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AIRBORNE ANTENNA COVERAGE REQUIREMENTS FOR THE TCV B-737 AIRCRAFT

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AIRBORNE ANTENNA COVERAGE REQUIREMENTS FOR THE TCV B-737 AIRCRAFT

Summary

A study was conducted to determine the airborne antenna line of sight look angle requirement for operation with a Microwave Landing System (MLS). This report presents the required azimuth and elevation line of sight look angles from an antenna located on an aircraft to three ground based antenna sites at the Wallops Flight Center (FPS-16 radar, MLS azimuth, and MLS elevation) as the aircraft follows specific approach paths selected as representative of MLS operations at the Denver, Colorado, terminal area. These required azimuth and elevation look angles may be interpreted as basic design requirements for antennae of the TCV B-737 airplane for MLS operations along these selected approach paths.

Introduction

Two areas of investigation included in the Terminal Configured Vehicle (TCV) program are Microwave Landing System (MLS) utilization and the Cockpit Display of Traffic Information (CDTI). The required facilities for these tasks, both airborne and ground based are located at Langley Research Center (LRC) and Wallops Flight Center (WFC). Landing guidance information will be transmitted to the aircraft from either an MLS (when available at WFC) or from a simulated MLS using the WFC FPS-16 Radar/Transponder Data System. For the CDTI case, an S-band video link has been implemented. The S-band transmit antenna is mounted on the FPS-16 pedestal. This report presents the azimuth and elevation look angles from the aircraft to the ground antenna sites for four flight profiles. The four terminal area flight profiles considered are those proposed by the FAA for the Denver, Colorado, terminal area for MLS operation studies. The Denver terminal area is shown in figure 1 with the four paths labeled profile 1, 2, 3, 4.

Description of Computer Program

A computer program was written in Basic for a Hewlett-Packard 2116 computer. See appendix A for the program listing. The computer program input parameters are:

1- distance between waypoints

2- aircraft heading, airspeed, and altitude at each waypoint

3- aircraft bank angle limit

4- turn radius

5- MLS coverage boundary

6- number of points to be investigated along each flight path segment

The program output parameters are:

1- x (runway center line), y (perpendicular to runway centerline) and flat earth z (local vertical) coordinate values for n (number of) aircraft positions along each flight path segment (refer to figure 1)

2- azimuth (beta) and elevation (alpha) look angles from the aircraft to either of three ground antenna sites for each x, y, z position

3- azimuth and elevation look angles from each ground antenna to aircraft at each x, y, z position

4- glideslope required to achieve the next waypoint altitude

5- slant range between aircraft and each ground antenna site

6- transmission loss for each slant range of item 5

7- statement as to whether aircraft is or is not within MLS coverage zone

8- bank angle

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9- aircraft groundspeed

10- distance to go to touchdown along the flight path

11- aircraft heading

The program performs any one of three operations as per the setting of three control words J4, J7, J8. Control word J4 sets the program for calculation and storage of the look angles to the MLS antenna sites and aircraft x, y position or calculation and storage of the look angles to the FPS-16 radar site. Control word J7 determines whether the program will store the flight path data or the look angles to the MLS. Control word J8 determines whether the program will print all data and store the look angles or only store. For the FPS-16 radar case, the operator must input the x, y (J5, J6) location of the radar relative to the touchdown point. For the MLS case, the azimuth antenna is sited 9,000 ft beyond the touchdown point on the runway centerline and the elevation antenna is sited adjacent to the touchdown point, 300 ft to the right of the runway centerline. The origin of the coordinate system is located at the touchdown point which is on the runway centerline 1,000 ft beyond threshold. Figure 2 gives the WFC runway and antenna geometry. Beginning at the outermost waypoint the aircraft proceeds to the next waypoint in n steps. This process continues from waypoint to waypoint until the first turn is reached. At this time the aircraft stops, assumes the designated bank angle in n steps, then continues around the turn in n steps. Upon completing the turn, the aircraft again stops and returns to wings level in n steps continuing on in a like manner to the touchdown point. The output parameters are computed at each of the n steps of each segment of the path.

Results

The results are presented in four data sets, one set for each of the four approach profiles investigated. In each case, the active runway at WFC is 04 as shown in the first figure of each set. Table 1 gives the parameters of each flight profile. The next three figures in each set are plots of the look angles. Negative azimuth angles are to the left of the aircraft longitudinal axis and negative elevation angles are below the aircraft lateral axis. For profile 1 (figure 3), the look angle to the MLS azimuth antenna (figure 3a) varied from 3° to -167° in azimuth and 25° to -36° in elevation. The look angle to the MLS El-1 antenna (figure 3b) varied from 90° to -165° in azimuth and 24° to -36° in elevation. The look angle to the FPS-16 radar (figure 3c) varied from -1° to -167° in azimuth and 24° to -37° in elevation. For profile 2 (figure 4) the look angle to the MLS azimuth antenna (figure 4a) varied from 14° to -167° in azimuth and 24° to -31° in elevation. The look angle to the MLS El-1 antenna (figure 4b) varied from 17° to -161° in azimuth and 24° to -28° in elevation. The look angle to the FPS-16 radar (figure 4c) varied from 17° to -167° in azimuth and 24° to -29° in elevation. Profiles 3 and 4 (figures 5, a, b, c, and 6 a, b, c) are very similar with the azimuth angle varying from -20° to 160° and the elevation angle varying from 25° to -35°. For the other WFC runways, the look angles to the MLS antenna are identical to those of 04 and only slightly different for the FPS-16 radar.

Concluding Remarks

The antenna coverage requirements based on four specific flight profiles have been determined. The antenna has been designed as per these requirements and found, due to hardware location constraints, to have considerably less

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elevation coverage than the required -35° in the turn to the downwind leg. It is recommended, therefore, that the design be implemented as is and adjustments be made to the flight profiles such that the turn to the downwind leg occurs outside of the MLS coverage zone. This change in the profile will not be detrimental to the planned research in MLS utilization or CDTI.

References

1. Mitre Corporation presentation at Langley Research Center. "Functional Description of a Ground Based Metering and Spacing System Using MLS."

2. Reeder, John P.; Taylor, Robert T.; and Walsh, Thomas M.: New Design and Operating Techniques and Requirements for Improved Aircraft Terminal Area Operations. NASA TMX-72006, December 1974.

Table 1

	Profile 1	Profile 2	Profile 3	Profile 4
H 1 degrees	40	40	40	40
H 2 degrees	40	40	40	40
H 3 degrees	130	130	310	310
H 4 degrees	220	220	220	220
H 5 degrees	133	182	263	309
S 1 nm	5	5	5	5
S 2 nm	7	7	7	7
S 3 nm	2	2	4	4
S 4 nm	6.5	19.5	7	7
S 5 nm	25	14	26	19
S 6 nm	16	23	18	19.5
Altitude ft/groundspeed knots				
at PT 1	1750/130	1750/130	1750/130	1750/130
at PT 2	2750/160	2750/160	2750/160	2750/160
at PT 3	2750/160	2750/160	2750/160	2750/160
at PT 4	2750/180	2750/180	2750/180	2750/180
at PT 5	2750/180	2750/180	2750/180	2750/180
at PT 6	3750/200	6750/250	3750/200	3750/200
at PT 7	3750/200	6750/250	3750/200	3750/200
at PT 8	7750/250	8750/250	6750/250	6750/250
at PT 9	12750/350	12750/350	12750/350	12750/350

H is aircraft heading in degrees

S is length of flight path segment in nautical miles

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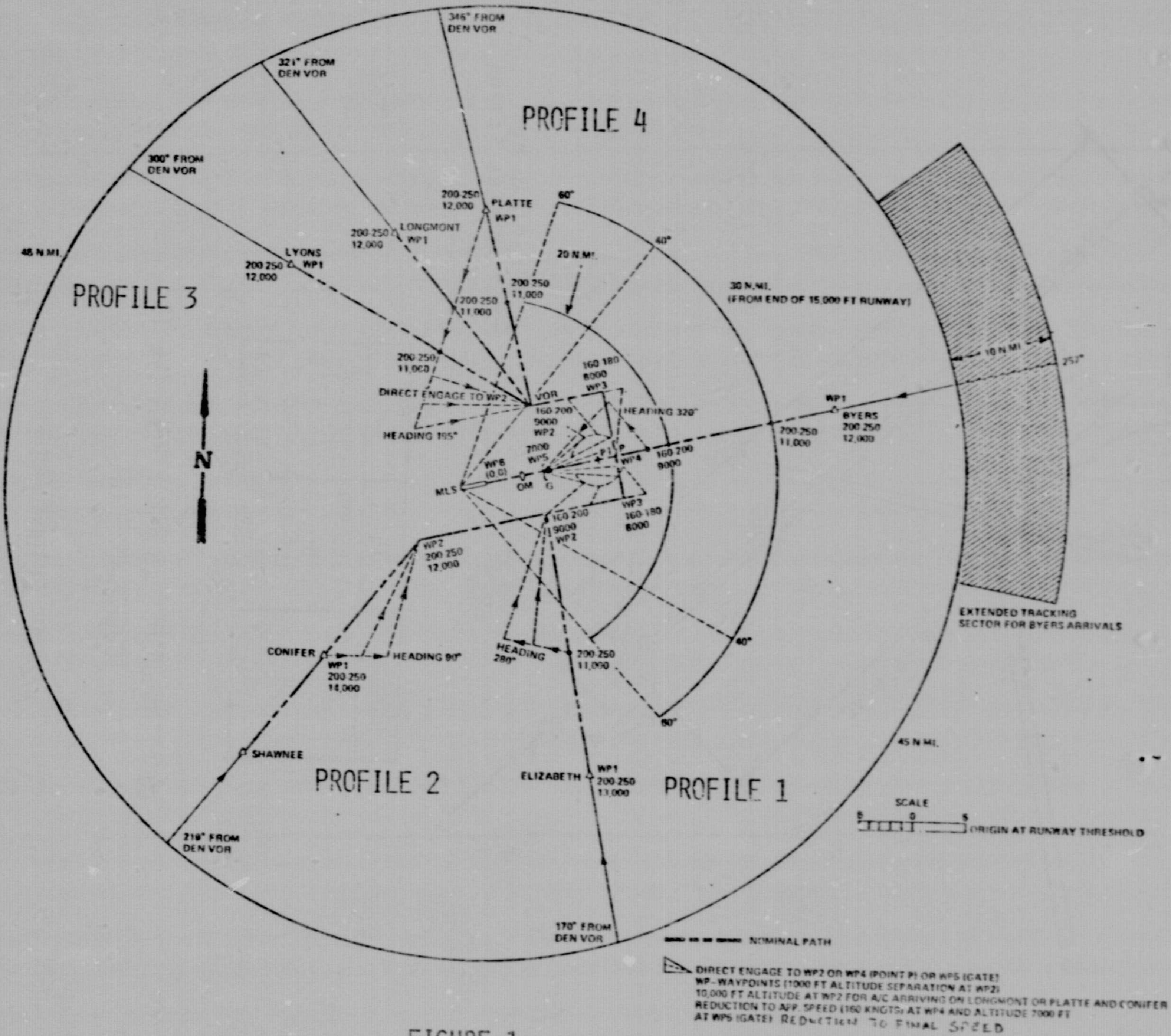

