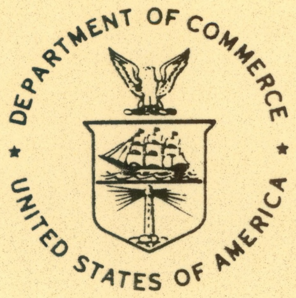
NOAA Western Region Computer Programs and
Problems NWS WRCP - No. 22



RADAR BORESIGHTING VERIFICATION PROGRAM

Salt Lake City, Utah
November 1980

U.S. DEPARTMENT OF COMMERCE / National Oceanic and Atmospheric Administration / National Weather Service

PREFACE

This Western Region publication series is considered as a subset of our Technical Memorandum series. This series will be devoted exclusively to the exchange of information on and documentation of computer programs and related subjects. This series was initiated because it did not seem appropriate to publish computer program papers as Technical Memoranda; yet, we wanted to share this type of information with all Western Region forecasters in a systematic way. Another reason was our concern that in the developing AFOS-era there will be unnecessary and wasteful duplication of effort in writing computer programs in National Weather Service (NWS). Documentation and exchange of ideas and programs envisioned in this series hopefully will reduce such duplication. We also believe that by publishing the programming work of our forecasters, we will stimulate others to use these programs or develop their own programs to take advantage of the computing capabilities AFOS makes available.

We solicit computer-oriented papers and computer programs from forecasters for us to publish in this series. Simple and short programs should not be prejudged as unsuitable.

The great potential of the AFOS-era is strongly related to local computer facilities permitting meteorologists to practice in a more scientific environment. It is our hope that this new series will help in developing this potential into reality.

NOAA Western Region Computer Programs and Problems NWS WRCP

1 Standard Format for Computer Series. June 1979
2 AFOS Crop and Soil Information Report Program. Ken Mielke, July 1979.
3 Decoder for Significant Level Transmissions of Raobs. John A. Jannuzzi, August 1979.
4 Precipitable Water Estimate. Elizabeth Morse, October 1979.
5 Utah Recreational Temperature Program. Kenneth M. Labas, November 1979.
6 Normal Maximum/Minimum Temperature Program for Montana. Kenneth Mielke, Dec. 1979.
7 Plotting of Ocean Wave Energy Spectral Data. John R. Zimmerman, Dec. 1979.
8 Raob Plot and Analysis Routines. John Jannuzzi, January 1980.
9 The SWAB Program. Morris S. Webb, Jr., April 1980. (PB 80-196041)
10 Flash-Flood Procedure. Donald P. Laurine and Ralph C. Hatch, April 1980. (PB 80-198658
11 Program to Forecast Probability of Summer Stratus in Seattle Using the Durst Objective Method. John Zimmerman, May 1980.
12 Probability of Sequences of Wet and Dry Days. Hazen H. Bedke, June 1980.
13 Automated Montana Hourly Weather Roundup. Joe L. Johnston, July 1980. (PB81102576)
14 Lightning Activity Levels. Mark A. Mollner, July 1980. (PB81108300)
15 Two Fortran Applications of Wind-Driven Ekman Water Trnasport Theory: Upwelling Index and Storm Tide. Kent S. Short, July 1980. (PB81102568)
16 AFOS System Local Database Save and Rebuild Procedures or A Master Doomsday Program. Brian W. Finke, July 1980. (PB81108342)
17 AFOS/RDOS Translator Subroutine. Morris S. Webb, Jr., August 1980. (PB81108334)
18 AFOS Graphics Creation from Fortran. Alexander E. MacDonald
19 DATAKEYØ Repair Program. Paul D. Tolleson, August 1980. (PB81102543)
20 Contiguous File Transfer from the DPCM to the DCM. Paul D. Tolleson, September 19
21 Freezing Level Program. Kenneth B. Mielke, September 1980.

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RADAR BORESIGHTING VERIFICATION PROGRAM

Thomas E. Adler

Data Acquisition Division
National Weather Service Western Region Headquarters
Salt Lake City, Utah
November 1980

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DEPARTMENT OF COMMERCE
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NATIONAL OCEANIC AND
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RADAR BORESIGHTING VERIFICATION PROGRAM

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I. General Information

A. Summary:

This program calculates true solar altitude and azimuth for a given Julian day and time (GMT). Calculated angles are compared with those observed using solar boresighting methods described in Federal Meteorological Handbook (FMH) No. 7. A document is produced which lists both observed and calculated solar angular data and differences between the two, the Julian day and time (GMT) of each observation, and the average error between observed and calculated data. If corrective action is needed to bring the radar set within allowable tolerances, a message is so indicated on the computer-produced document.

