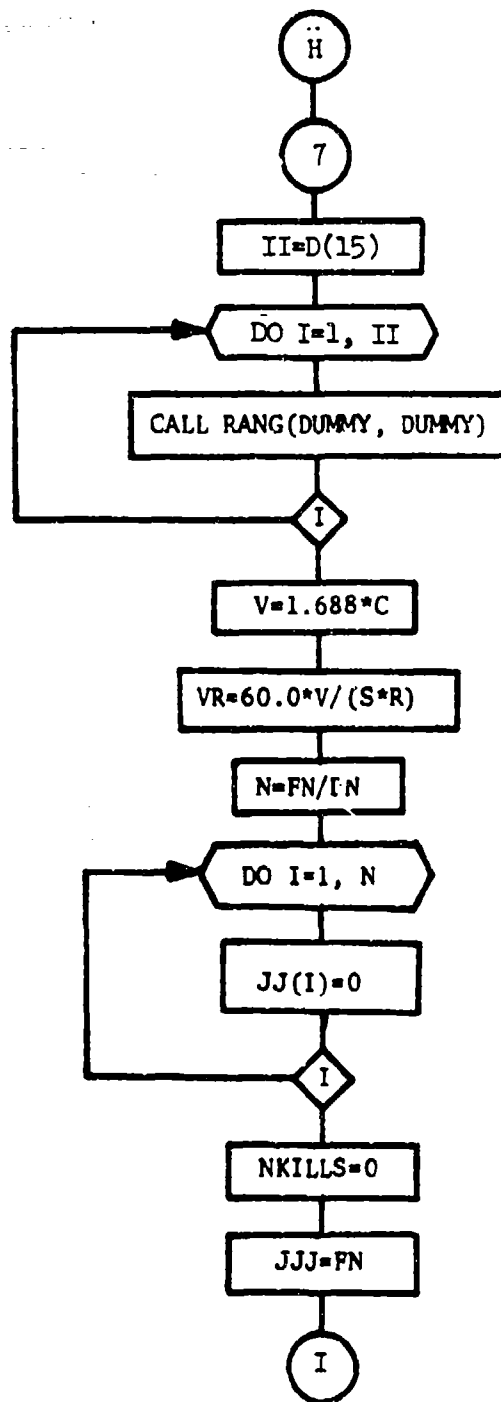


Figure 8. Flow Chart of Overlay 1,0 (Continued)

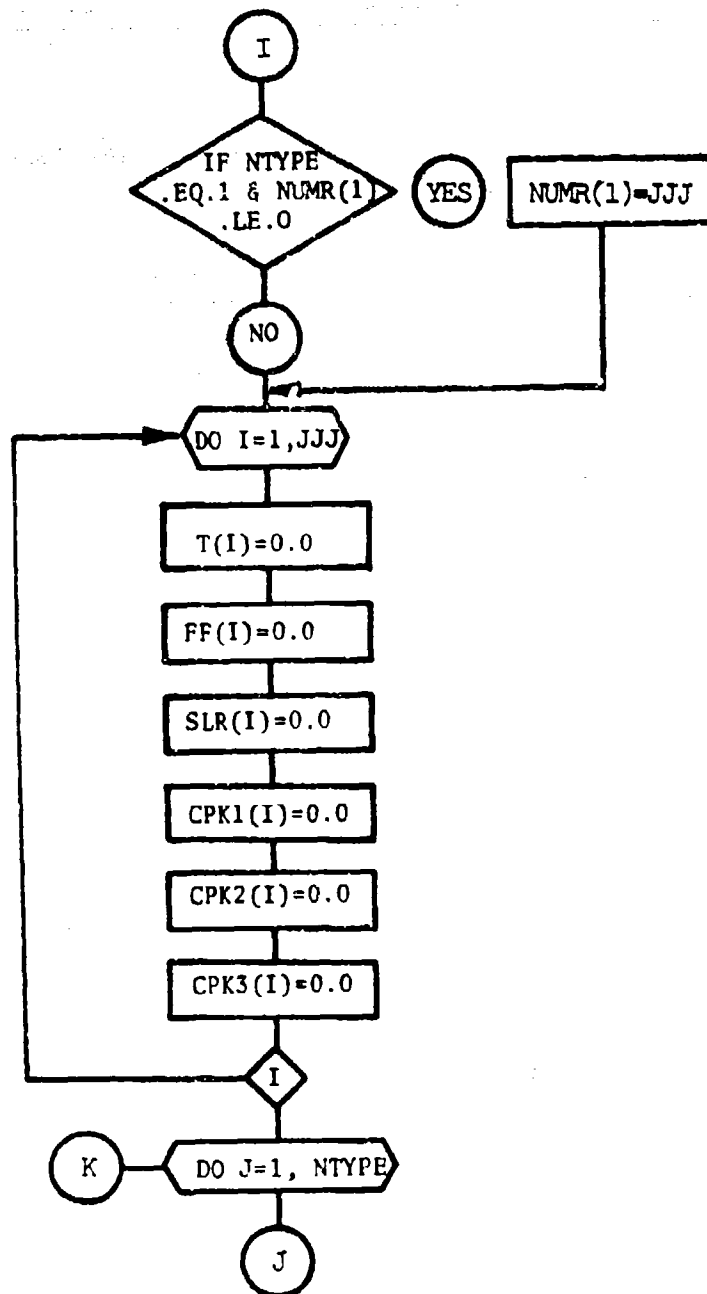


Figure 8. Flow Chart of Overlay 1,0 (Continued)

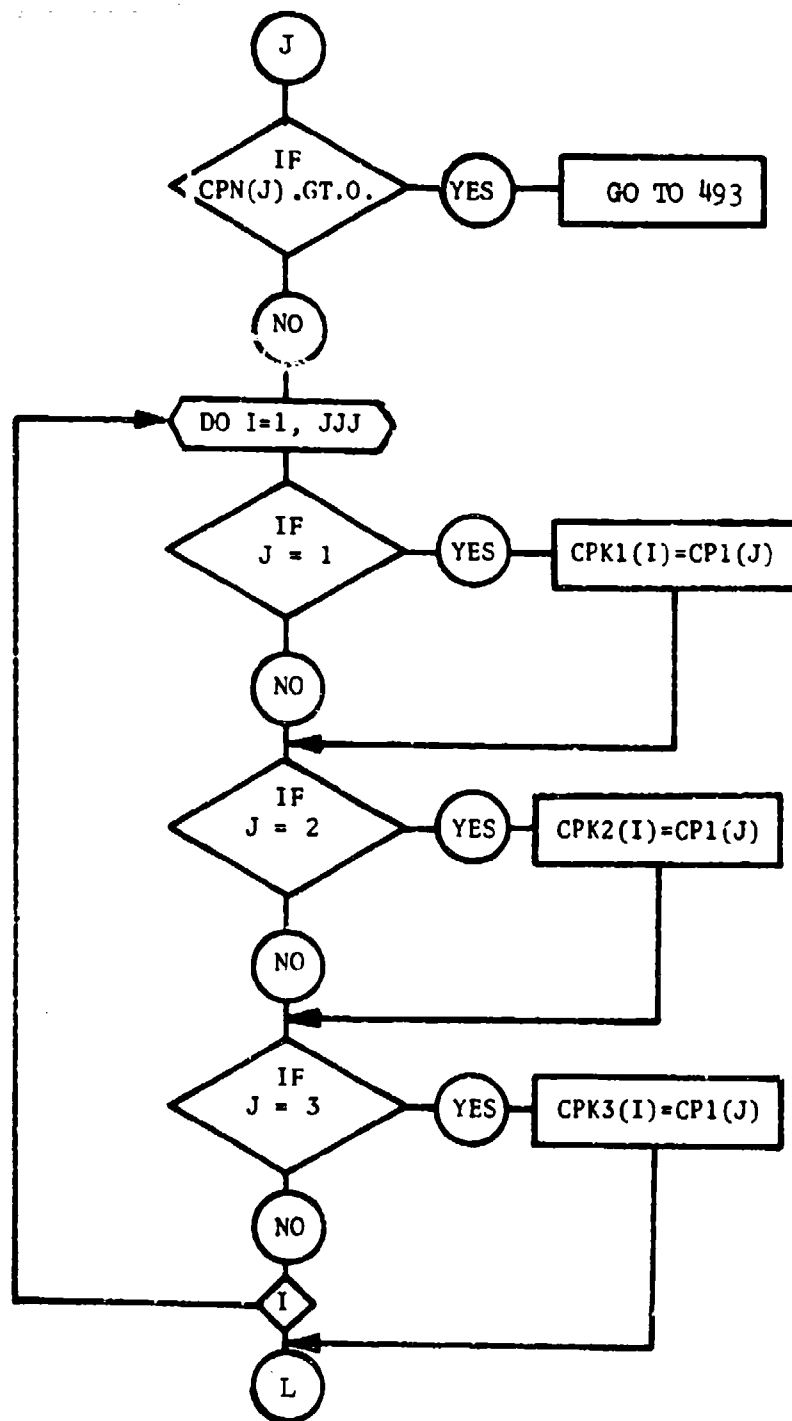


Figure 8. Flow Chart of Overlay 1,0 (Continued)