FIGURE 1

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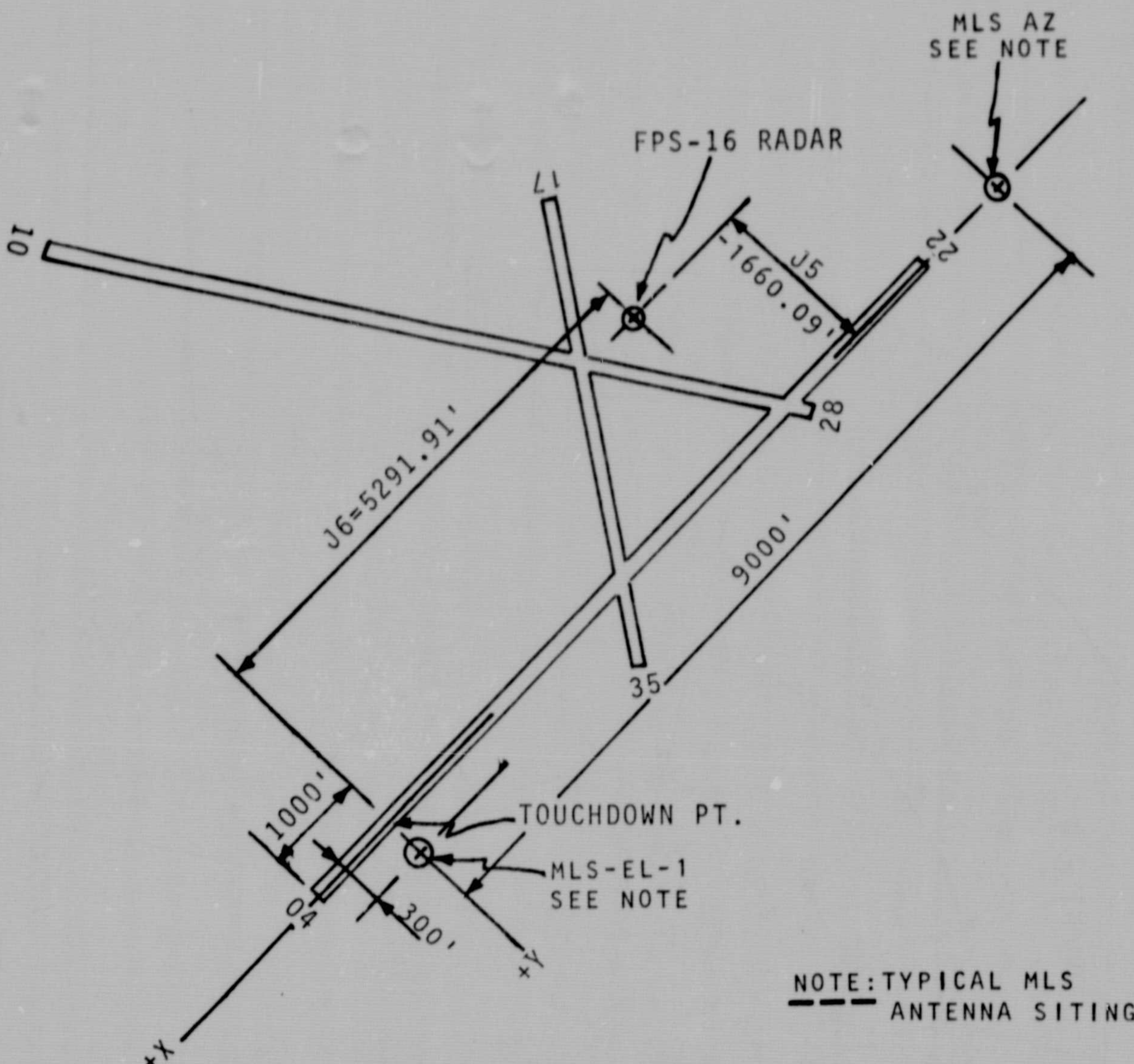

RUNWAY	J5	J6
04	-1660.09	-5291.91
22	1660.09	-1455.56
28	465.08	-987.2
10	-465.08	-4994.23

LOCATION OF FPS-16 RADAR RELATIVE TO TOUCHDOWN POINT

WALLOPS FLIGHT CENTER

FIGURE 2

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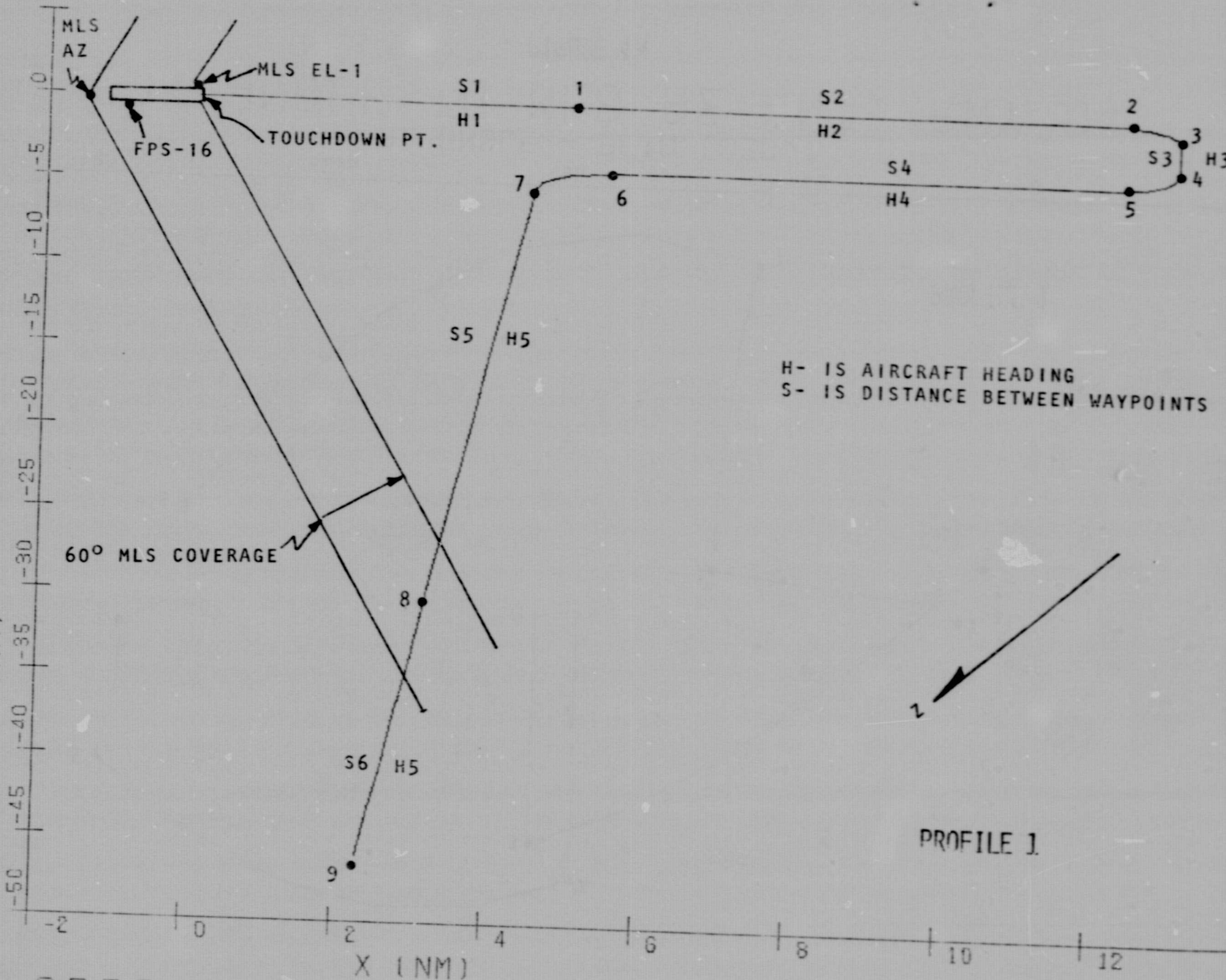
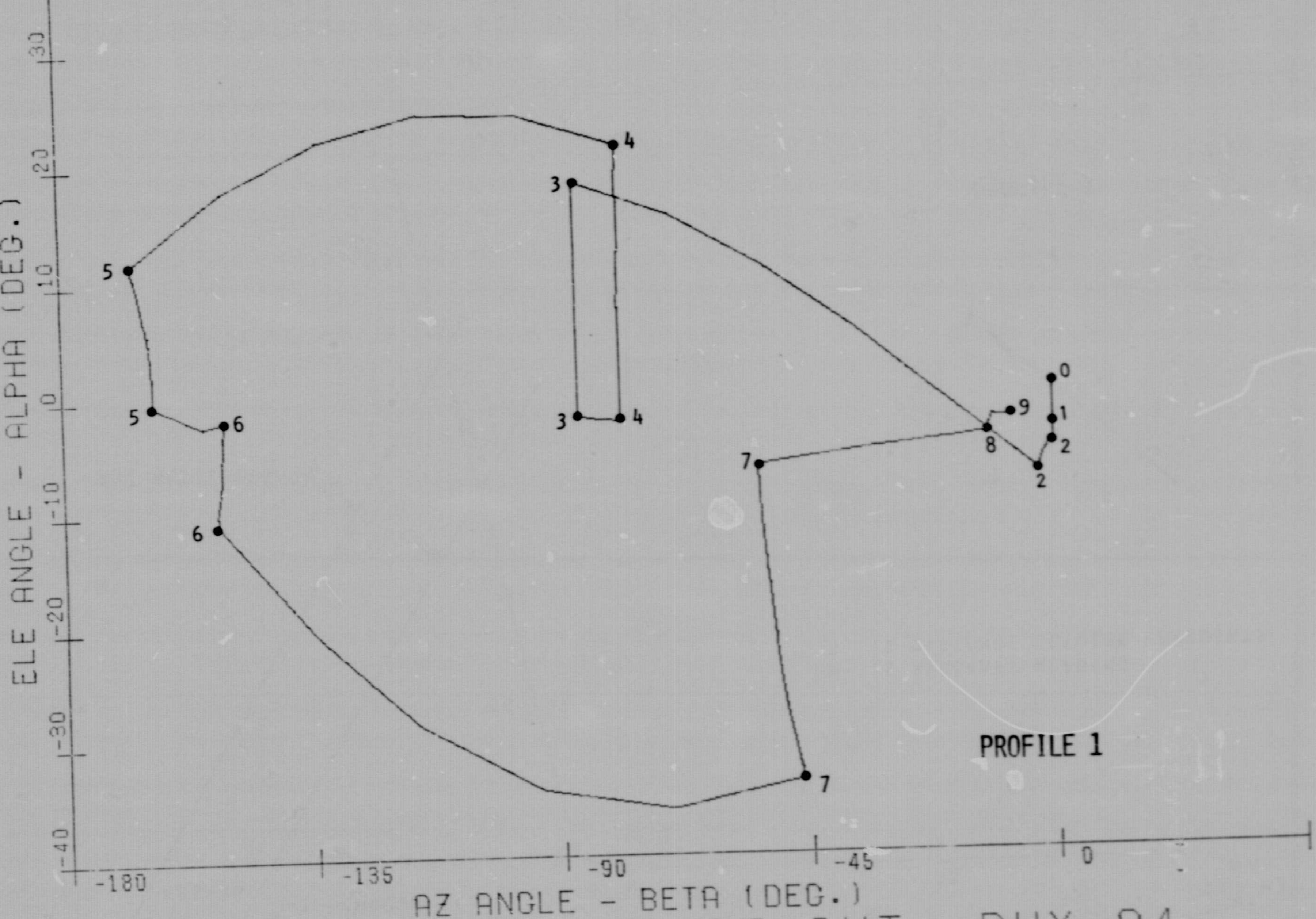


