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FAA WJH Technical Center
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FAA TECHNICAL CENTER LETTER REPORT

PROGRAMS TO COMPUTE THE FIGURES

OF MERIT FOR THE GLOBAL POSITIONING SYSTEM (GPS)

by

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AVAILABLE IN
ELECTRONIC FORMAT

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ABSTRACT

The programs were written to compute, on a Hewlett Packard minicomputer, the dilution of precision parameters for the Global Positioning System (GPS) and to plot these data versus Greenwich Mean Time (GMT). The programs evaluate the influence of satellite geometry upon these parameters and subsequently upon the accuracy of the GPS. The flowcharts of the programs, a printout of the transfer files, program listings and examples of the program output are included in this report.

This work was accomplished when the author, Erhard Buchberger, was on an exchange program at the FAA Technical Center from the West German Aerospace Establishment. For further information contact Robert Esposito, phone number (609) 641-8200, extension 3961.

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Key Words

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Dilution of Precision
Almanac
Flow Charts

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INTRODUCTION

BACKGROUND

The FAA Technical Center has made use of a GPS almanac program originally written at the Texas A&M University for execution on a Texas Instrument 990/4 minicomputer (Reference 1). This program computes satellite azimuth and elevation, satellite rise and fall time and the geometric dilution of precision. M. Magrogan (Reference 2) modified these routines to analyze FAA test results on a Digital Equipment Corporation PDP-11/34 minicomputer.

SCOPE

This report documents further modifications and additions which permit the GPS almanac program to run on a Hewlett Packard (HP) 1000 minicomputer with the main task of computing the dilution of precision factors for the case of four space-vehicles, and of three satellites plus altitude input.

DISCUSSION

The major changes made by the Technical Center include:
- An almanac unpacking subroutine developed by N. Watts for the HP.
- Revision of the computation of the GPS epoch time.
- A matrix inversion subroutine which detects singularities.
- Computation of the dilution of precision factors for three satellites plus altitude data.
- Use of double precision in all computations.

In addition, all main programs allow several different types of input data to be used. In doing so, the programs ask for the data with an explaining comment. The main programs also include Block Data, that is, parts in which the Common Blocks are initially defined. This was not necessary with the PDP-11.

Table 1 displays the time parameters which are needed in some of the programs as input parameters. Special attention must be given to the fact that different units (day and second) and different origins are used.

The order of Keplerian parameters, which are included in the almanac and used to compute the satellite trajectories, is listed in table 2. Note that parameters 9 through 14 are computed in the program HDOO, with μ (used to calculate the mean motion) as the earth's universal gravitational constant. The algorithms and equations used in this program are given in references 5 through 9.

Three coordinate systems (reference 3) based on WGS-72 reference ellipsoid are utilized.

1. An earth-centered-earth-fixed (ECEF) system.
2. The east-north-up (ENU) system.
3. Geographic latitude, longitude and altitude.

Appendix A contains the transfer files for the main programs HDOO, PLGH, EBGD1, and EBGH. Appendix B gives the flowcharts for these programs plus the subroutines HDO1 and EB05. Appendix C provides listings of these programs and all subroutines. Each program is called on the HP computer with its name, and user prompting explicity asks for the required inputs. Appendix D and E respectively give examples of the data files and program output.

Program: HDOO (Pages C-1 through C-8)

This program computes and prints out the position of up to 4 satellites in ECEF coordinates and in azimuth and elevation angle related to the user position and HDOP and GDOP. It also generates a plot file with the figures of merit.

The following input data must be prepared: User position in geographical coordinates (latitude (LAT), longitude, (LON), and altitude (ALT) in feet). If the location is the FAA Technical Center, this information is already stored in the program. After the program has received user position, the geographical coordinates are converted into ECEF and printed out. The next data requested are the user times. The routine needs the start (TSTART) and stop time (TFIN) of the time interval to be evaluated, the time increment (TDEL) - (i.e., the difference between the points in time, for which the calculations are made), the time of collection (TC) of the almanac, and the date of use (DTU)-(see also table 1).

Then, the choice must be made whether the computations should be made with 4 satellites or 3 satellites plus altitude information. When 3 satellites are selected, the fourth satellite is simulated in the center of the earth.

The next decision concerns the input of the almanac for the satellites:

(1) If the almanac is on a magnetic tape, it must be stated so and then the entire almanac file is read from the tape. After this is successfully completed, the input is requested of the PRN No. of the first space vehicle. The program checks whether the satellite data is on tape. If not, the request is repeated, otherwise, the next satellite is requested.