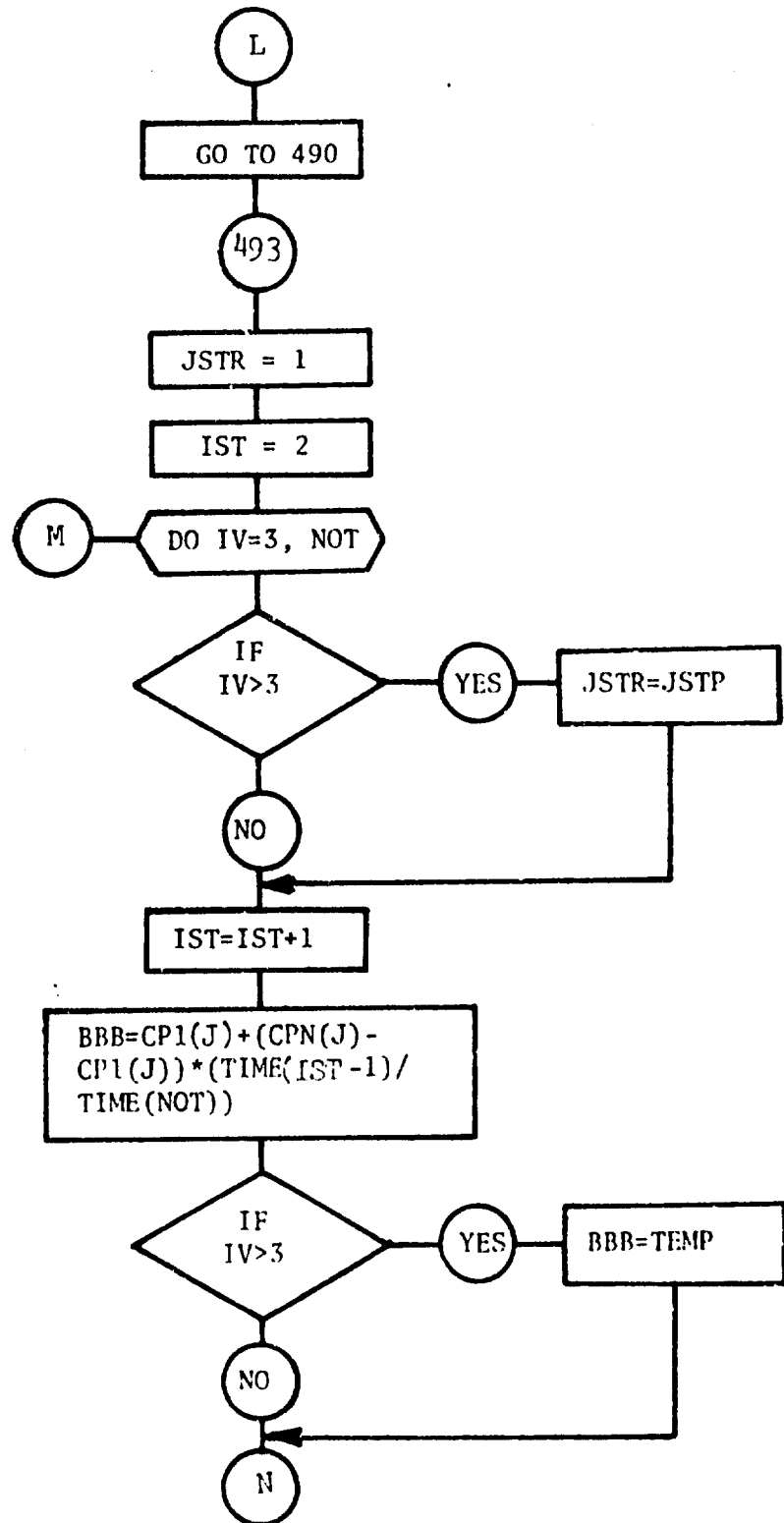


Figure 8. Flow Chart of Overlay 1,0 (Continued)

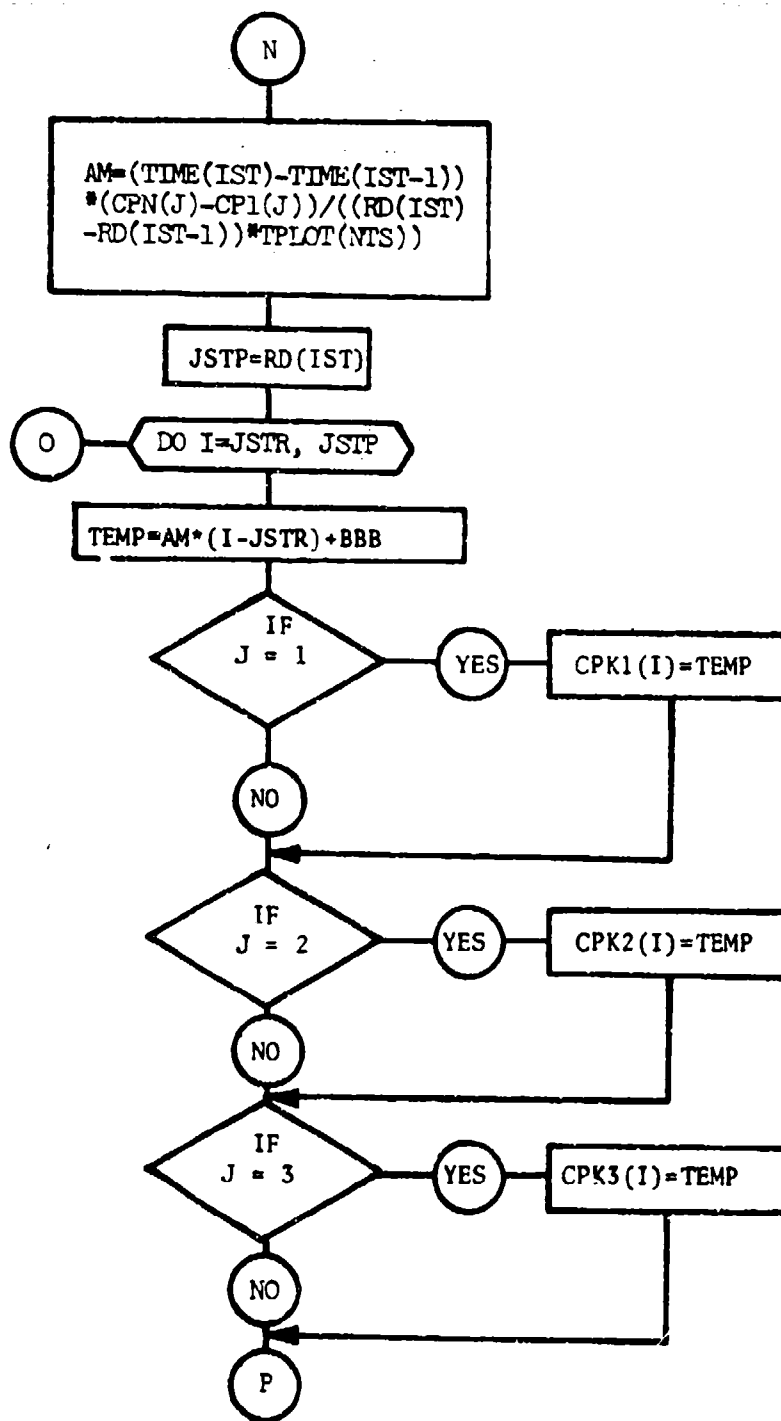


Figure 8. Flow Chart of Overlay 1,0 (Continued)

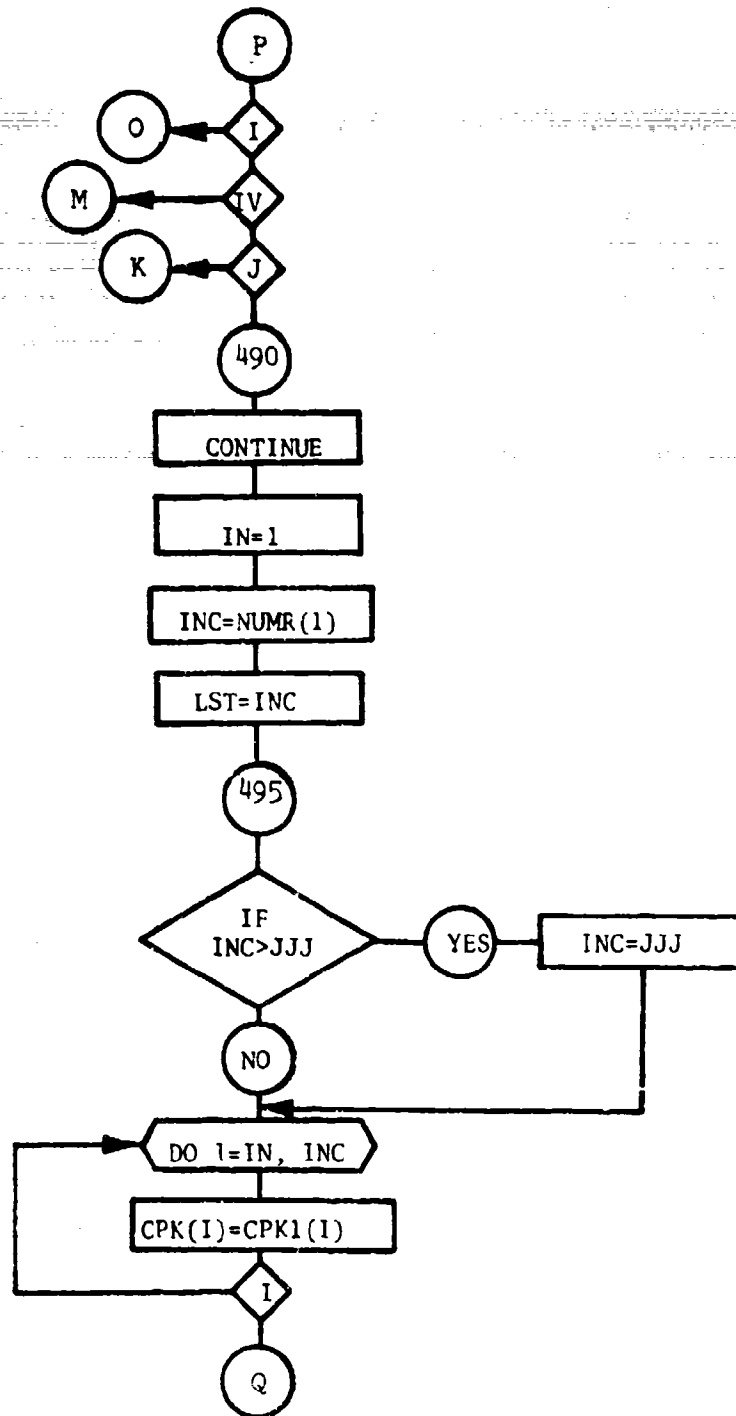


Figure 8. Flow Chart of Overlay 1,0 (Continued)