B. Environment:

The program is written in Data General Extended BASIC and is designed to run on the standard Eclipse S-230 minicomputer of AFOS using the Dasher as an input/output terminal. The program, including BASIC, needs 17K of memory to be executed; therefore, it can run in the background partition of any WSFO and selected WSOs while AFOS is running in the foreground partition. Stations (WSOs) without sufficient memory to run the program in background will have to "take AFOS down" and run the program in foreground. If the program is run in less than 10 minutes, data will not be lost to the WSO as the parent AFOS at the WSFO will buffer their data for approximately 10 minutes.

C. References:

Formulas used to calculate solar elevation and azimuth angles are listed in FMH No. 7, "Radar Observations". Software is described in Data General Corporation's Extended BASIC Users Manual No. 093-000065-06.

II. Application

A. Program Description:

Variables:

A	Latitude of Station
B (1 to 20)	Number of Observations
C (1 to 20)	Julian Day of Observation
D (1 to 20)	Angular Fraction of Year
E (1 to 20)	Radar Observed Azimuth Angle
F (1 to 20)	Radar Observed Elevation Angle
G (1 to 3)	Program Counter
H	Solar Hour Angle

H2	Solar Hour Angle (h) + .01 minutes
I (1 to 40)	Program Counter
J (1 to 20)	Program Counter
K (1 to 20)	Time (GMT) of Radar Angular Observation
L	Longitude of Station
M	True Solar Noon
R	Program Counter
S	Solar Declination
T (1 to 20)	Decimal Equivalent of K
T (21 to 40)	T (1 to 20) + .01 minutes
V	Program Counter
W (1 to 20)	Calculated Solar Azimuth Angle
W (21 to 40)	Calculated Solar Azimuth Angle at H2
W (41)	Average of W (1) to W (20)
X (1 to 20)	Calculated Solar Elevation Angle
X (21 to 40)	Calculated Solar Elevation Angle at H2
X (41)	Average of X (1) to X (20)
Y (1 to 20)	SIN W (1 to 40)
Z	Partial Equation used to determine Solar Declination

String Variables:

B$	Date (Current Date)
J$	Station Name

Constants:

P	$\pi/180$
Q	SIN 23°26'28" = Angle of Inclination of the Earth's Axis

Functions and Algorithms:

The program begins by asking for input of the date (B$). The current date is entered using a slash (/) to separate month from day and day from year (7/28/80).

The program asks for input of station (J$). The station is entered by giving station name (WSFO LOS ANGELES CA, WSO LAS VEGAS NV, etc.). CAUTION: Do not use commas or periods when entering station.

The program asks for input of latitude (A). Latitude of the radar is entered in degrees and minutes with a decimal point separating degrees from minutes. Program flags latitudes greater than 90 degrees and asks for entry of (A) again.

The program asks for input of longitude (L) which is entered in degrees and minutes. A decimal point is used to separate degrees from minutes. Longitudes greater than 140 degrees or less than 100 degrees are flagged and entry of (L) is again requested.

The program asks for the number of observations to be entered (B). Maximum number of observation that can be entered is 20. (B) is used as an end counter in a program loop to input values of Julian day (C), time (GMT) (K), azimuth angle (E), and elevation angle (F) observed during solar boresighting.

The program flags times greater than 2400, azimuth angles less than 60 or greater than 300 degrees, and elevation angles greater than 90 degrees. When flags are invoked, this causes a counter (G), set to zero before each line of input, to be incremented by one. If, at the end of input checks, G is greater than 0, the program requests that the last line of input be reentered. Loop is ended when I = B.

The program enters a loop where the question, "Are corrections needed to input data?" is asked. If question is answered "yes", a line of input data can be reentered. After a line of input is reentered, program asks, "Any more corrections?". A "yes" answer will allow another line of input data to be corrected. Loop continues until a "no" answer is received.

The program converts time (K) to decimal equivalent with Loop I = 1 to B.

$$T(I) = k(I)/100$$

$$T(I) = INT(T(I)) + \frac{100(T(L)) - INT(T(I))}{60}$$

The program establishes an observation time .01 minutes greater than the actual time of observation.

$$T(I+20) = T(I) + .01$$

Program converts latitude (A) and longitude (L) to decimal equivalent.

$$A = INT(A) + \frac{100(A - INT(A))}{60}$$

$$L = INT(L) + \frac{100(L - INT(L))}{60}$$

The program converts Julian date (C) to angular fraction of year (D).