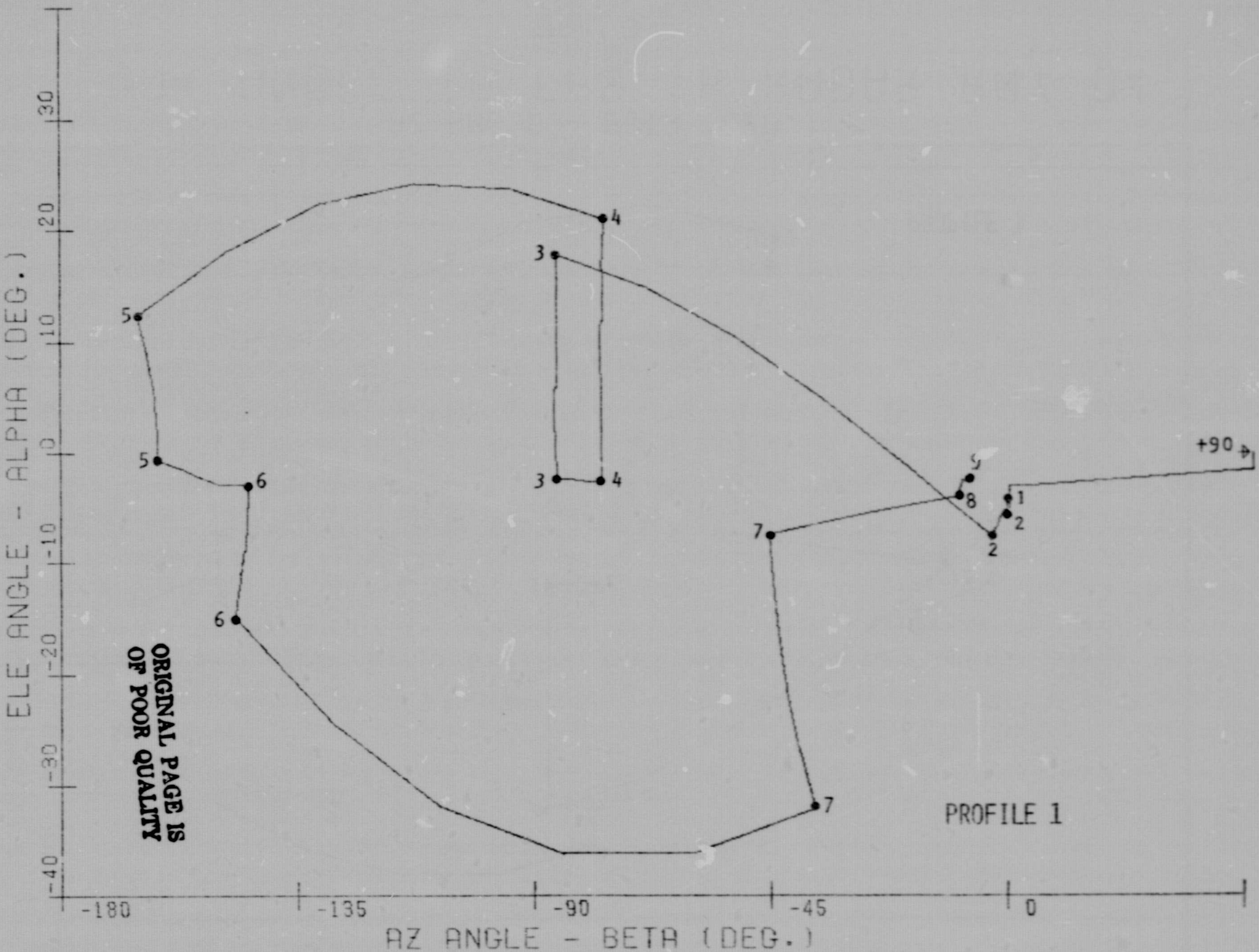
APPROACH TO WFC RWY 04

FIGURE 3



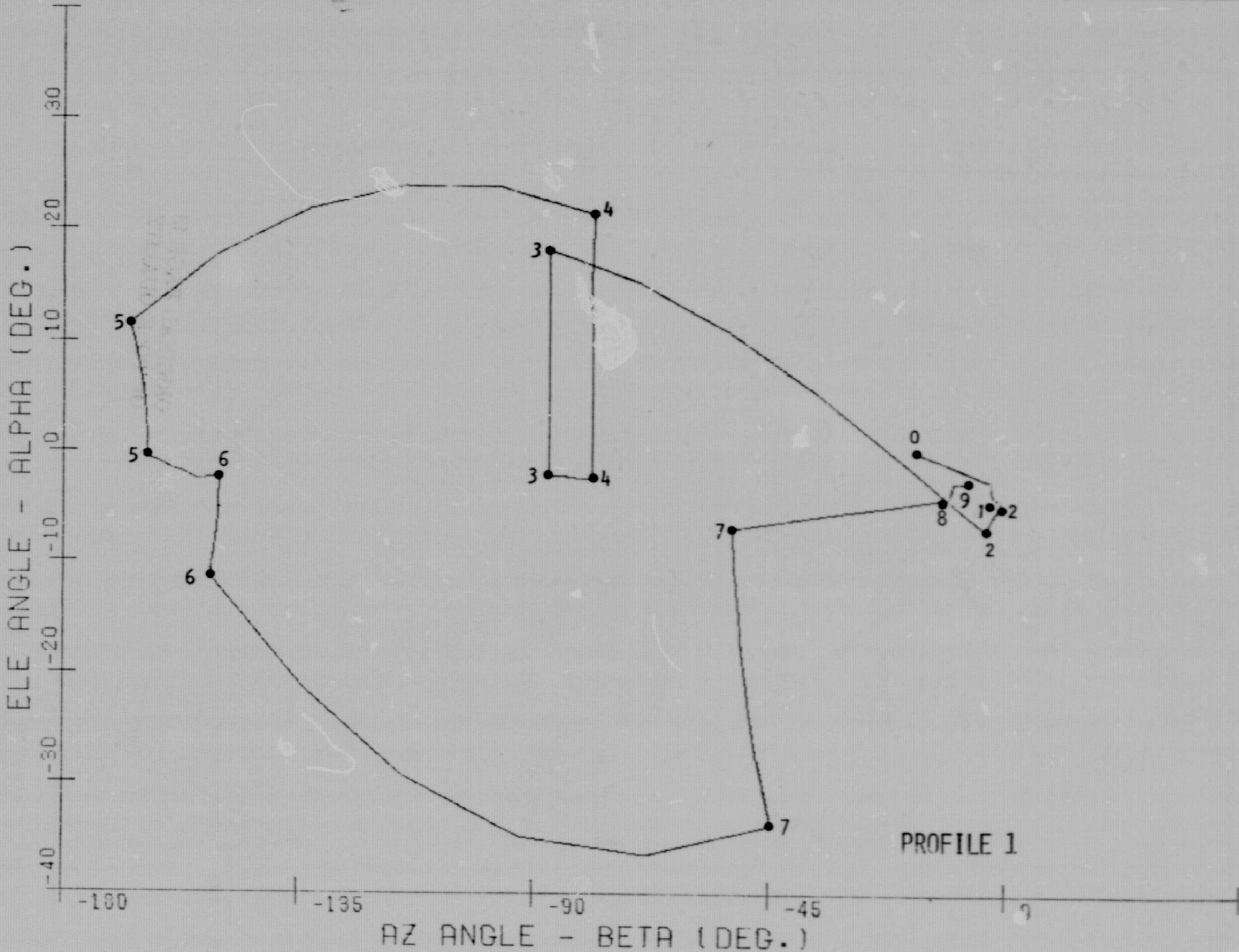
LOOK ANGLE TO MLS AZ ANT. RWY 04

FIGURE 3A



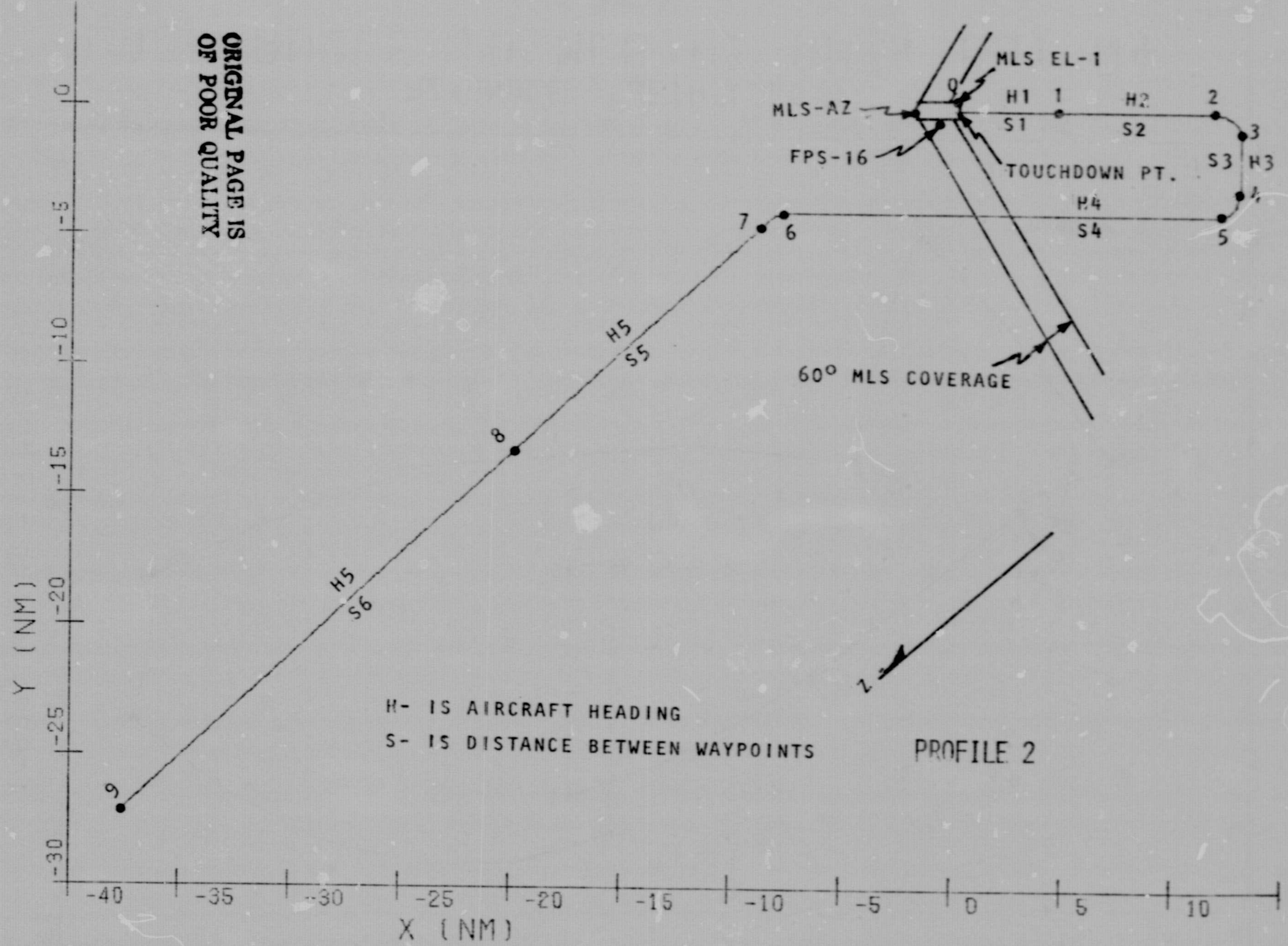
LOOK ANGLE TO MLS EL-1 ANT. RWY 04