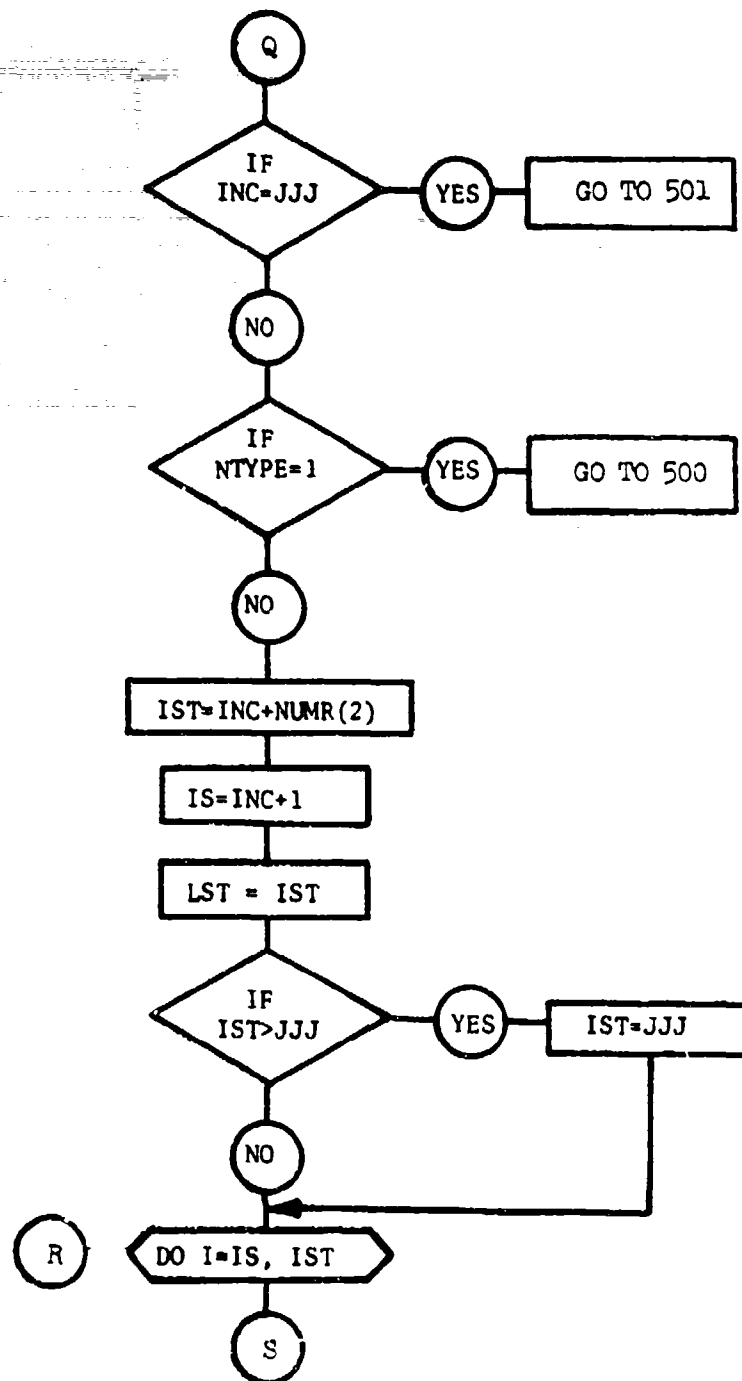


Figure 8. Flow Chart of Overlay 1,0 (Continued)

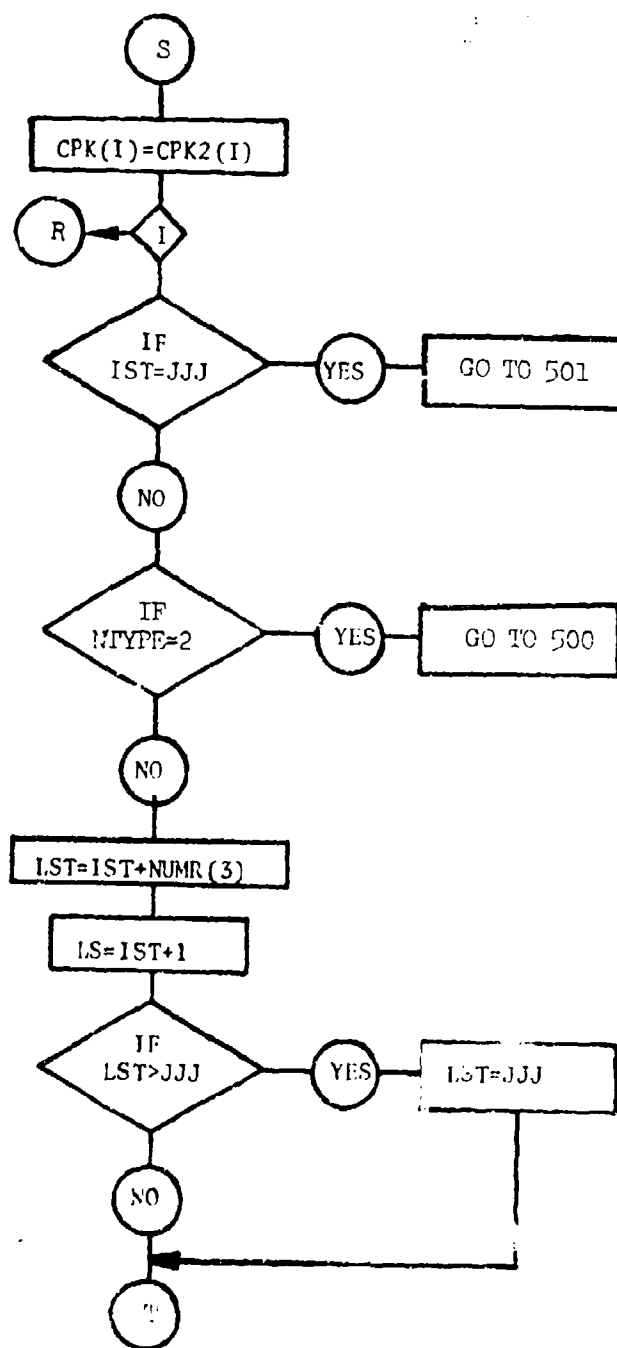


Figure 8. Flow Chart of Overlay 1,0 (Continued)

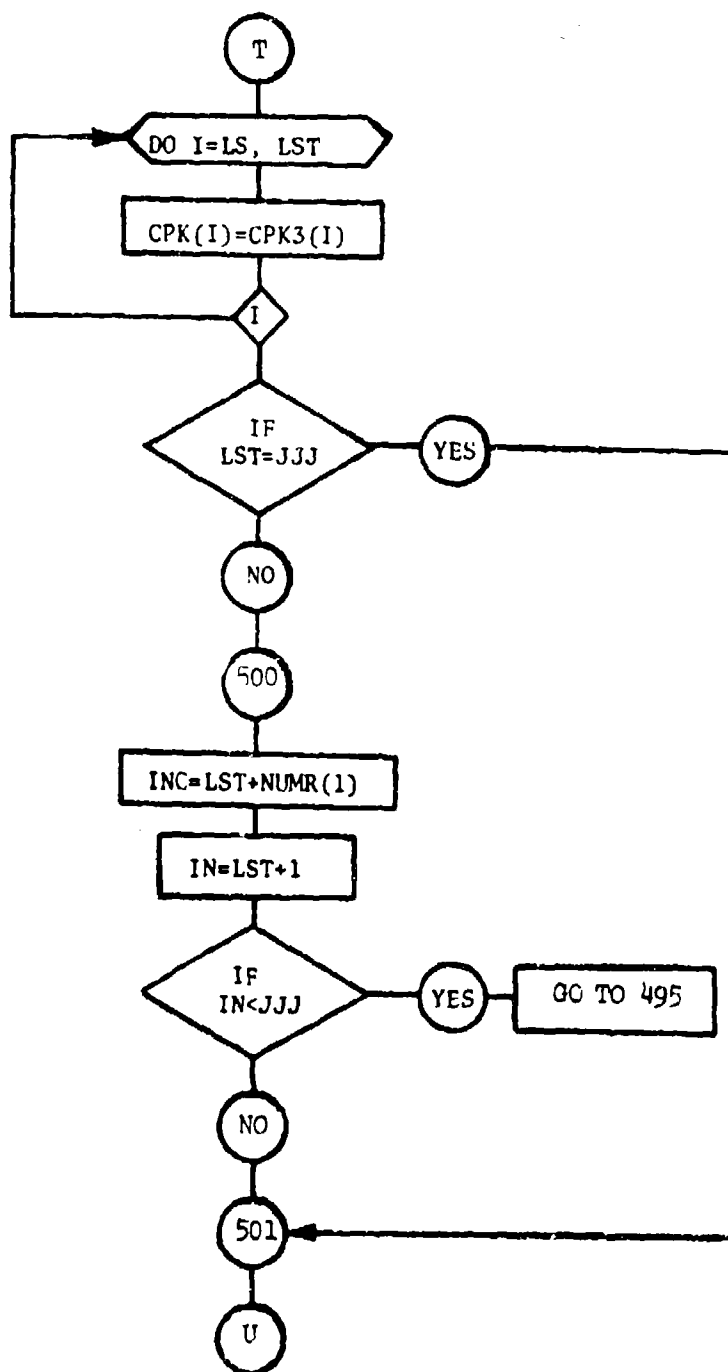


Figure 8. Flow Chart of Overlay 1,0 (Continued)

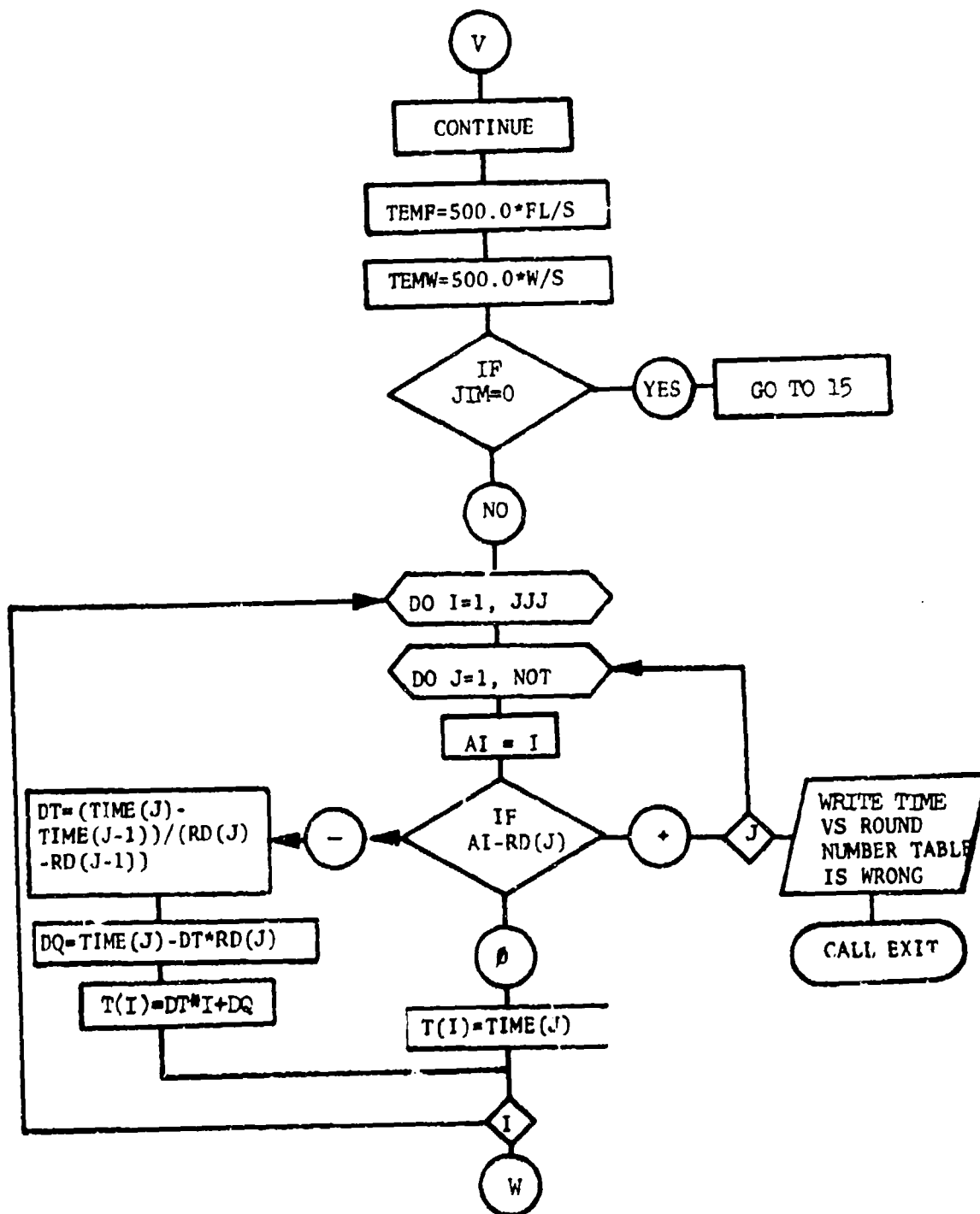


Figure 8. Flow Chart of Overlay 1,0 (Continued)