The program enters a loop where True Solar Noon, Solar Declination, Solar Hour Angle, Solar Elevation Angle, and Solar Azimuth Angles are calculated for each observation time and each observation time plus .01 minutes. The calculations for observation time plus .01 minutes are needed to determine in what azimuth quadrant--0 to 90, 90 to 180, 180 to 270, or 270 to 360--the sun is located.

True Solar Noon (M)

$$M = 12 + .1236SIN(D) - .0043COS(D) + .1538\ SIN\ 2D + .068\ COS\ 2D$$

Solar Declination (S)

SIN(S) = (SIN 23°26'38")SIN Z

Z is defined by the relationship

$$Z = 279.935 + D + 1.9148 \text{ SIN } D - .0795 \text{ COS } D + .0199 \text{ SIN } 2D - .0016 \text{ COS } 2D$$

Solar Hour Angle (H)

$$H = 15(T-M) - L$$

Solar Elevation Angle (X)

$$\text{SIN}(X) = \text{SIN}(A)\ \text{SIN}(S) + \text{COS}(A)\ \text{COS}(S)\ \text{COS}(H)$$

Solar Azimuth Angle (W)

$$\text{SIN}(W) = \frac{-\text{COS}(S)\ \text{SIN}(H)}{\text{COS}(X)}$$

The program enters a loop where the following variables are averaged: observed elevation angle (E), observed azimuth angle (F), calculated elevation angle (X), and calculated azimuth angle (W). The program then determines the difference between average observed angles and average calculated angles.

The program produces, in duplicate, a document that shows all observed and calculated data and averages. If corrective action is needed, it is so noted within the document.

B. Machine Requirements:

Data General Extended BASIC and this program "RADAR.TA" requires 17K of memory to run. Both "BASIC" and "RADAR.TA" reside in 135 blocks of a floppy disk.

III. Procedures

A. Input:

After both "BASIC" and this program have been loaded, the program is started using the command "RUN". The Date, Station, Latitude, Longitude, and number of observations are input when requested by the program. After the above entries, the variables C, K, E, and F are entered in that order, on a single line for each observation. Each variable is separated from the next by a comma. When all input is correctly entered, a document is output to the Dasher. (See Figure 1.)

B. Initiation of Program:

Place the floppy disk containing both BASIC and this program into DP(X). Using the Dasher as the input/output terminal, proceed as follows:

1) DIR DP(X):BASIC

2) BASIC

3) LOAD "RADAR.TA"

4) RUN

The program procedure guides the operator through the use of the program. All data manipulation is handled by the program.

After the program has been run, proceed as follows to sign off. Note: Program can be interrupted during execution by depressing the escape key on the Dasher.

5) KILL (To get out of BASIC)

6) RELEASE DP(X)

C. Output:

Figure 2 shows the program output to the Dasher which is generated in duplicate.

FIGURE 1

```
DIR DP1:BASIC
R
BASIC
BASIC  REVISION 4.10  08/31/76

ACCOUNTING?
DIRECTORY SPECIFIER: DP1
     10/20/80 00:10 SIGN ON, SC

*LOAD "RADAR.TA"
*RUN
DATE? 10/20/80
STATION? WSO SACRAMENTO CA
LATITUDE? 38.35
LONGITUDE? 121.30
NO. OF OBS. ? 11
 ? 189,1506,108.1,9.1
 ? 289,1535,113.6,14.3
 ? 289,1648,127.6,26.2
 ? 289,1706,131.3,28.8
 ? 289,1740,139.8,33.4
 ? 289,1806,146.4,36.8
 ? 290,1452,106.7,5.9
 ? 290,1532,113.1,13.2
 ? 290,1608,119.9,18.9
 ? 290,1655,129.9,27.1
 ? 290,1709.,132.0,28.8
ARE CORRECTIONS NEEDED TO INPUT?
YES = 1    NO = 0 1
WHAT DATA LINE? 1
RETYPE DATA LINE                 1
 ? 289,1506,108.1,9.1
 ANY MORE CORRECTIONS?
 YES = 1    NO = 0 1
WHAT DATA LINE? 11
RETYPE DATA LINE                 11
 ? 290,1709,132.0,28.8
 ANY MORE CORRECTIONS?
 YES = 1    NO = 0 0
```