FIGURE 3B



LOOK ANGLE TO FPS-16 RADAR RWY 04

FIGURE 3c



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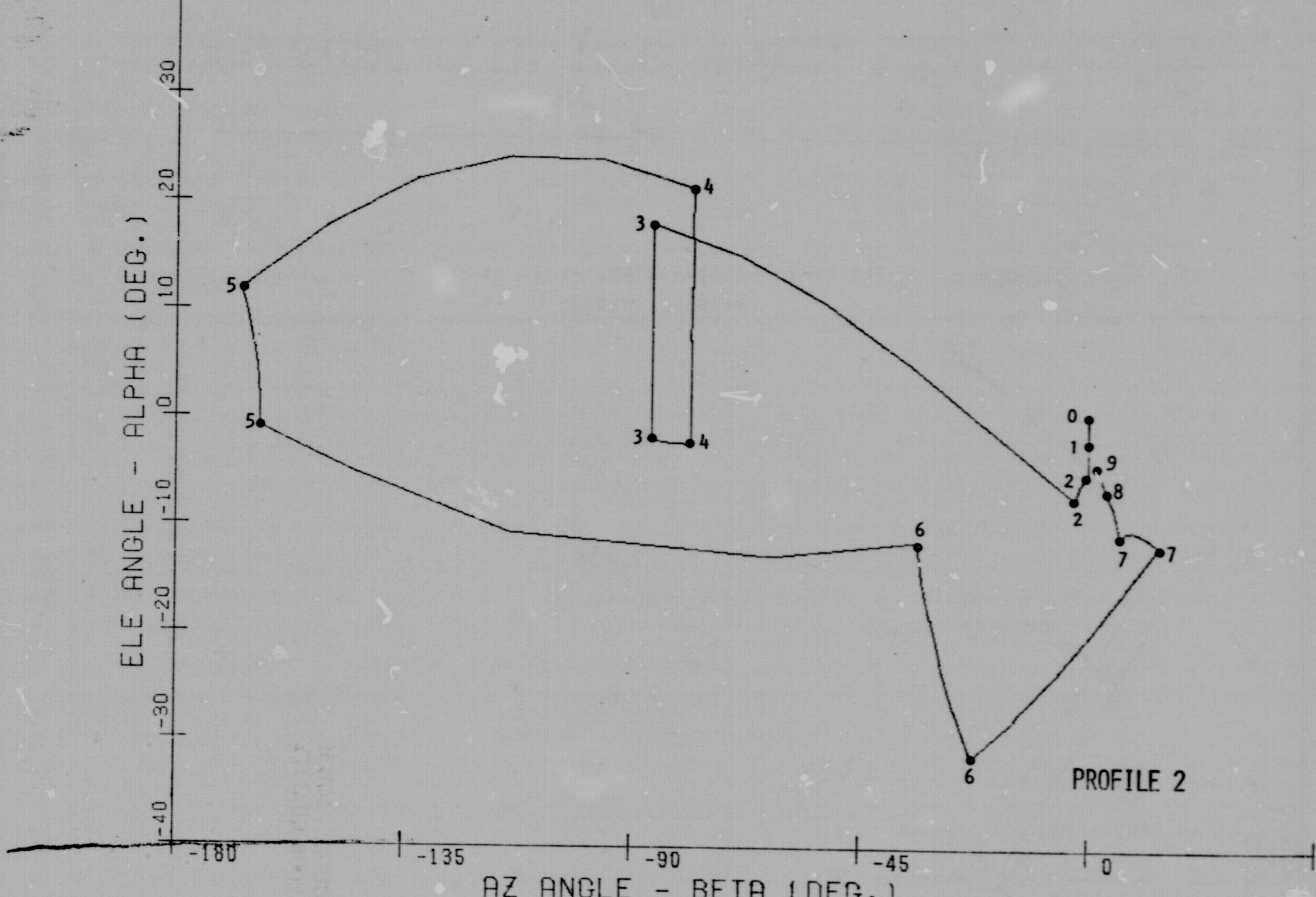
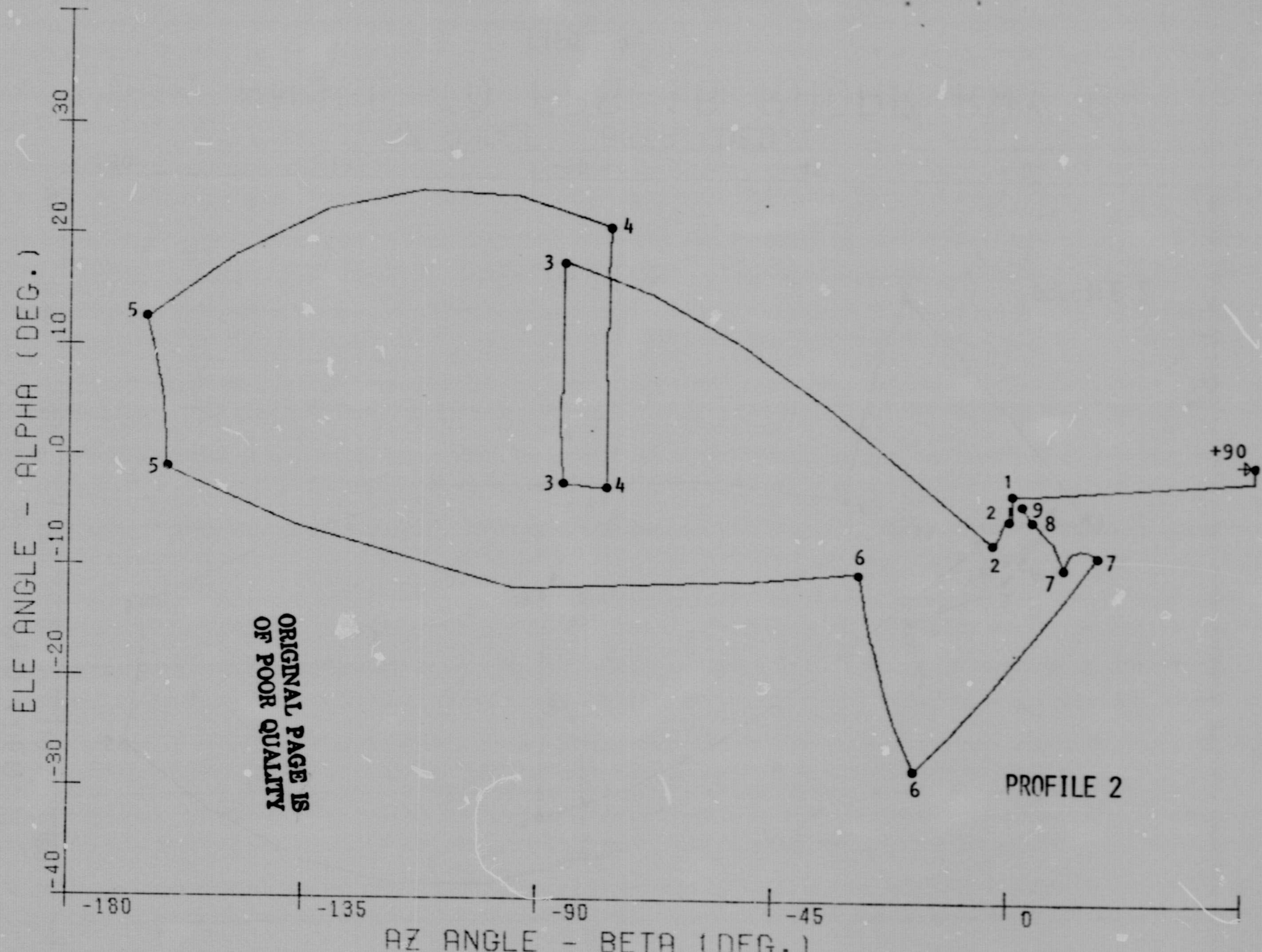
APPROACH TO WFC RWY 04