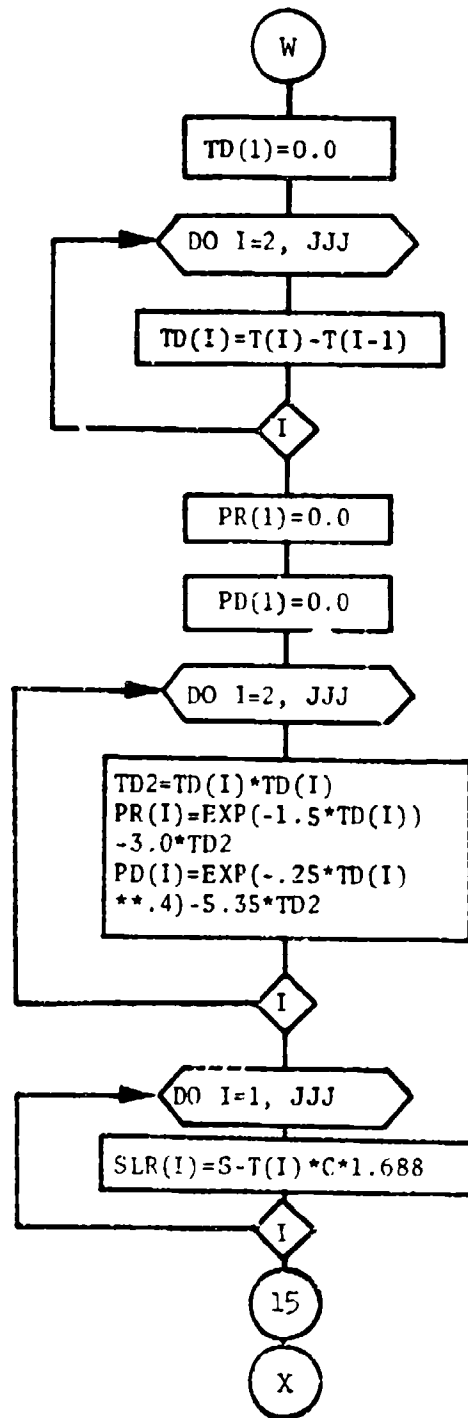


Figure 8. Flow Chart of Overlay 1,0 (Continued)

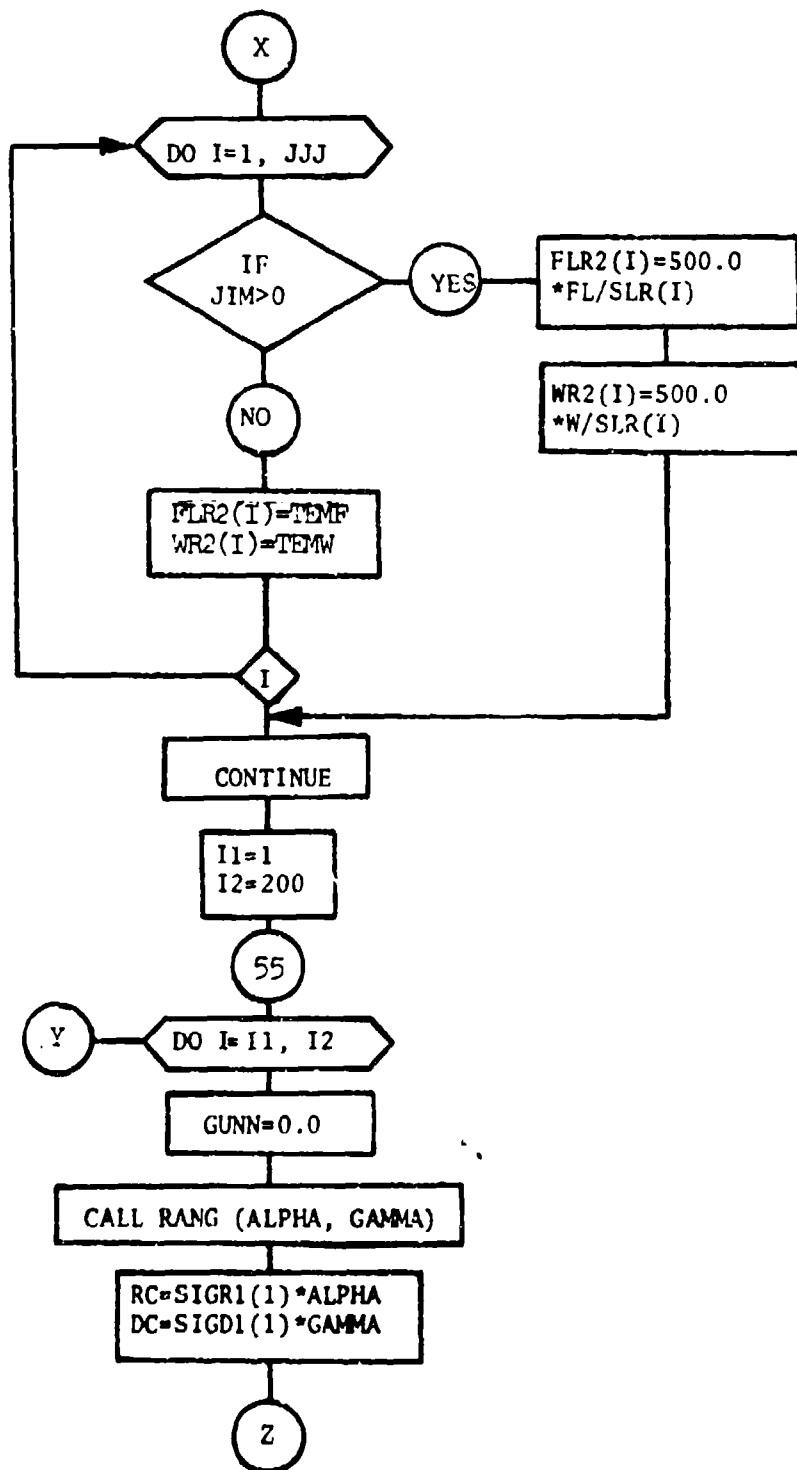


Figure 8. Flow Chart of Overlay 1,0 (Continued)

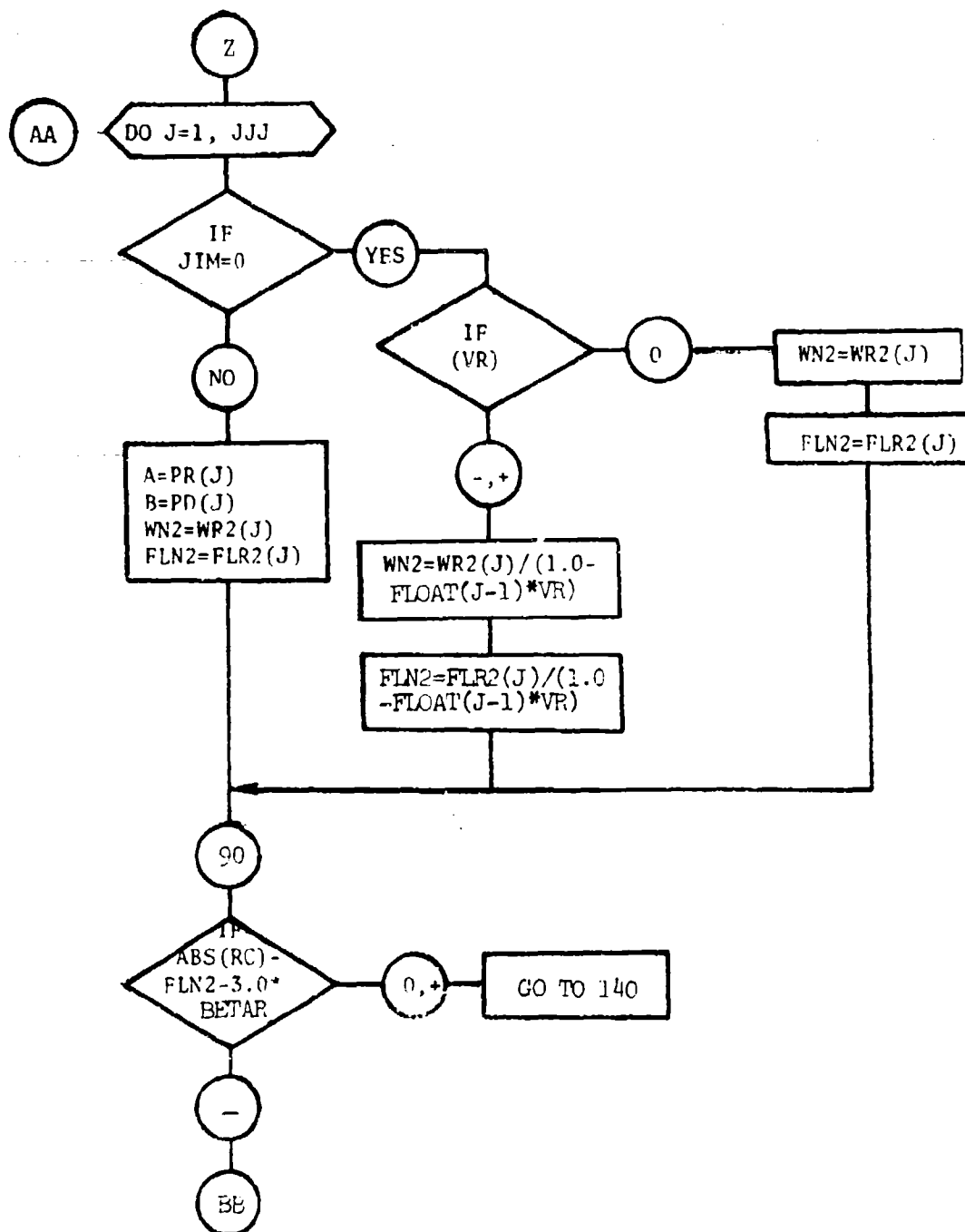


Figure 8. Flow Chart of Overlay 1,0 (Continued)