FIGURE 2

SOLAR RADAR ORIENTATION CHECK

DATE: 10/20/80

STATION: WSO SACRAMENTO CA

LATITUDE: 38.5833 LONGITUDE: 121.5

JULIAN DAY	TIME GMT	SOLAR AZIMUTH ANGLES RADAR INDICATED	CALCULATED	ERROR	SOLAR ELEVATION ANGLES RADAR INDICATED	CALCULATED	ERROR
289	1506	108.1	108.5	0.4	9.1	8.9	-0.2
289	1535	113.6	113.5	-0.1	14.3	14.2	-0.1
289	1648	127.6	127.6	0.0	26.2	26.5	0.3
289	1706	131.3	131.6	0.3	28.8	29.2	0.4
289	1740	139.8	139.8	0.0	33.4	33.9	0.5
289	1806	146.4	146.8	0.4	36.8	35.9	0.1
290	1452	106.7	106.5	-0.2	5.9	6.1	0.2
290	1532	113.1	113.2	0.1	13.2	13.5	0.3
290	1608	119.9	119.8	-0.1	18.9	19.8	0.9
290	1655	129.9	129.4	-0.5	27.1	27.3	0.2
290	1709	132.0	132.6	0.6	28.8	29.4	0.6
AVERAGES:		124.4	124.5	0.1	22.0	22.3	0.3