FIGURE 4



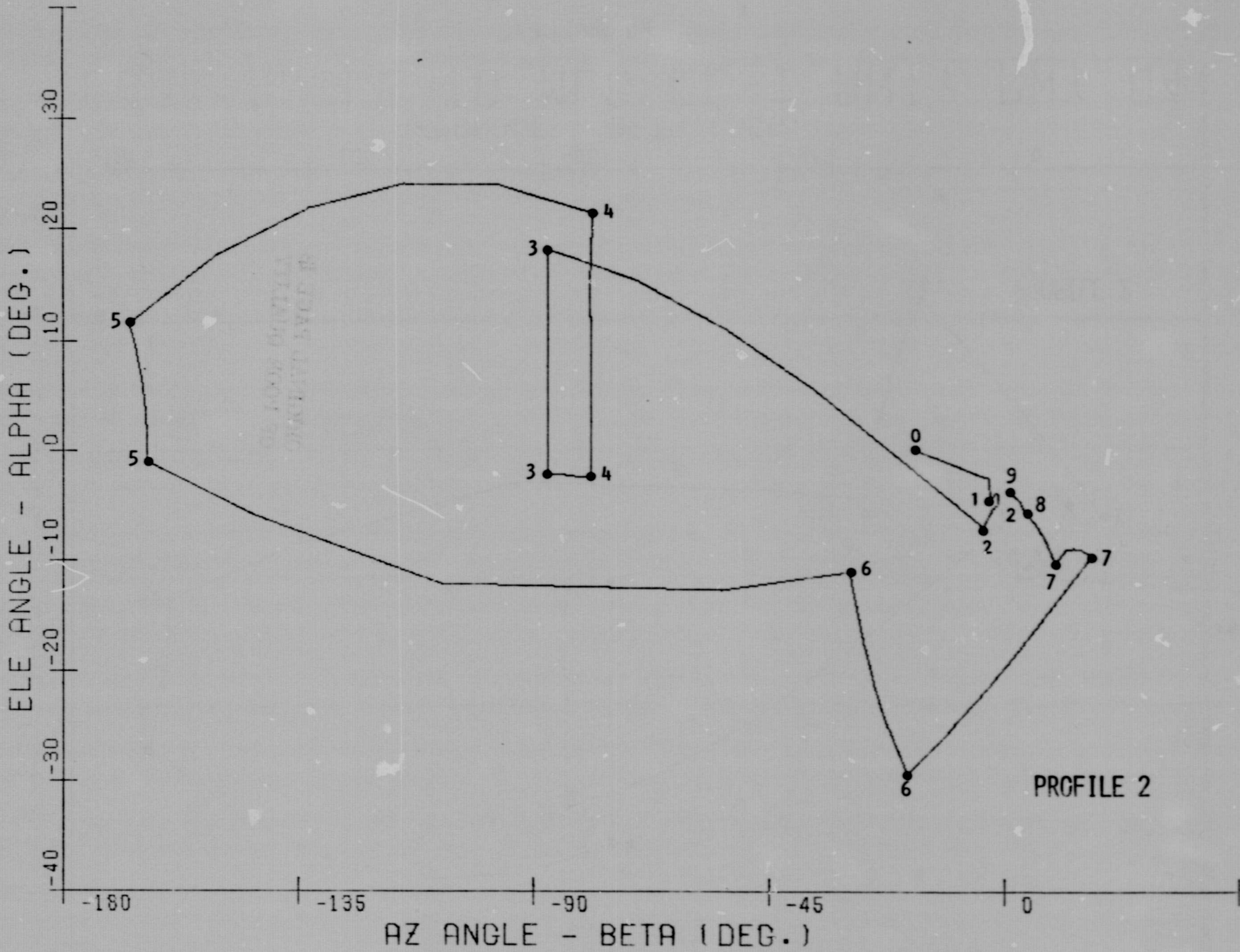
LOOK ANGLE TO MLS AZ ANT. RWY 04

FIGURE 4A



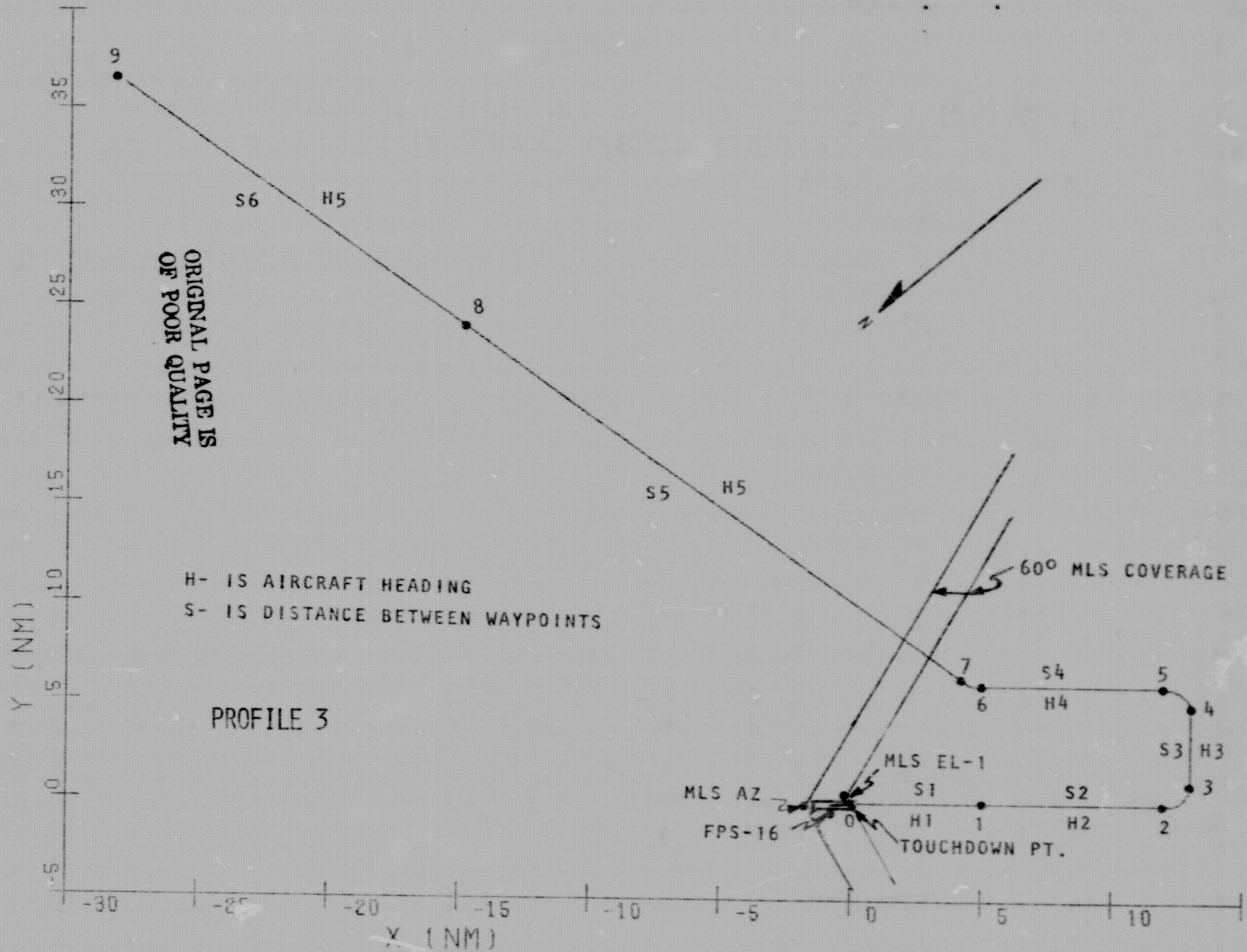
LOOK ANGLE TO MLS EL-1 ANT, RWY 04

FIGURE 4B



LOOK ANGLE TO FPS-16 RADAR RWY 04

FIGURE 4c



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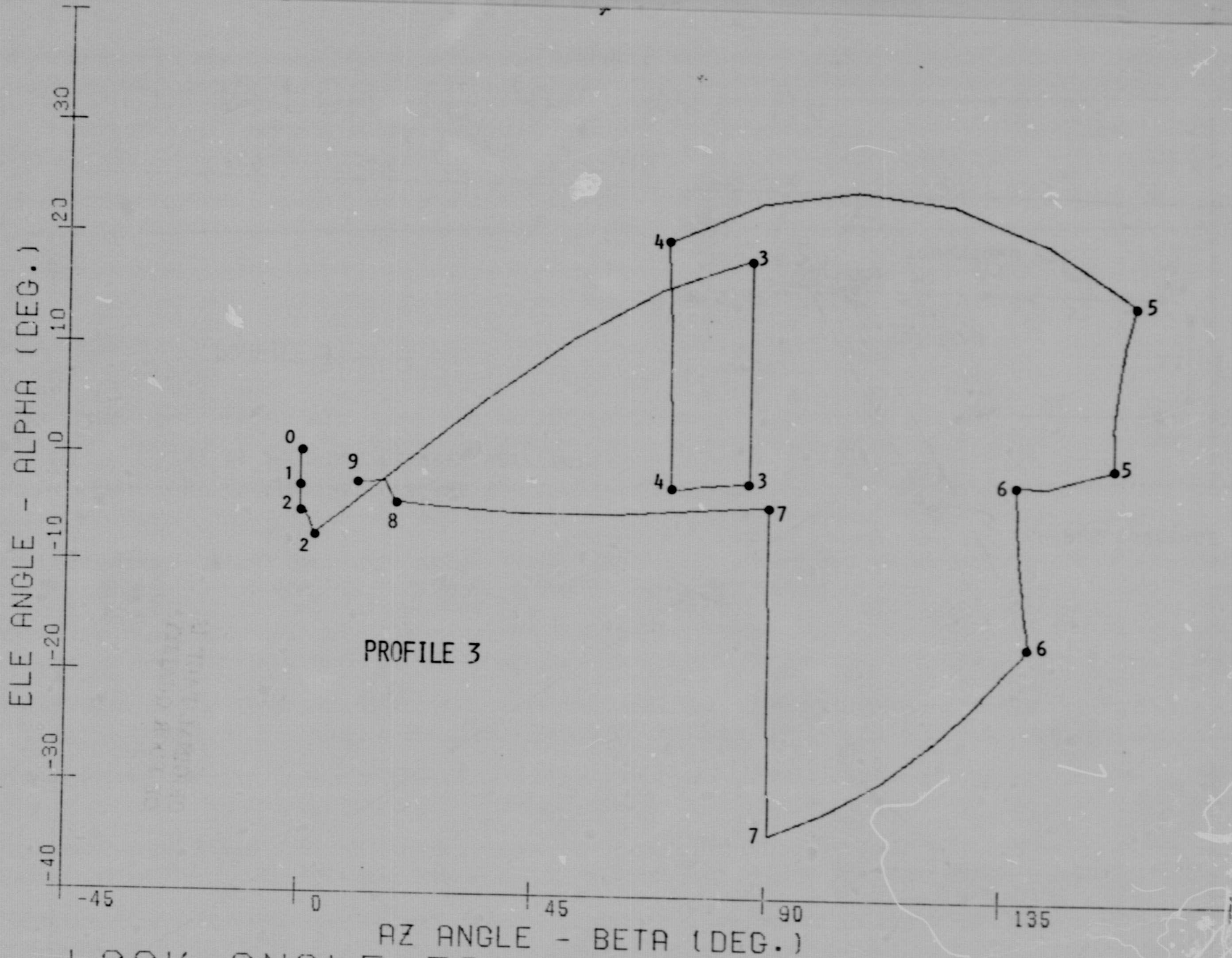
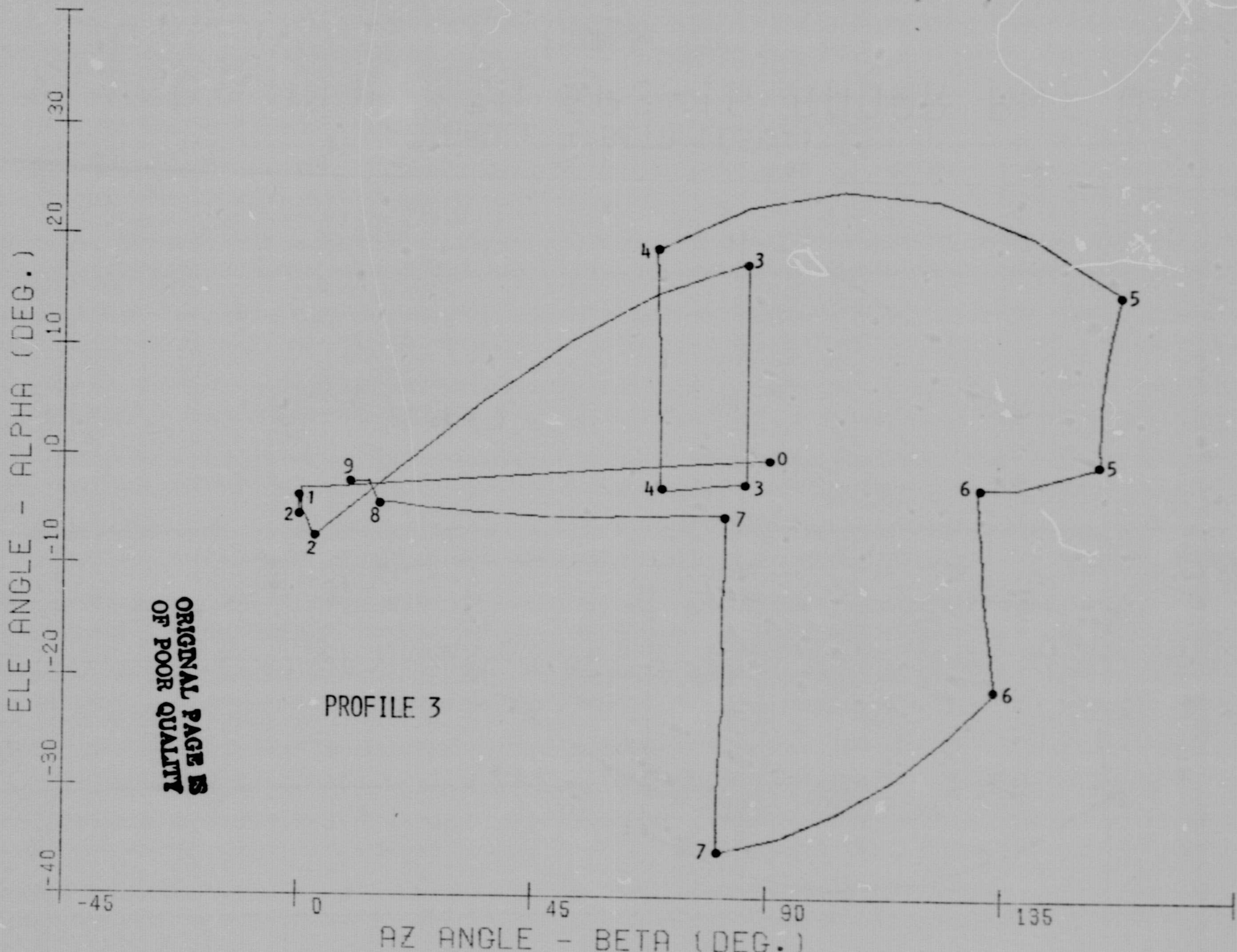
APPROACH TO WFC RWY 04