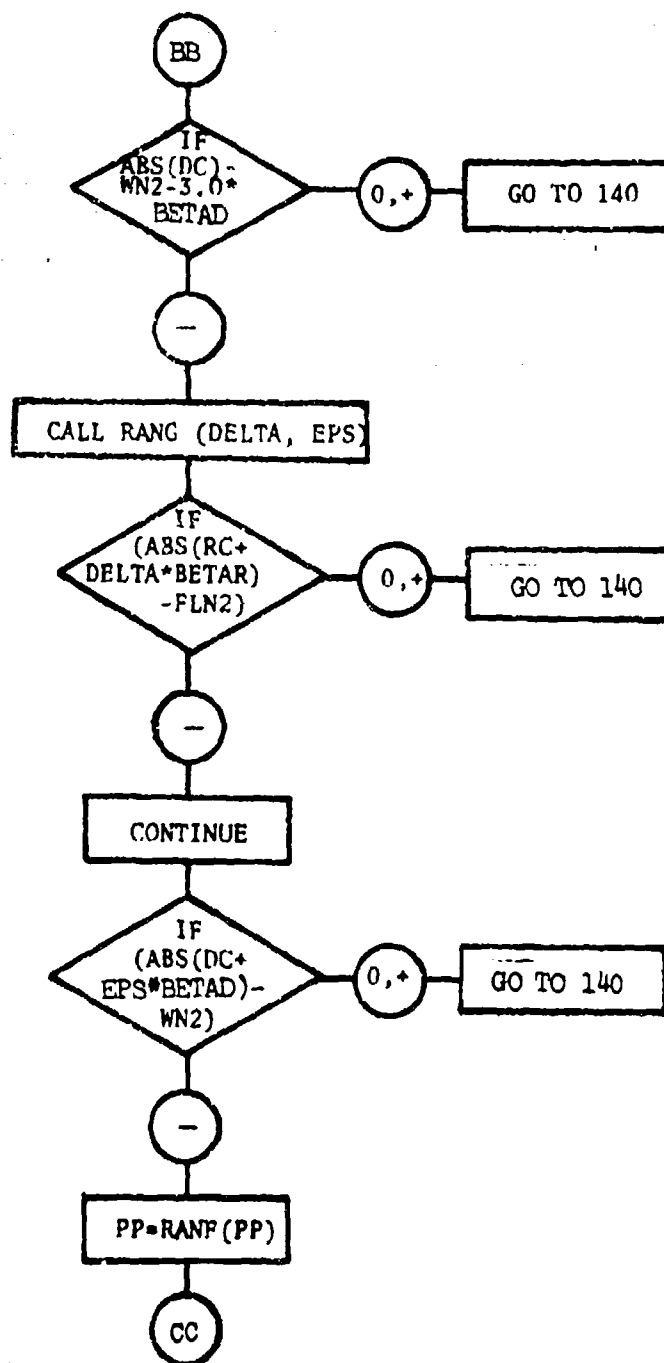


Figure 8. Flow Chart of Overlay 1,0 (Continued)

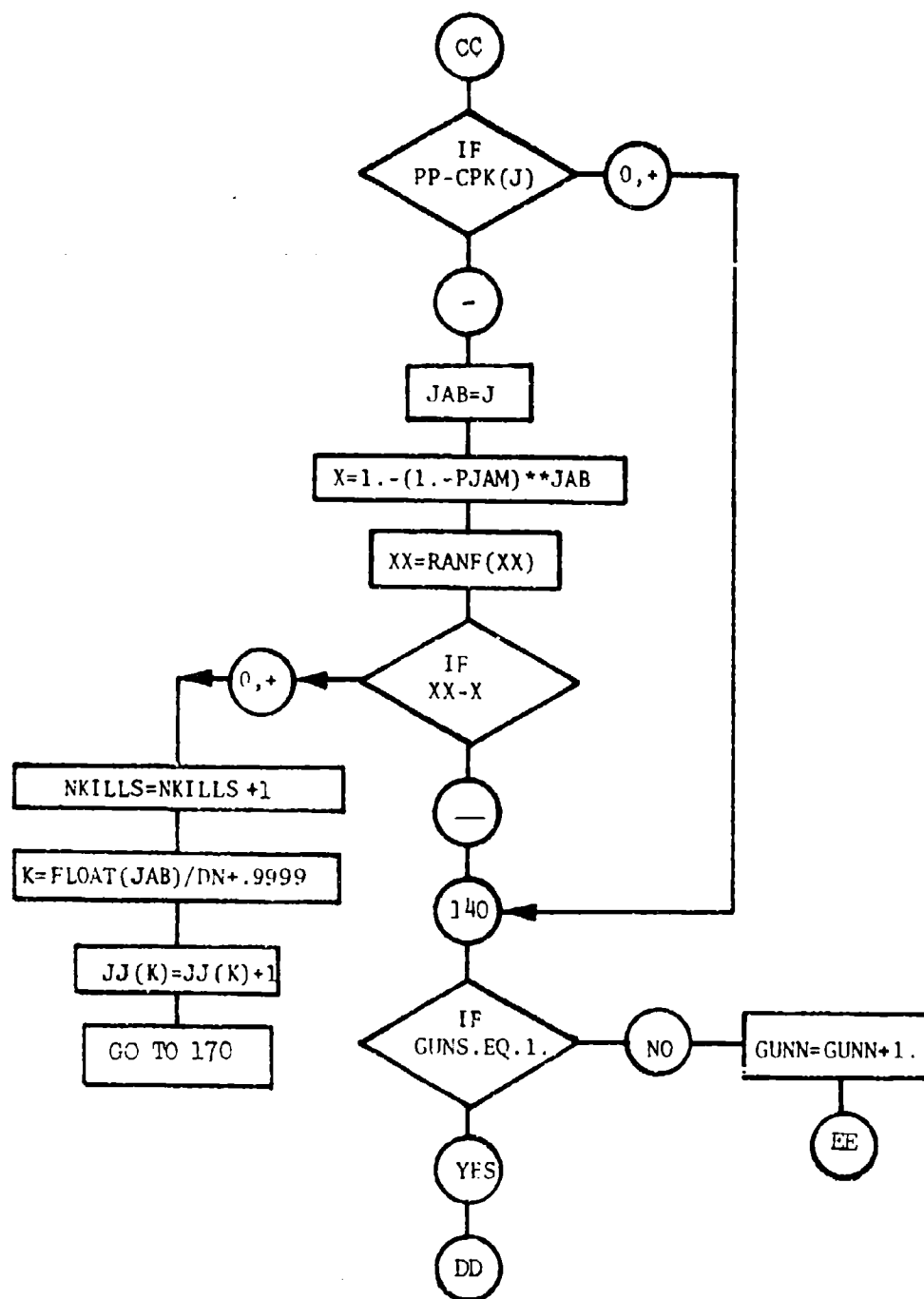


Figure 8. Flow Chart of Overlay 1,0 (Continued)

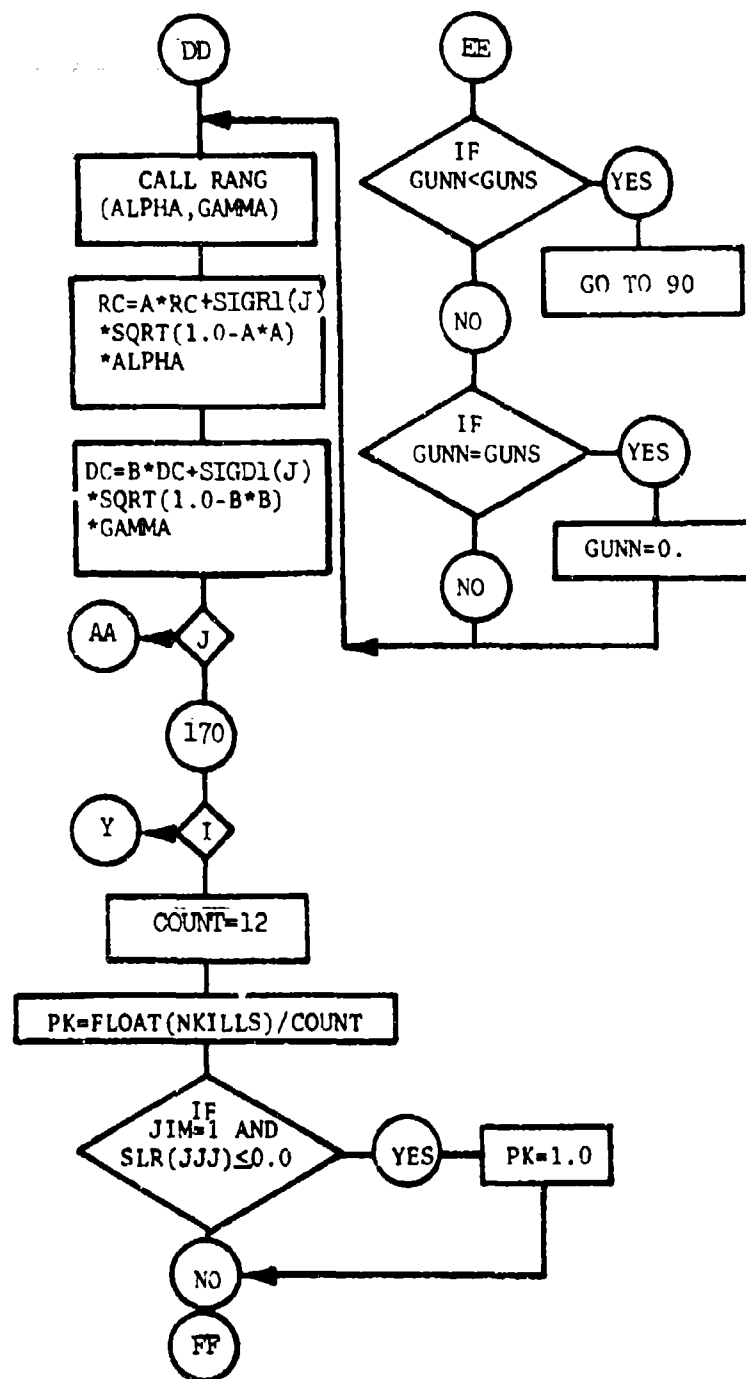


Figure 8. Flow Chart of Overlay 1,0 (Continued)