D. Program Listing Follows:

```
*LIST
0010 REM FILE NAME IS RADAR.TA
0020 DIM B[20]
0030 DIM C[20]
0040 DIM K[20]
0050 DIM E[21]
0060 DIM F[21]
0070 DIM J[20]
0080 DIM I[40]
0090 DIM T[40]
0100 DIM D[20]
0110 DIM X[41]
0120 DIM Y[40]
0130 DIM W[41]
0140 DIM J$[25]
0150 DIM B$[17]
0160 INPUT "DATE? ",B$
0170 INPUT "STATION? ",J$
0180 INPUT "LATITUDE? ",A
0190 IF A>90 THEN GOTO 0210
0200 GOTO 0230
0210 PRINT "YOU HAVE ENTERED AN INCORRECT LATITUDE. ",A
0220 GOTO 0180
0230 INPUT "LONGITUDE? ",L
0240 IF L>140 THEN GOTO 0270
0250 IF L<100 THEN GOTO 0270
0260 GOTO 0290
0270 PRINT "YOU HAVE ENTERED AN INCORRECT LONGITUDE  ",L
0280 GOTO 0230
0290 INPUT "NO. OF OBS. ? ",B
0300 FOR I=1 TO B
0310   LET G=0
0320   INPUT C[I],K[I],E[I],F[I]
0330   IF K[I]>2400 THEN GOTO 0350
0340   GOTO 0370
0350   PRINT "YOU HAVE ENTERED AN INCORRECT TIME. ",K[I]
0360   LET G=1
0370   IF E[I]<60 THEN GOTO 0400
0380   IF E[I]>300 THEN GOTO 0400
0390   GOTO 0430
0400   PRINT "CHECK THE LAST AZIMUTH ANGLE. ",E[I]
0410   INPUT "DO YOU WANT TO CORRECT THE DATA?   YES = 1   NO = 0",R
0420   LET G=G+R
0430   IF F[I]>90 THEN GOTO 0450
0440   GOTO 0470
0450   PRINT "YOU HAVE ENTERED AN INCORRECT ELEVATION ANGLE ",F[I]
0460   LET G=1
0470   IF G=0 THEN GOTO 0500
0480   PRINT "REENTER THE LAST LINE OF INPUT."
0490   GOTO 0310
0500 NEXT I
```

```
0510 PRINT "ARE CORRECTIONS NEEDED TO INPUT? "
0520 INPUT "YES = 1     NO = 0 ",V
0530 IF V=0 THEN GOTO 0600
0540 INPUT "WHAT DATA LINE? ",J
0550 PRINT "RETYPE DATA LINE ",J
0560 INPUT C[J],K[J],E[J],F[J]
0570 PRINT " ANY MORE CORRECTIONS? "
0580 INPUT " YES = 1     NO = 0 ",V
0590 IF V=1 THEN GOTO 0540
0600 LET P=SYS(15)/180
0610 REM CONVERT TIME TO DECMILE EQUIVALENT
0620 FOR I=1 TO B
0630   LET T[I]=K[I]/100
0640   LET T[I]=INT(T[I])+(T[I]-INT(T[I]))*100/60
0650   LET T[I+20]=T[I]+.01
0660 NEXT I
0670 REM TO CONVERT LAT AND LON TO DEC EQU
0680 LET A=INT(A)+(((A-INT(A))*100)/60)
0690 LET L=INT(L)+(((L-INT(L))*100)/60)
0700 REM TO CONVERT JULIAN DATE TO ANGULAR FRACTION OF YEAR
0710 FOR I=1 TO B
0720   LET D[I]=(C[I]-1)*360/365.242
0730 NEXT I
0740 FOR I=1 TO B
0750   LET M=12+(.1236*SIN(D[I]*P))-(.0043*COS(D[I]*P))
0760   LET M=M+(.1538*SIN(2*D[I]*P))+(.0608*COS(2*D[I]*P))
0770   LET Z=279.935+D[I]+(1.9148*SIN(D[I]*P))
0780   LET Z=Z-(.0795*COS(D[I]*P))+(.0199*SIN(2*D[I]*P))
0790   LET Z=Z-(.0016*COS(2*D[I]*P))
0800   LET Q=.397851
0810   LET S=Q*SIN(Z*P)
0820   LET S=S/SQR(1-(S*S))
0830   LET S=ATN(S)
0840   LET S=S*1/P
0850   REM SOLVE FOR SOLAR HOUR ANGLE
0860   LET H=(15*(T[I]-M))-L
0870   LET H2=(15*(T[I+20]-M))-L
0880   REM TO COMPUTE SOLAR EL ANGLE
0890   LET X[I]=(SIN(A*P)*SIN(S*P))
0900   LET X[I+20]=(SIN(A*P)*SIN(S*P))
0910   LET X[I]=X[I]+(COS(A*P)*COS(S*P)*COS(H*P))
0920   LET X[I+20]=X[I+20]+(COS(A*P)*COS(S*P)*COS(H2*P))
0930   LET X[I]=X[I]/SQR(1-(X[I]*X[I]))
0940   LET X[I+20]=X[I+20]/SQR(1-(X[I+20]*X[I+20]))
0950   LET X[I]=ATN(X[I])
0960   LET X[I+20]=ATN(X[I+20])
0970   LET X[I]=X[I]*1/P
0980   LET X[I+20]=X[I+20]*1/P
0990   REM TO COMPUTE SOLAR AZ ANGLE
1000   LET Y[I]=-(COS(S*P)*SIN(H*P))/COS(X[I]*P)
1010   IF Y[I]=1 THEN GOTO 1240
1020   IF Y[I]=-1 THEN GOTO 1260
1030   IF Y[I]=0 THEN GOTO 1280
1040   LET Y[I+20]=-(COS(S*P)*SIN(H2*P))/COS(X[I+20]*P)
1050   IF Y[I+20]=1 THEN GOTO 1240
1060   IF Y[I+20]=-1 THEN GOTO 1260
1070   IF Y[I+20]=0 THEN GOTO 1280
1080   LET W[I]=Y[I]/SQR(1-(Y[I]*Y[I]))
```

```
1090   LET W[I+20]=Y[I+20]/SQR(1-(Y[I+20]*Y[I+20]))
1100   LET W[I]=ATN(W[I])
1110   LET W[I+20]=ATN(W[I+20])