FIGURE 5



LOOK ANGLE TO MLS AZ ANT. RWY 04

FIGURE 5A



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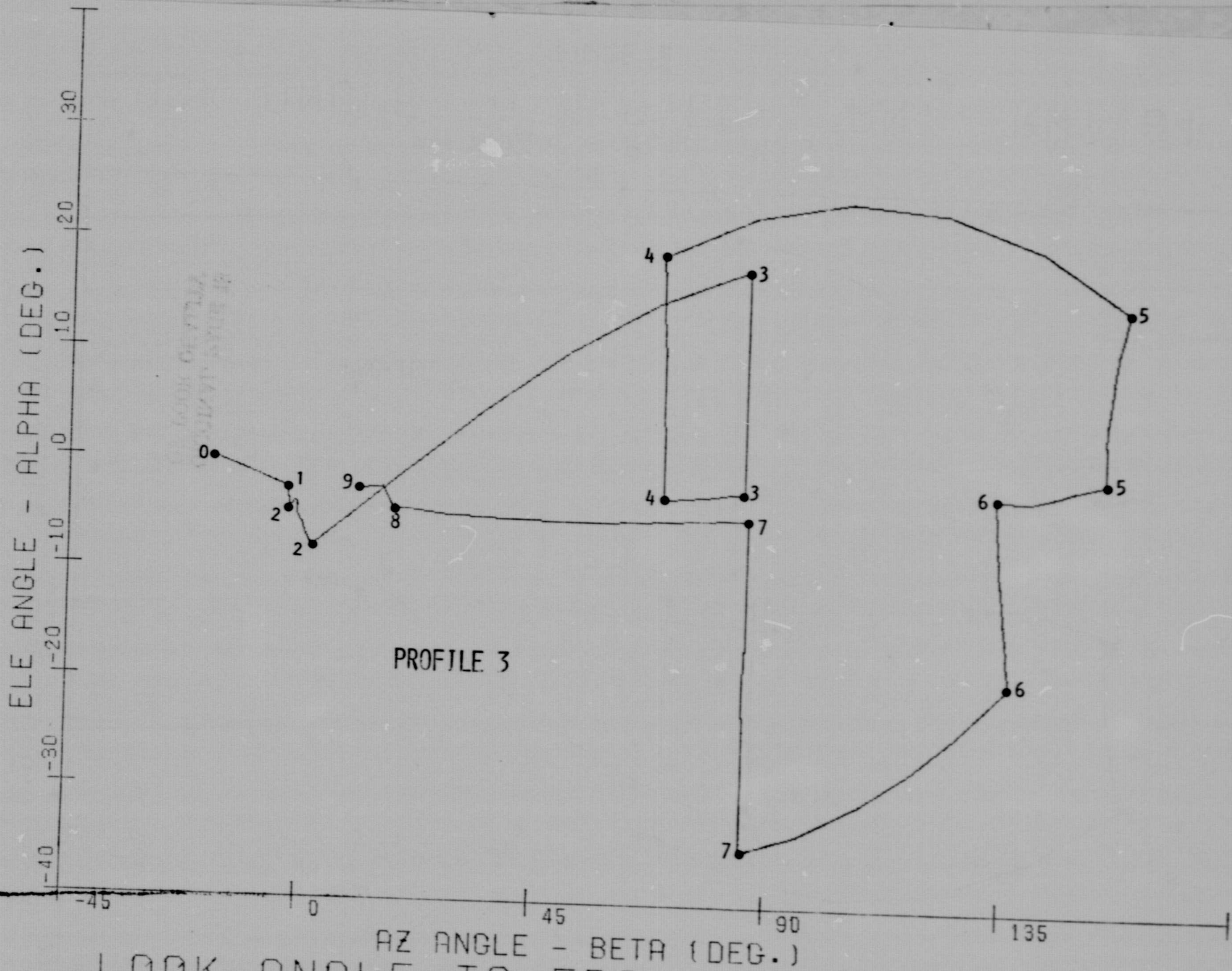
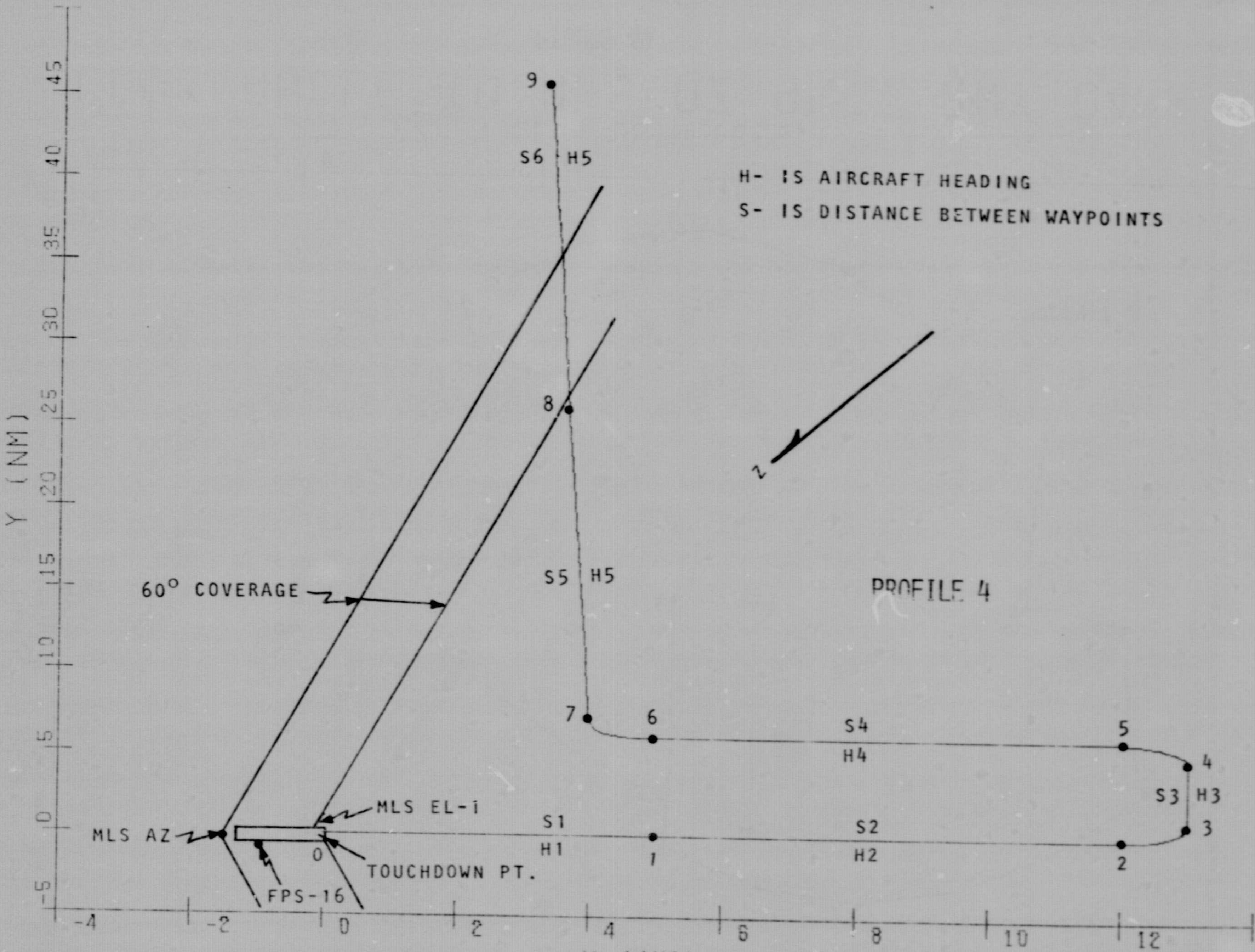
LOOK ANGLE TO MLS EL-1 ANT. RWY 04

FIGURE 5B



LOOK ANGLE TO FPS-16 RADAR RWY 04

FIGURE 5c



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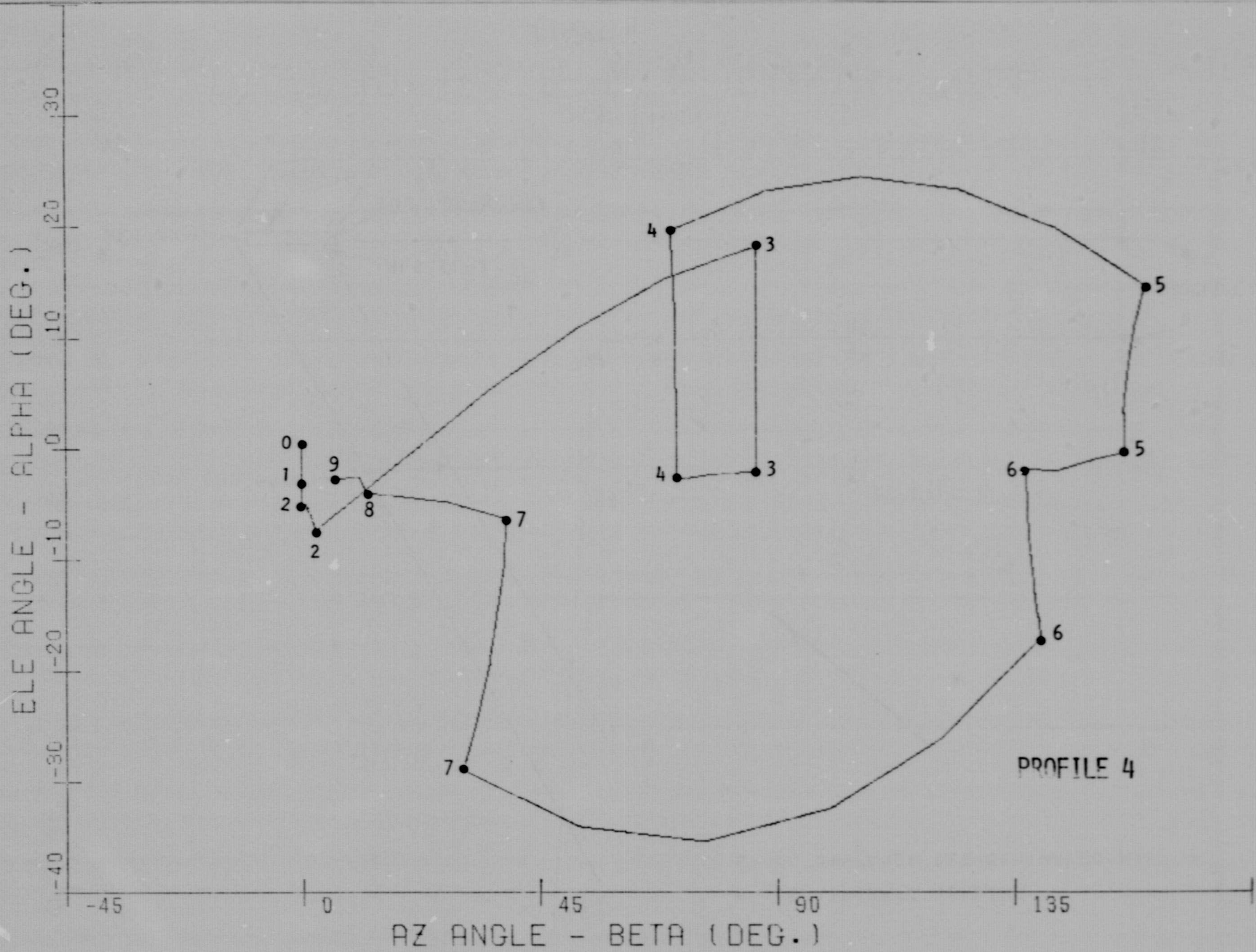
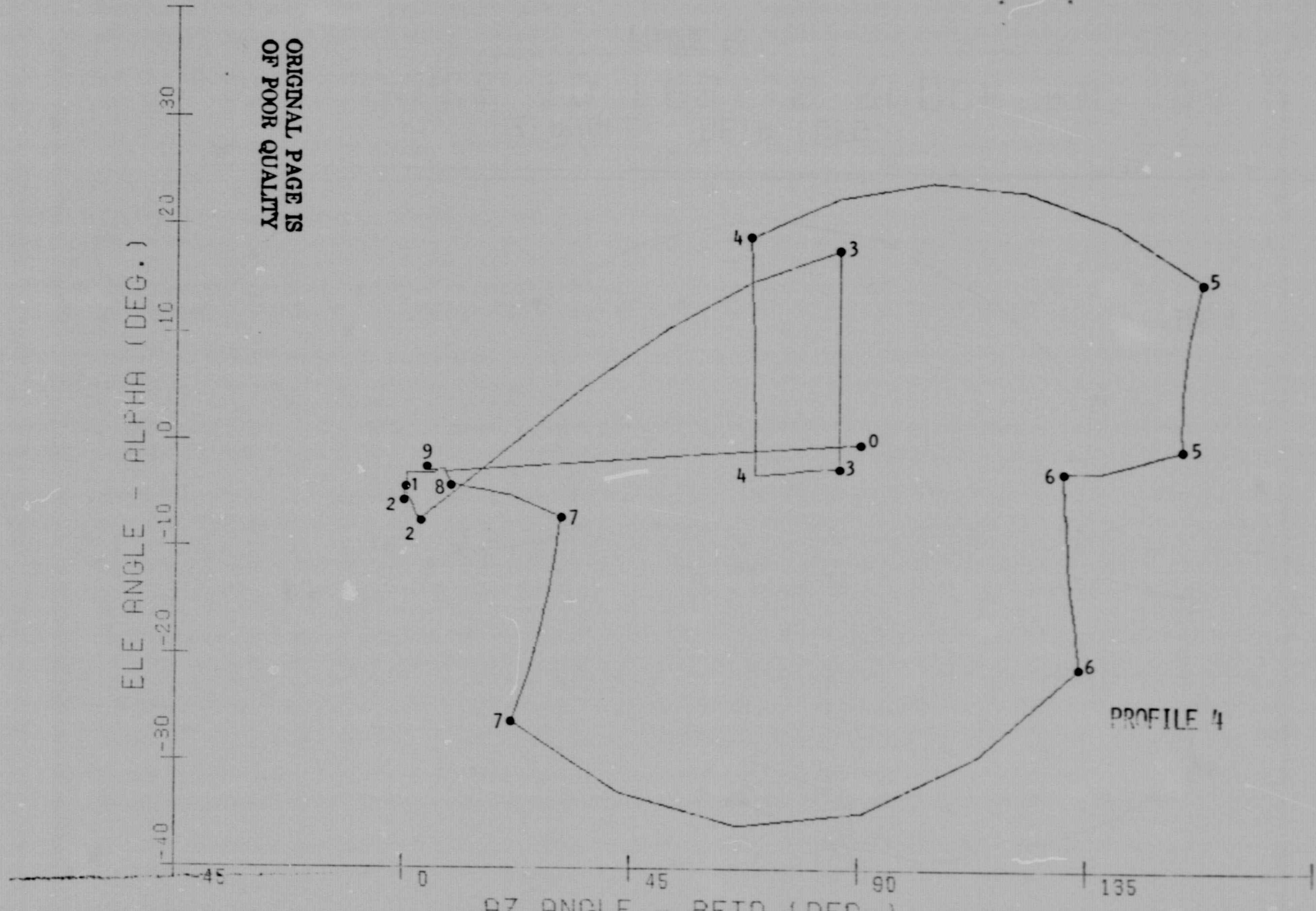
APPROACH TO WFC RUNWAY 04