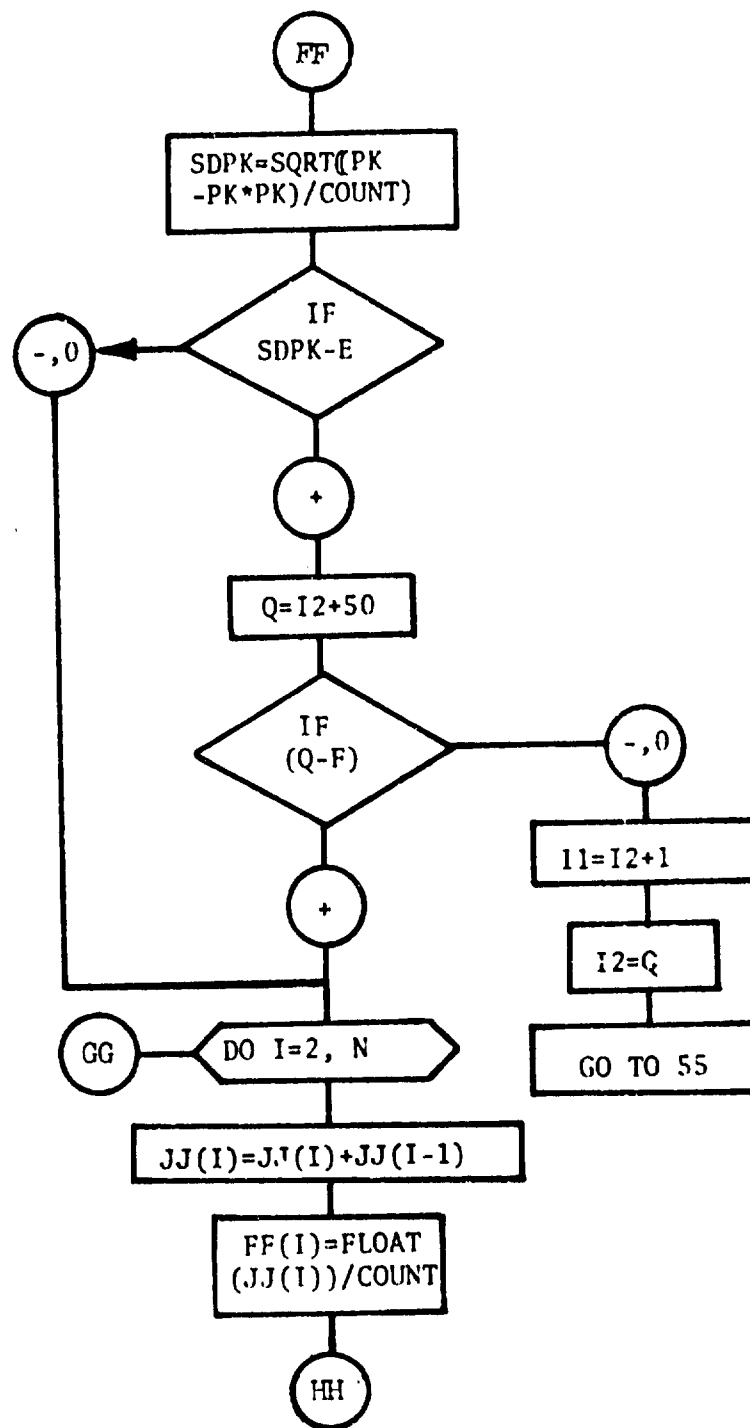


Figure 8. Flow Chart of Overlay 1,0 (Continued)

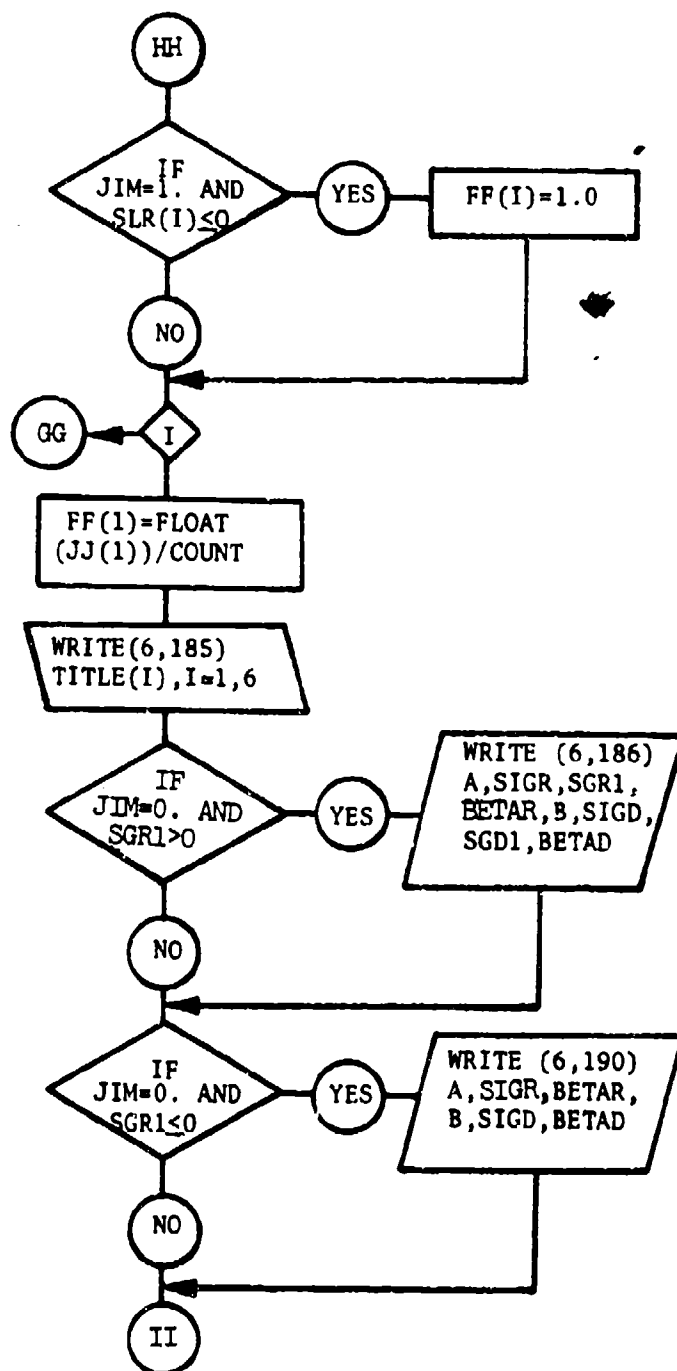


Figure 8. Flow Chart of Overlay 1,0 (Continued)

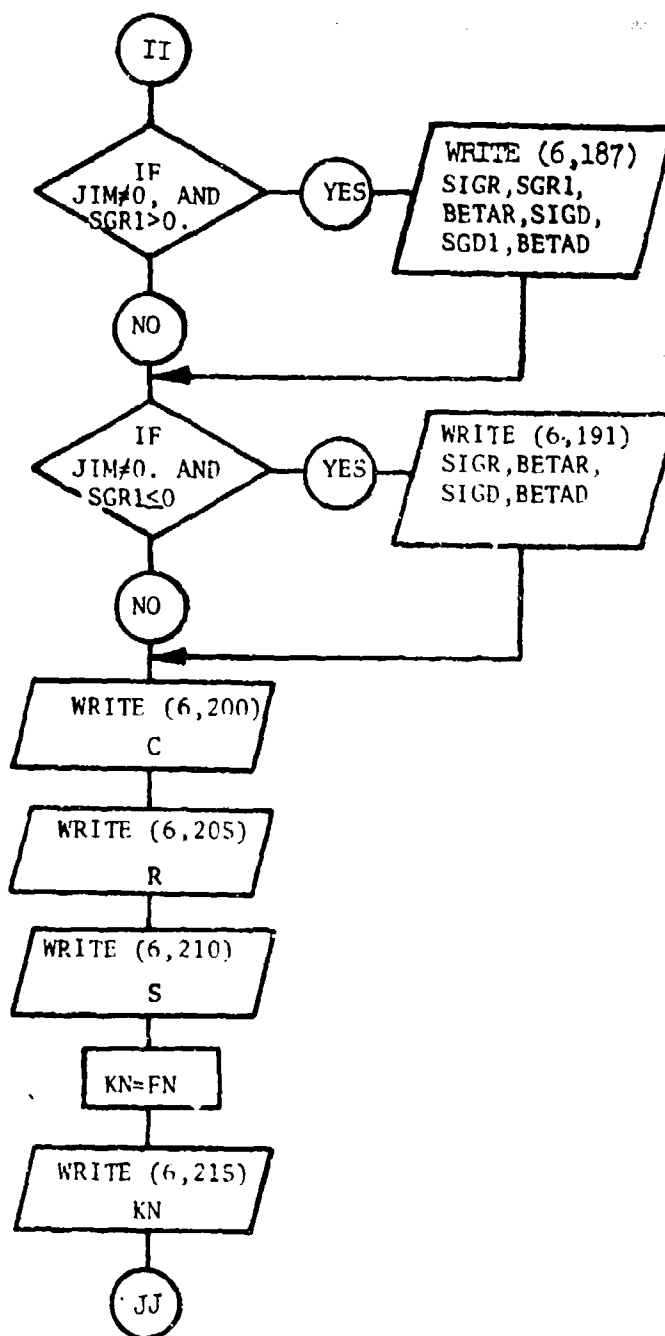


Figure 8. Flow Chart of Overlay 1,0 (Continued)

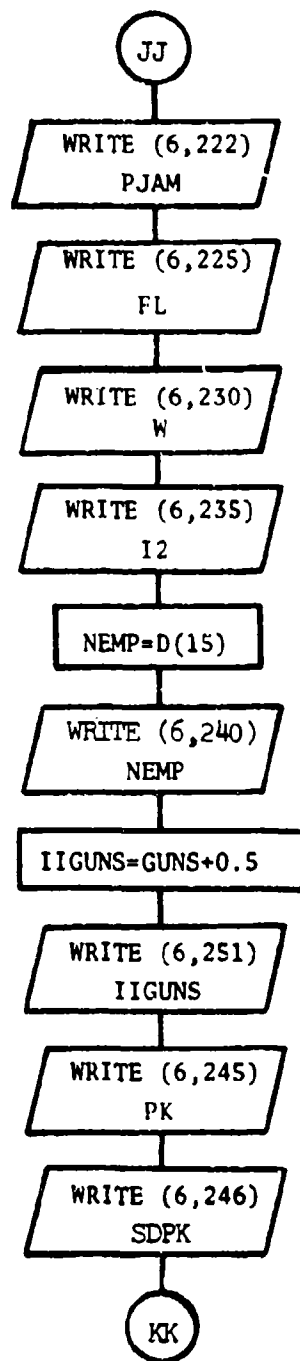


Figure 8. Flow Chart of Overlay 1,0 (Continued)