1120   LET W[I]=W[I]*1/P
1130   LET W[I+20]=W[I+20]*1/P
1140   IF Y[I]<=0 THEN GOTO 1190
1150   IF W[I]-W[I+20]>0 THEN GOTO 1170
1160   GOTO 1290
1170   LET W[I]=180-W[I]
1180   GOTO 1290
1190   IF W[I]-W[I+20]<0 THEN GOTO 1220
1200   LET W[I]=180-W[I]
1210   GOTO 1290
1220   LET W[I]=360+W[I]
1230   GOTO 1290
1240   LET W[I]=90
1250   GOTO 1290
1260   LET W[I]=270
1270   GOTO 1290
1280   LET W[I]=180
1290 NEXT I
1300 FOR I=1 TO B
1310   LET E[21]=E[21]+E[I]
1320   LET F[21]=F[21]+F[I]
1330   LET W[41]=W[41]+W[I]
1340   LET X[41]=X[41]+X[I]
1350 NEXT I
1360 LET E[21]=E[21]/B
1370 LET F[21]=F[21]/B
1380 LET W[41]=W[41]/B
1390 LET X[41]=X[41]/B
1400 FOR I=1 TO 5
1410   PRINT
1420 NEXT I
1430 FOR G=1 TO 2
1440   PAGE =80
1450   PRINT "----------------------------------------";
1460   PRINT "----------------------------------------"
1470   FOR I=1 TO 5
1480     PRINT
1490   NEXT I
1500   PRINT  TAB(29);"SOLAR RADAR ORIENTATION CHECK"
1510   PRINT
1520   PRINT
1530   PRINT
1540   PRINT "DATE: ",B$
1550   PRINT
1560   PRINT "STATION: ",J$
1570   PRINT
1580   PRINT "LATITUDE: ",A,"LONGITUDE: ",L
1590   PRINT
1600   PRINT "----------------------------------------";
1610   PRINT "----------------------------------------"
1620   PRINT
1630   PRINT  TAB(18);"SOLAR AZIMUTH ANGLES";
1640   PRINT  TAB(49);"SOLAR ELEVATION ANGLES"
1650   PRINT  TAB(14);"------------------------------";
1660   PRINT  TAB(46);"------------------------------"
1670   PRINT "JULIAN  TIME     RADAR";
```

```
1680   PRINT  TAB(48);"RADAR"
1690   PRINT  TAB(1);"DAY      GMT  INDICATED";
1700   PRINT  TAB(24);" CALCULATED  ERROR";
1710   PRINT  TAB(46);"INDICATED  CALCULATED  ERROR"
1720   PRINT "----------------------------------------";
1730   PRINT "----------------------------------------"
1740   PRINT
1750   FOR I=1 TO B
1760     PRINT USING "#####",C[I];
1770     PRINT USING "   ####",K[I];
1780     PRINT USING "    ###.#",E[I];
1790     PRINT USING "        ###.#",W[I];
1800     PRINT USING "   --#.#    ",W[I]-E[I];
1810     PRINT USING "   ##.#    ",F[I];
1820     PRINT USING "    ##.#    ",X[I];
1830     PRINT USING "--#.#",X[I]-F[I]
1840   NEXT I
1850   FOR I=1 TO 4
1860     PRINT
1870   NEXT I
1880   PRINT  TAB(4);"AVERAGES:";
1890   PRINT USING "   ###.#  ",E[21];
1900   PRINT USING "      ###.#  ",W[41];
1910   PRINT USING " --#.#  ",W[41]-E[21];
1920   PRINT USING "      ##.#    ",F[21];
1930   PRINT USING "     ##.#  ",X[41];
1940   PRINT USING "  --#.#",X[41]-F[21]
1950   LET R=0
1960   LET V=0
1970   IF W[41]-E[21]>=.55 THEN GOTO 2000
1980   IF W[41]-E[21]<=-.55 THEN GOTO 2000
1990   GOTO 2030
2000   PRINT
2010   PRINT "AZIMUTH ANGLES ARE IN ERROR BY MORE THAN ONE-HALF DEGREE."
2020   LET V=1
2030   IF X[41]-F[21]>=.55 THEN GOTO 2060
2040   IF X[41]-F[21]<=-.55 THEN GOTO 2060
2050   GOTO 2090
2060   PRINT
2070   PRINT "ELEVATION ANGLES ARE IN ERROR BY MORE THAN ONE-HALF DEGREE."
2080   LET R=1
2090   LET V=V+R
2100   IF V=0 THEN GOTO 2240
2110   PRINT
2120   PRINT "THE RADAR ORIENTATION IS NOT WITHIN THE SPECIFIED TOLERANCES."
2130   PRINT "CORRECTIVE ACTION IS REQUIRED AND A NEW BORESIGHT OBSERVATION"
2140   PRINT "SHOULD BE SUBMITTED WITHIN 30 DAYS."
2150   IF V=2 THEN GOTO 2200
2160   FOR I=1 TO (31-B)
2170     PRINT
2180   NEXT I
2190   GOTO 2270
2200   FOR I=1 TO (29-B)
2210     PRINT
2220   NEXT I
2230   GOTO 2270
2240   FOR I=1 TO (37-B)
2250     PRINT
2260   NEXT I
2270 NEXT G
2280 END
```

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