FIGURE 6



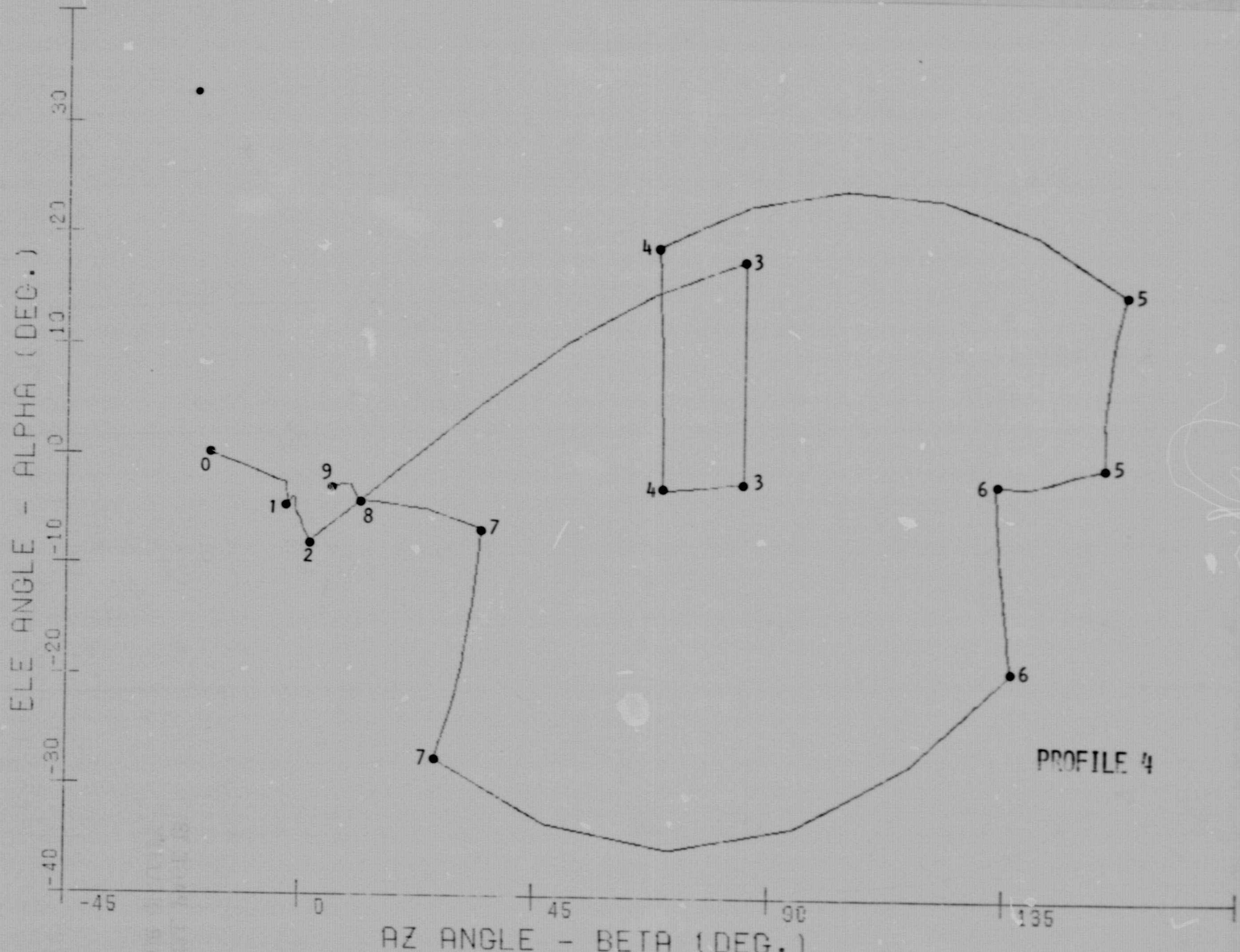
LOOK ANGLE TO MLS AZ ANT. RWY 04

FIGURE 6A



LOOK ANGLE TO MLS EL-1 ANT. RWY 04

FIGURE 6B



LOOK ANGLE TO FPS-16 RADAR RWY 04

FIGURE 6c

READY

APPENDIX A

```
12  PRINT "J4=0 FOR MLS OR TO PLOT PATH: NON-0 FOR FPS-16";
14  INPUT J4
16  IF J4=0 THEN 20
17  PRINT "INPUTJ5,J6 AS PER FINAL HEADING (H1)";
18  INPUT J5,J6
20  DIM A[32]
21  MAT A=ZER
22  LET L4=1
24  LET M4=0
26  LET N4=1
30  DIM I[32]
31  MAT I=ZER
32  LET L5=20
34  LET M5=0
36  LET N5=1
80  PRINT "J7=0 TO PLOT PATH: NON-0 FOR LOOK ANGLES";
82  INPUT J7
84  READ H1,H3,H4
86  DATA 40,310,220
88  READ H5
90  DATA 263
92  READ S1
94  DATA 5
96  READ S2
98  DATA 7
100  READ S3
110  DATA 4
120  READ S4
130  DATA 7
140  READ S5
150  DATA 26
160  READ S6
170  DATA 18
172  READ V0,Z0
174  DATA 130,0
180  READ V1,Z1
190  DATA 130,1750
200  READ V2,Z2
210  DATA 160,2750
220  READ V3,Z3
230  DATA 160,2750
240  READ V4,Z4
250  DATA 180,2750
260  READ V5,Z5
270  DATA 180,2750
280  READ V6,Z6
290  DATA 200,3750
300  READ V7,Z7
310  DATA 200,3750
```

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```
320  READ V8.Z8
330  DATA 250.6750
340  READ V9.Z9
350  DATA 350.12750
360  READ C.J.J1.J2
370  DATA 1.74533E-02.5.5.6076.1
380  READ U
390  DATA 60
400  READ R
410  DATA 1
414  PRINT "J8=0 TO PRINT ALL DATA & PLOT LOOK ANGLES:"
415  PRINT "NON-0 FOR PLOT ONLY (LOOK ANGLES OR PATH)";
416  INPUT J8
420  READ X0,Y0
430  DATA 0.0
500  LET X1=S1
510  LET Y1=0
520  LET X2=S1+S2
530  LET Y2=0
540  LET X3=X2+R
550  LET Y3=SGN(U)*R
560  LET X4=X3
570  LET Y4=Y3+SGN(U)*S3
580  LET X5=X2
590  LET Y5=Y4+SGN(U)*R
600  LET X6=X5-S4
610  LET Y6=Y5
620  LET E=H5-H4
625  GOSUB 5700
630  LET X7=X6-SGN(U)*R1*SIN(E*C)
640  LET Y7=Y6+SGN(U)*R1*(1-COS(E*C))
650  IF ABS(E)>180 THEN 670
660  GOTO 680
670  LET E=360-ABS(E)
680  LET X8=X7-S5*COS(ABS(E)*C)
690  LET Y8=Y7+SGN(U)*S5*SIN(ABS(E)*C)
700  LET X9=X8-S6*COS(ABS(E)*C)
710  LET Y9=Y8+SGN(U)*S6*SIN(ABS(E)*C)
711  IF J7=0 THEN 720
712  IF J8#0 THEN 850
715  CALL (8.1)
717  PRINT "
```

```
720  PRINT "X0="X0:"Y0="Y0:"Z0="Z0:"V0="V0
721  PRINT
722  PRINT "X1="X1;"Y1="Y1:"Z1="Z1;"V1="V1
723  PRINT
724  PRINT "X2="X2:"Y2="Y2:"Z2="Z2:"V2="V2
725  PRINT
726  PRINT "X3="X3;"Y3="Y3:"Z3="Z3:"V3="V3
727  PRINT
728  PRINT "X4="X4:"Y4="Y4:"Z4="Z4:"V4="V4
729  PRINT
730  PRINT "X5="X5:"Y5="Y5:"Z5="Z5:"V5="V5
731  PRINT
732  PRINT "X6="X6:"Y6="Y6:"Z6="Z6:"V6="V6
733  PRINT
734  PRINT "X7="X7;"Y7="Y7:"Z7="Z7;"V7="V7
735  PRINT
736  PRINT "X8="X8:"Y8="Y8:"Z8="Z8:"V8="V8
737  PRINT
738  PRINT "X9="X9:"Y9="Y9:"Z9="Z9:"V9="V9
739  PRINT
745  PRINT "H1="H1:"H3="H3:"H4="H4:"H5="H5
750  PRINT
755  PRINT "S1="S1:"S2="S2:"S3="S3:"S4="S4
760  PRINT
850  LET H=H5
860  LET B=0
862  LET S8=R1*C*ABS(E)
864  LET S9=R*C*90
866  LET S=S1+S2+S9+S3+S9+S4+S8+S5+S6
870  LET L=(X9-X8)/J
880  LET M=(Y9-Y8)/J
890  LET N=(Z9-Z8)/J
900  LET O=(V9-V8)/J
910  LET K=S6/J
920  LET X=X9
930  LET Y=Y9
940  LET Z=Z9
950  LET V=V9
960  LET G=ATN((Z9-Z8)/(S6*J2))/C
962  IF J8#0 THEN 970
965  PRINT "S5="S5;"S6="S6:"S8="S8:"S9="S9
970  GOSUB 6800
1110  GOSUB 4500
1120  IF S>S1+S2+S9+S3+S9+S4+S8+S5+K/2 THEN 970
1130  LET L=(X8-X7)/J
1140  LET M=(Y8-Y7)/J
1150  LET N=(Z8-Z7)/J
1160  LET O=(V8-V7)/J
1170  LET K=S5/J
1172  LET G=ATN((Z8-Z7)/(S5*J2))/C
1180  GOSUB 6800
1330  GOSUB 4500
1340  IF S>S1+S2+S9+S3+S9+S4+S8+K/2 THEN 1180
```

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```
1350  LET E6=ABS(E)
1360  LET W=E6/J1
1362  LET G=0
1364  LET K=S8/J1
1370  LET B5=-SGN(U)*ATN((1.688↑2*V7↑2)/(32.2*R1*J2))/C
1375  GOSUB 6800
1450  GOSUB 4800
1460  GOSUB 6800
1480  LET E6=E6-W
1490  LET H=H-SGN(U)*W
1500  IF H>360 THEN 1520
1510  GOTO 1530
1520  LET H=H-360
1530  IF H<0 THEN 1550
1540  GOTO 1560
1550  LET H=360+H
1560  LET X=X6-R1*SIN(E6*C)
1570  LET Y=Y6+SGN(U)*R1*(1-COS(E6*C))
1580  LET S=S-K
1590  IF S>S1+S2+S9+S3+S9+S4+K/2 THEN 1460
1600  GOSUB 6800
1690  GOSUB 6600
1710  LET L=(X6-X5)/J
1720  LET M=(Y6-Y5)/J
1730  LET N=(Z6-Z5)/J
1740  LET O=(V6-V5)/J
1750  LET K=S4/J
1760  LET G=ATN((Z6-Z5)/(S4*J2))/C
1770  GOSUB 4500
1870  GOSUB 6800
1880  IF S>S1+S2+S9+S3+S9+K/2 THEN 1770
1890  LET E1=0
1900  LET W=90/J1
1905  LET K=S9/J1
2010  LET G=0
2011  LET B5=SGN(U)*ATN((1.688↑2*V↑2)/(32.2*R*J2))/C
2012  GOSUB 6800
2015  GOSUB 4800
2020  GOSUB 6800
2025  LET E1=E1+W
2030  LET H=H+SGN(U)*W
2040  IF H>360 THEN 2060
2050  GOTO 2070
2060  LET H=H-360
2070  IF H<0 THEN 2090
2080  GOTO 2100
2090  LET H=360+H
2100  LET X=X5+R*SIN(E1*C)
2110  LET Y=Y4+SGN(U)*R*COS(E1*C)
2120  LET S=S-K
2130  IF S>S1+S2+S9+S3+K/2 THEN 2020
2140  GOSUB 6800
2250  GOSUB 6600
2260  LET L=(X4-X3)/J
```

```
2270  LET M=(Y4-Y3)/J
2280  LET N=(Z4-Z3)/J
2290  LET Q=(V4-V3)/J
2300  LET K=S3/J
2310  LET G=ATN((Z4-Z3)/(S3*J2))/C
2320  GOSUB 4500
2420  GOSUB 6800
2430  IF S>S1+S2+S9+K/2 THEN 2320
2440  LET E1=90
2450  LET W=E1/J1
2455  LET K=S9/J1
2560  LET G=0
2570  LET B5=SGN(U)*ATN((1.688↑2*V↑2)/(32.2*R*J2))/C
2575  GOSUB 4800
2577  GOSUB 6800
2580  LET E1=E1-W
2590  LET H=H+SGN(U)*W
2600  IF H>360 THEN 2620
2610  GOTO 2630
2620  LET H=H-360
2630  IF H<0 THEN 2650
2640  GOTO 2660
2650  LET H=360+H
2660  LET X=X2+R*SIN(E1*C)
2670  LET Y=Y3-SGN(U)*R*COS(E1*C)
2680  LET S=S-K
2690  IF S>S1+S2+K/2 THEN 2577
2700  GOSUB 6800
2800  GOSUB 6600
2810  LET L=(X2-X1)/J
2820  LET M=(Y2-Y1)/J
2830  LET N=(Z2-Z1)/J
2840  LET O=(V2-V1)/J
2850  LET K=S2/J
2860  LET G=ATN((Z2-Z1)/(S2*J2))/C
2870  GOSUB 4500
2980  GOSUB 6800
2990  IF S>S1+K/2 THEN 2870
3000  LET L=X1/J
3010  LET M=Y1/J
3020  LET N=(Z1-Z0)/J
3030  LET K=S1/J
3035  LET O=(V1-V0)/J
3040  LET G=ATN((Z1-Z0)/(S1*J2))/C
3050  GOSUB 4500
3200  GOSUB 6800
3210  IF S>K/2 THEN 3050
3215  LET G=0
3360  CALL (3,A[1],1,L4)
3365  CALL (3,I[1],1,L5)
3370  PRINT "L4="L4
3375  PRINT "L5="L5
3380  PRINT "M4="M4
3381  PRINT "M5="M5
```