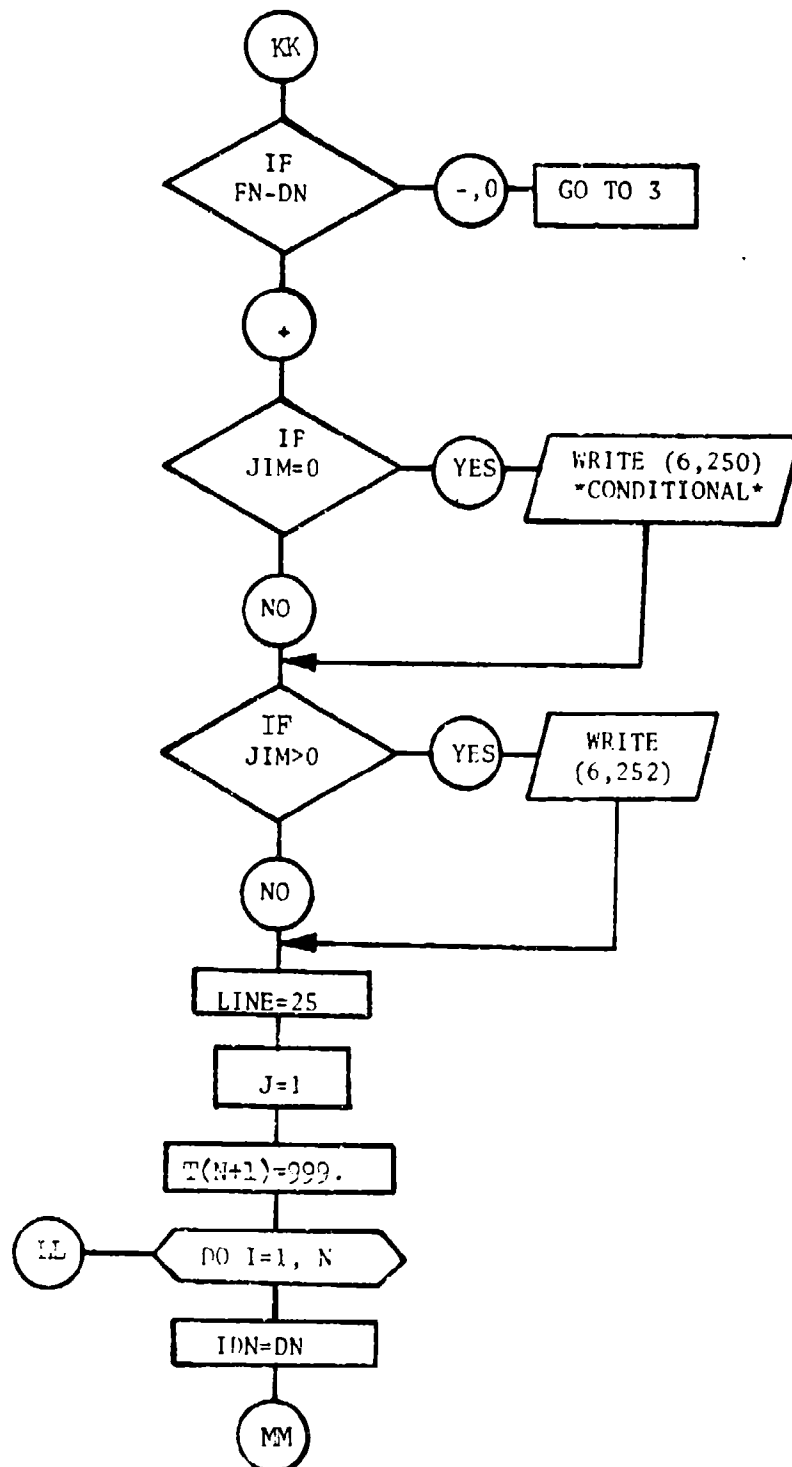


Figure 8. Flow Chart of Overlay 1,0 (Continued)

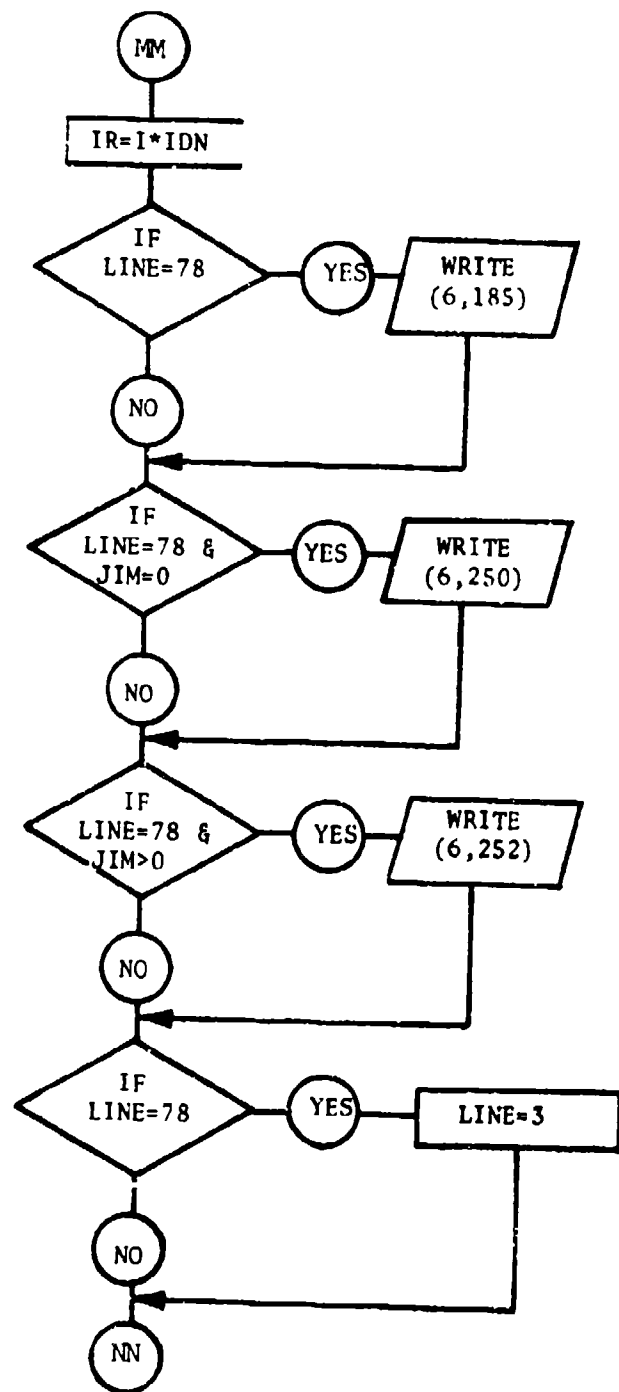


Figure 8. Flow Chart of Overlay 1,0 (Continued)

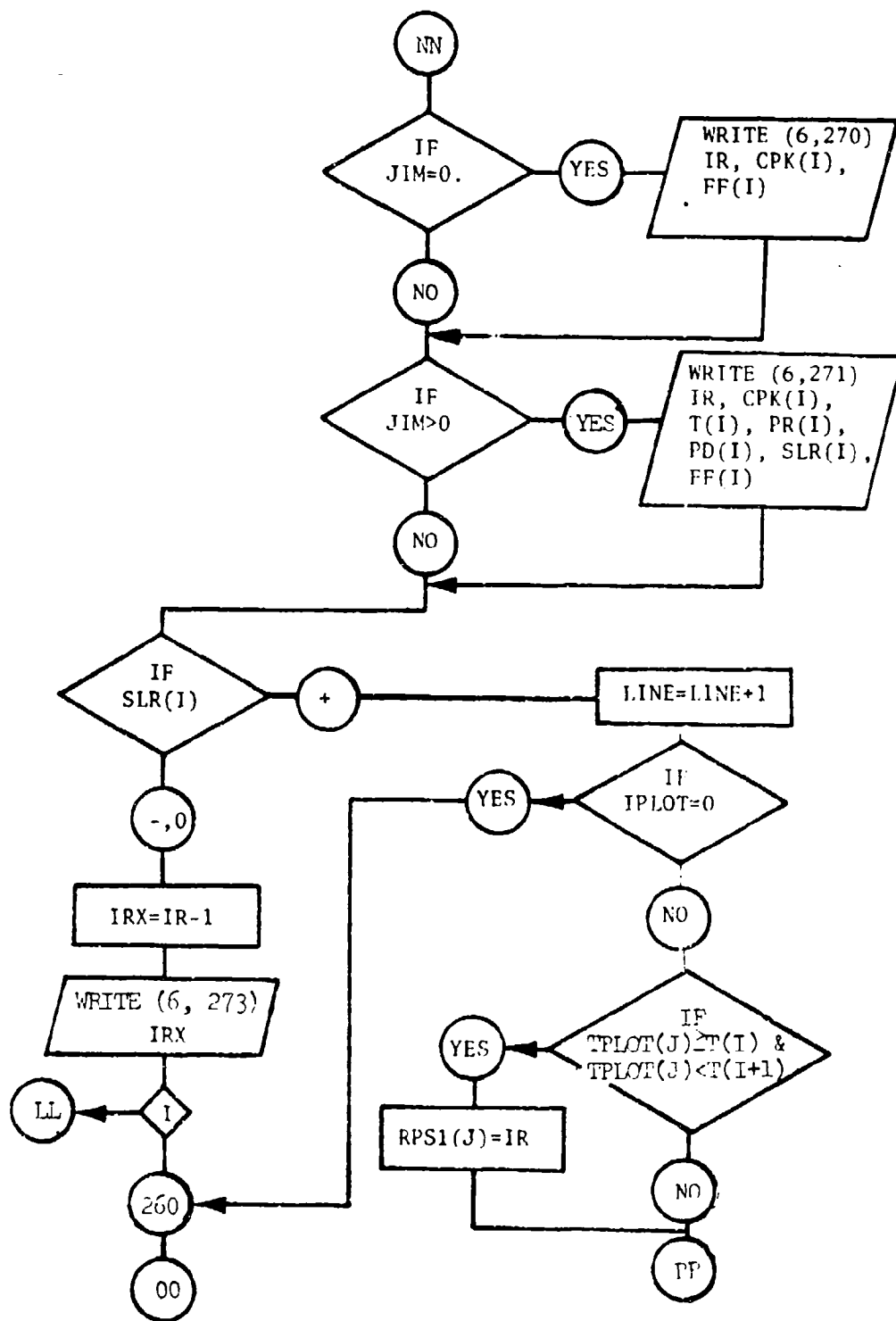


Figure 8. Flow Chart of Overlay 1,0 (Continued)

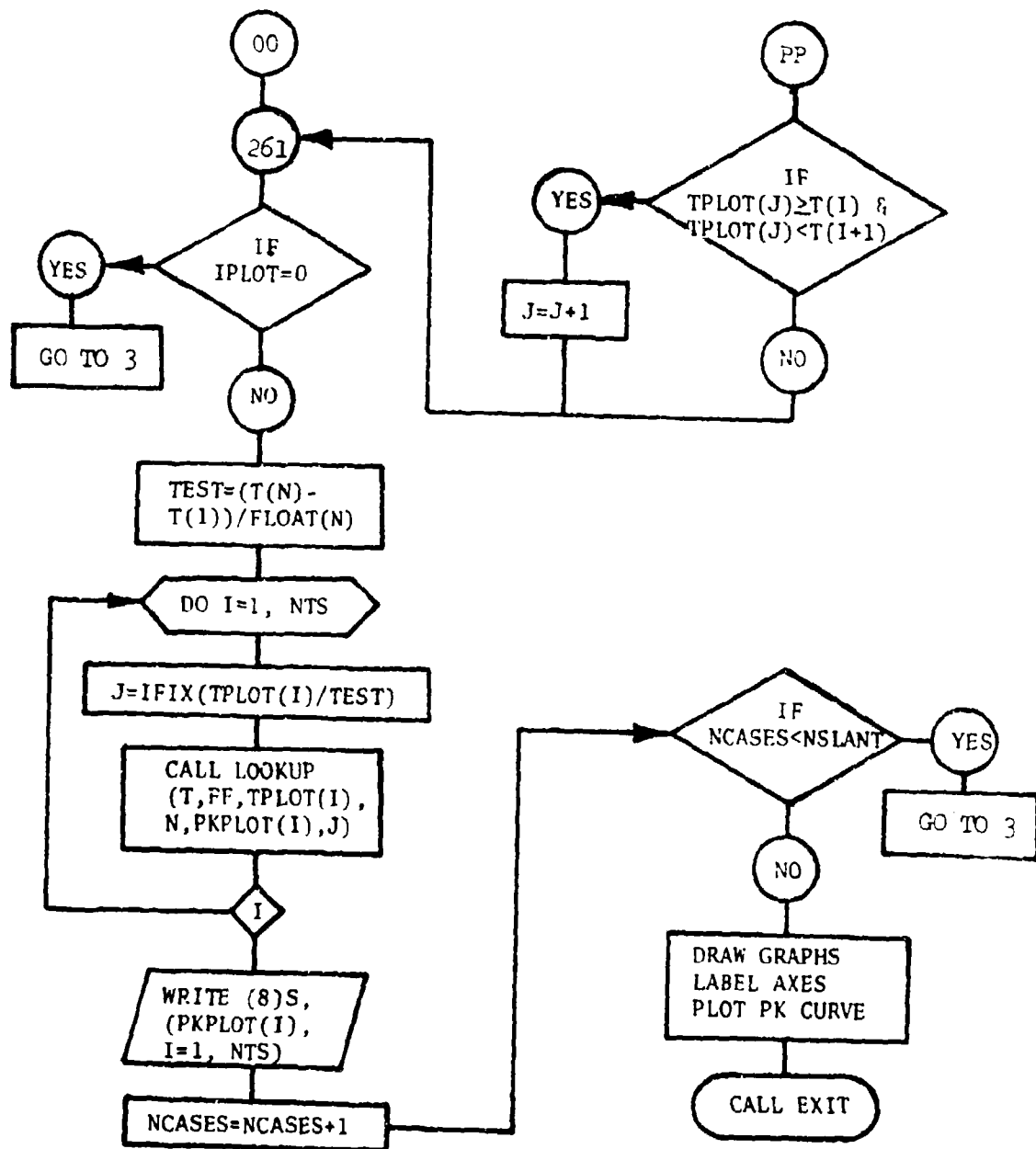


Figure 8. Flow Chart of Overlay 1,0 (Concluded)

APPENDIX C

P0655 PROGRAM LISTING

Appendix C contains a FORTRAN program listing of the air-to-ground gun simulation program complete with three overlays and three subroutines.

```

1  OVERLAY(1,FILE,0,0)
   PROGRAM P0655 (INPUT=129, OUTPUT=129, TAPE5=INPUT, TAPE6=OUTPUT, TAPE4=
5  129, TAPE8=1, FILMPL=0)
   DIMENSION IPLOT (10)
   COMMON/ENDOD1/IEOF, ITEST, IGO, JIM, IPLOT, IOPT, NTS, TPLOT
   ITEST = 1
   CALL FORCEV
   ASSIGN 100 TO IEOF
10  CALL OVERLAY(SLAFILE,1,0,6HRECALL)
   CALL OVERLAY(SLAFILE,2,0,6HRECALL)
   IF (IGO.EQ.0) GO TO 100
   CALL OVERLAY(SLAFILE,1,0,6HRECALL)
100 CONTINUE
   CALL EXIT
15  END

```

97


```

200      GUNN = 0.
      CALL RANG(ALPHA,GAMMA)
      RC = SIGR(11)*ALPHA
      DC = SIGO(11)*GAMMA
      DO 150 J=1,JJ
      IF (JIM.EQ.0) GO TO 60
      A = PR(J)
      B = PD(J)
      MN2=MR2(J)
      GO TO 90
      FLN2 = FLR2(J)
      GO TO 90
      60 IF (VR) 90,70,80
      70 FLN2=FLR2(J)
      GO TO 90
      80 MN2=MR2(J)/(1.0-FLOAT(J-1)*VR)
      FLN2=FLR2(J)/(1.0-FLOAT(J-1)*VR)
      90 IF (R2) 100,110,120
      100 IF (R2) 100,110,120
      110 CALL RANG(DELTA,EP)
      120 IF (R2) 100,110,120
      130 IF (R2) 100,110,120
      130 IF (R2) 100,110,120
      132 JAB = J
      XX = 1. - (1. - PJAM)**JAB
      XX = RANF(XX)
      IF (XX - X) 140,160,160
      140 IF (GUNS.EQ.1) GO TO 145
      C C C
      MULTIPLE GUNS
      GUNN = GUNN+1.
      IF (GUNN.LT.GUNS) GO TO 90
      IF (GUNN.EQ.GUNS) GUNN = 0.
      145 CALL RANG(ALPHA,GAMMA)
      RC = A*RC+SIGR(11)*SORT(1.0-A**2)*ALPHA
      DC = B*DC+SIGO(11)*SORT(1.0-B**2)*GAMMA
      150 CONTINUE
      GO TO 170
      160 MKILLS = MKILLS + 1
      X = FLOAT(JAB)/DN + 0.9999
      JJK = JJK + 1
      170 CONTINUE
      PK = FLOAT (MKILLS)/COUNT
      IF (JIM.EQ.1.AND.SLR(JJ).LE.0.0) PK = 1.0
      SDPK = SORT (PK - PK*PK)/COUNT
      173 Q = 12 + 50
      IF (Q - F) 174,174,175
      174 I1 = I2 + 1
      GO TO 55
      175 DO 180 I=2,JJ
      JJK(I) = JJK(I-1) + JJK(I-1)
      FF(I) = FLOAT(JJK(I))/COUNT
      180 IF (JIM.EQ.1.AND.SLR(I).LE.0.0) FF(I) = 1.0
      FF(I) = FLOAT (JJK(I))/COUNT
      WRITE(6,185) (TITLE(I),I=1,6)
      185 FORMAT(1H1,3X,6A0)
      IF (JIM.EQ.0.AND.SR1.GT.0.0) WRITE(6,186) A,SIGR,SR1,BETAR,B,
      1 SIGO,SDO1,BETAD
      IF (JIM.EQ.0.AND.SR1.LE.0.0) WRITE(6,190) A,SIGR,BETAR,B,SIGO,BETAD

```


PROGRAM RUN	74/74	OPT=1	FTM 4.5410	22/07/76	14.32.33	PAGE 8
460	1001	DO 1001 I=1,6		P0655	469	
		SLR(I) = 1000.0*FLOAT(I)		P0655	470	
	1002	MCASES = 6		P0655	471	
		IF (CODE(1,500)) TCODE, WCODE, RPS, C, R, DIVE, BURSTL, RNOSTL		P0655	472	
		IF (CODE(1,500)) SIGR, SIGD, BETAR, BETAD		P0655	473	
	5000	FORMAT(2A5, 6F10.0)		P0655	474	
	5001	CALL SETMIV(74.35.65.121)		P0655	475	
		GO TO 590		P0655	476	
465	C	BRANCH TO PLOT SEQUENCE AND RETURN HERE.		P0655	477	
	1003	READ(1,500) (CPK(I), I=1,6), PTITLE		P0655	478	
		IF (CODE(1,500)) GO TO 400		P0655	479	
470	C	IF (CPK(1)) 1002, 1002, 351		P0655	480	
		WRITE(16, 419)		P0655	481	
	410	FORMAT(11P)		P0655	482	
	410	CALL EXI		P0655	483	
475	511	CONTINUE		P0655	484	
		END		P0655	485	
				P0655	486	
				P0655	487	
				P0655	488	
				P0655	489	
				P0655	490	

[illegible]

22/07/76 14.J2.33

FTN 4.5+410

PROGRAM GENIP 74/74 OPT=1

```

265      IF(K4 .LE. ITGL) GO TO 96
        K5 = 1
        K4 = K3+1
        IF(K3 .LE. IVEL) CALL INSERT
        IF(K3 .LE. IVEL) GO TO 94
        K5 = 1
        K4 = 1
        K2 = K2+1
        IF(K2 .GT. I9ALE) GO TO 4860
        DO 4850 J = 1,10
          DO 4850 I = 1,M
            CKILA(I,J) = CKILA(I,J)
            M = MOSL
            GO TO 97
          CONTINUE
        4850
        4860
        K5 = 1
        K4 = 1
        K2 = 1
        IF(K1 .GT. IAIM) GO TO 4980
        DO 4980 J = 1,10
          DO 4980 I = 1,M
            CKILA(I,J) = CKILA(I,J)
            M = MOSL
            GO TO 97
          CONTINUE
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INITIAL DISTRIBUTION

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USAFE/DOQ	1
PACAF/DOO	1
TAC/XPSY	1
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ASD/ENFEA	1
AJL	1
AFSC LIA OF/Code 143	2
OGDEN ALC/MMMP	2
AFIS/INTA	1
DDC	2
AFATL/DLODL	2
AFATL/DL	1
AFATL/DLD	1
AFATL/DLY	1
ADTC/XR	1
ADTC/SD	2
USAFTAWC/TRADOC-LO	1
OF ASST SEC DEF/SA	1
HQ USAF/OA	1
HQ USAF/SA	1
HQ USAF/RDPA	1
AFSC/SDW	1
NAVSYSWPN CEN/Code GA	1
US NAVAL WPNS CEN/Code 407	1
US NAVAL WPNS CEN/Code 456	1
AFATL/DLYV	1
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ASD/XRP	1
TAC/INA	1
USA TRADOC Sys Analys Act	1
AFATL/DLODR	1
COMIPAC/I-232	1
ASD/YXT	1
NSWC/Code GC	1
AMSAA/AMXSY-D	1
AMSAA/AMXSY-S	1
NAVWPNCEN/Code 40701	1
NAVWPNCEN/Code 12	1
NAVWPNCEN/Code 40703	1
NAVWPNCEN/Code 408	1
NSWC	1
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NSWC/Code GAC	1