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```
3382  IF J8#0 THEN 3400
3385  PRINT "
```

```
3390  CALL (8,0)
3400  GOTO 9999
4500  LET X=X-L
4510  LET Y=Y-M
4520  LET Z=Z-N
4530  LET V=V-O
4540  LET S=S-K
4550  RETURN
4700  PRINT
4701  PRINT
4705  PRINT "X="X;"Y="Y;"Z="Z
4710  PRINT
4720  PRINT "HEADING="H;"BANK="B;"GS="G;"DTG="S;"V="V
4740  RETURN
4800  LET B=B5/J1
4810  GOSUB 6800
4890  LET B=B+B5/J1
4900  IF ABS(B)<ABS(B5)-ABS(B5)/(2*J1) THEN 4810
4910  RETURN
5000  LET B=-C*B
5001  LET X=X*J2
5002  LET Y=Y*J2
5003  LET H=C*(H-H1)
5004  GOSUB 5500
5006  LET X=X+9000
5008  GOSUB 5030
5009  IF J8#0 THEN 5014
5010  PRINT "TO AZ SITE:";
5012  GOSUB 5210
5014  GOSUB 5300
5016  LET X=X-9000
5020  LET Y=Y-300
5022  GOSUB 5030
5023  IF J8#0 THEN 5027
5024  PRINT "TO EL-1 SITE:";
5025  GOSUB 5210
5027  GOSUB 5400
5028  LET Y=Y+300
5029  GOTO 5180
5030  LET P9=X*COS(P)*COS(H)-Y*COS(P)*SIN(H)+Z*SIN(P)
5040  LET Q9=X*(SIN(B)*SIN(P)*COS(H)-COS(B)*SIN(H))
5050  LET Q9=Q9-Y*(SIN(B)*SIN(P)*SIN(H)+COS(B)*COS(H))
5060  LET Q9=Q9-Z*SIN(B)*COS(P)
5070  LET R9=X*(COS(B)*SIN(P)*COS(H)+SIN(B)*SIN(H))
5080  LET R9=R9-Y*(COS(B)*SIN(P)*SIN(H)-SIN(B)*COS(H))
5090  LET R9=R9-Z*COS(B)*COS(P)
5100  LET A9=ATN(R9/SQR(P9*P9+Q9*Q9))*57.2958
5110  IF P9#0 THEN 5130
5120  LET P9=.1
5122  PRINT "X=.1"
5130  LET B9=ATN(Q9/P9)*57.2958
5140  IF P9>0 THEN 5160
5150  LET B9=SGN(Q9)*180+B9
```

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```
5160 RETURN
5180 LET P=-P/C
5190 LET B=-B/C
5200 LET H=H1+H/C
5202 LET X=X/J2
5203 LET Y=Y/J2
5205 RETURN
5210 PRINT "ALPHA ="A9:"BETA ="B9:"PITCH ="P
5230 RETURN
5300 LET A[N4]=B9
5310 LET A[N4+1]=A9
5320 LET M4=M4+1
5340 LET N4=N4+2
5350 IF N4>32 THEN 5365
5360 RETURN
5365 CALL (3.A[1].1.L4)
5370 LET N4=1
5380 LET L4=L4+1
5385 MAT A=ZER
5390 RETURN
5400 LET I[N5]=B9
5405 LET I[N5+1]=A9
5410 LET M5=M5+1
5415 LET N5=N5+2
5420 IF N5>32 THEN 5430
5425 RETURN
5430 CALL (3.I[1].1.L5)
5435 LET N5=1
5440 LET L5=L5+1
5445 MAT I=ZER
5450 RETURN
5455 LET A[N4]=X
5458 LET A[N4+1]=Y
5460 LET M4=M4+1
5462 LET N4=N4+2
5464 IF N4>32 THEN 5468
5466 RETURN
5468 CALL (3.A[1].1.L4)
5470 LET N4=1
5472 LET L4=L4+1
5474 MAT A=ZER
5476 RETURN
5500 LET P=3-G
5510 LET P=P+42*(SQR(1+TAN(B)^2)-1)
5520 LET P=-C*P
5530 RETURN
5700 LET B=ATN((1.688^2*V7^2)/(32.2*R*J2))/C
5705 IF B>30 THEN 5720
5707 LET R1=1
5710 RETURN
5720 LET R1=(1.688^2*V7^2)/(32.2*J2*TAN(30*C))
5730 RETURN
6000 LET X=X*J2
6002 LET Y=Y*J2
```

```
6005  LET D=SQR(X↑2+(Y-300)↑2+Z↑2)
6010  LET T=8.68589*LOG(66.42*D)
6020  LET F=(ATN((Y-300)/X))/C
6022  IF X>0 THEN 6030
6025  LET F=SGN(U)*(180-ABS(F))
6030  LET F2=SQR(X↑2+(Y-300)↑2)
6040  LET E8=(ATN(Z/F2))/C
6045  IF ABS(F)>ABS(U) THEN 6054
6050  PRINT "INSIDE MLS COVERAGE ZONE"
6052  GOTO 6055
6054  PRINT "OUTSIDE MLS COVERAGE ZONE"
6055  PRINT "FROM EL1 SITE:";
6060  PRINT "AZ="F;"EL="E8;"RANGE="D/6076.1;"LOSS="T
6070  LET D1=SQR((X+9000)↑2+Y↑2+Z↑2)
6080  LET T1=8.68589*LOG(66.42*D1)
6090  LET F1=(ATN(Y/(X+9000)))/C
6092  IF X>-9000 THEN 6100
6095  LET F1=SGN(U)*(180-ABS(F1))
6100  LET F3=SQR((X+9000)↑2+Y↑2)
6110  LET E2=(ATN(Z/F3))/C
6120  PRINT "FROM AZ SITE:";
6130  PRINT "AZ="F1;"EL="E2;"RANGE="D1/6076.1;"LOSS="T1
6140  LET X=X/J2
6150  LET Y=Y/J2
6500  RETURN
6600  LET B=B-B5/J1
6605  GOSUB 6800
6690  IF ABS(B)>ABS(B5)/(2*J1) THEN 6600
6700  RETURN
6800  IF J7#0 THEN 6806
6802  GOSUB 5455
6804  RETURN
6806  IF J8#0 THEN 6810
6808  GOSUB 4700
6810  IF J4#0 THEN 6050
6820  GOSUB 5000
6825  IF J8#0 THEN 6880
6830  GOSUB 6000
6840  GOTO 6880
6850  GOSUB 7000
6855  IF J8#0 THEN 6880
6860  GOSUB 8000
6870  GOSUB 9000
6880  RETURN
7000  LET B=-C*B
7010  LET H=C*(H-H1)
7012  LET X=X*J2
7014  LET Y=Y*J2
7020  GOSUB 5500
7030  LET Y=Y-J5
7040  LET X=X-J6
7050  GOSUB 5630
7055  IF J8#0 THEN 7075
7060  PRINT "TO FPS-16 SITE"
```

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```
7070  GOSUB 5210
7075  GOSUB 5300
7080  LET Y=Y+J5
7090  LET X=X+J6
7110  GOTO 5180
7120  RETURN
8000  LET X=X*J2
8002  LET Y=Y*J2
8005  LET D=SQR((X-J6)↑2+(Y-J5)↑2+Z↑2)
8010  LET T=8.68589*LOG(66.42*D)
8020  LET F=ATN((Y-J5)/(X-J6))/C
8022  IF X>J6 THEN 8030
8025  LET F=SGN(U)*(180-ABS(F))
8030  LET F2=SQR((X-J6)↑2+(Y-J5)↑2)
8040  LET E8=ATN(Z/F2)/C
8060  PRINT "FROM FPS-16 SITE"
8070  PRINT "AZ="F;"EL="E8;"RANGE="D/6076.1;"LOSS="T
8087  LET X=X/J2
8088  LET Y=Y/J2
8090  RETURN
9000  LET X=X*J2
9010  LET Y=Y*J2
9020  LET F3=(ATN((Y-300)/X))/C
9030  IF X>0 THEN 9040
9035  LET F3=SGN(U)*(180-ABS(F3))
9040  IF ABS(F3) <= ABS(U) THEN 9090
9050  PRINT "OUTSIDE MLS COVERAGE ZONE"
9060  LET X=X/J2
9070  LET Y=Y/J2
9080  RETURN
9090  PRINT "INSIDE MLS COVERAGE ZONE"
9100  GOTO 9060
9999  END

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15. Supplementary Notes

16. Abstract

A computer analysis was performed for the TCV B-737 following some specific flight paths to determine the azimuth and elevation look angles to three ground antenna sites at Wallops Flight Center. The results provided the airborne antenna design group with volumetric coverage data required during the performance of Microwave Landing System and Cockpit Display of Traffic Information experiments.

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