(2) The second choice is to provide the program with the names of data files containing an almanac for each space vehicle, or the data can be typed in over the keyboard.

After the steps are successfully completed, the routine computes the rest of the almanac parameters, and prints all inputs out together with a title. The calculation and the output of the results take place after a prompting of a user selected name (less than 6 characters) of a plot file for the GDOP.

Program: PLHG (Pages C-9 through C-11)

This program is a continuation of HDOO. It was created because the plot software needs approximately 38,000 words of memory space since both routines together exceed the memory limits of the computer.

PLHG plots two data files generated by HDOO to compare HDOPs computed with three and with four satellites. After the input of the first file name, the user declares the logical unit of the plotting device and the ID of the device subroutine to initialize the plotter. Examples for this would be:

a)	LU = 20	ID = 5	Device: Printer
b)	LU = 1	ID = 1	Device: Monitor

Data is needed to enable the routine to draw a grid, select a time slot out of the complete files, and start and stop time. To ensure that data is available in the files for this period, because the records are formatted, the file can be looked up directly. Finally, the name of the second file must be entered, and the program then generates a plot as described under program HDOO.

Program: EBGD1 (Pages C-12 through C-14)

This program also delivers as final results HDOP and GDOP, but it does not utilize the satellite almanac as input data. The operator selects whether the H-matrix is inserted directly or whether the azimuth and elevation angles of the satellites are inputed. This routine then calculates the figures of merit, and also prints out the intermediate steps of the matrix conversions. The program can be used to evaluate the influence of special space vehicle geometries on the HDOP and GDOP.

Program: EBGH (Pages C-15 through C-19)

The routine also computes the figures of merit from user and satellite positions. It is possible to input the needed data over the keyboard; that is, to type the user position in geographical coordinates, the number of satellites to be used (three or four), and the satellite position in ECEF coordinates. Also, the operator may read the data from a file by providing the file name. Depending on the number of space vehicles stored in the file (NSAT), the program will print out an error message (NSAT <3), will ask whether the system is altimeter aided (NSAT = 3) or will just start computing (NSAT = 4). Due to restrictions in the subroutines, the system in this stage has to be altimeter aided, i.e., a fourth satellite is simulated in the earth center.

The H-matrix is computed in a different way from the other programs; the rotation of the marix into the ENU system is a separate step. This was made to check whether the programs deliver the same results. The program EBGH delivers a printout similar to EBGD1. It prints all matrices, the figures of merit, and the satellite positions.

Subroutine Description

EBO2: computes the rotation matrix, given on page C-20.
EBO3: converts user geographical coordinates into the ECEF system, given on page C-21.
EBO5: calls EBO6 and EBO7 and computes satellite azimuth and elevation,given on page C-22.
EBO6: computes satellite position in ECEF, given on page C-23.
EBO7: computes user to satellite distance, given on page C-24.
EBO9: multiplies two matrices, given on page C-25.
EB12: converts seconds into hours, minutes and seconds, given on page C-26.
EB14: unpacks the almanac data (with assembly language subroutine DINTF), given on pages C-27 through C-29.
MINVD: inverts the matrices from the "Scientific Subroutine" package from DEC (Reference 4) given on pages C-32 through C-34.
DINTF. assembly language subroutine, unpacks the almanac data (with subroutine EB12), given on page C-35.
ENU: computes rotation matrix, given on page C-36.
HTRAN: converts H-matrix into its transpose, given on page C-37.
MLHHT: multiples the transpose of H-matrix by H-matrix, given on page C-38.
INVHP: inverts the matrices, but does not check for singularities, given on pages C-39 and C-40.

The previosuly tested subroutines ENU, HTRAN, MLHHT, and INVHP (from references 1 and 2) were used in one program to check the computations made by the other subroutines for a non-singluar matrix.

REFERENCES

1. A GPS Almanac, Wong, C.S., Texas A&M University.

2. Global Positioning System (GPS) Satellite Elevation and Azimuth Angles, Michael Magrogan, Letter Report, FAA, 1982.

3. Computer Program Development Specification for the Z-User-Set, Specification No. GP-US-305.

4. The Scientific Subroutine Package, Digital Equipment Corporation.

5. Handbook of Astronautical Engineering, Koelle, H.H., McGraw Hill, 1961.

6. Principle of Operation of NAVSTAR and System Characteristics, Milliken, R.J. and Zoller, C.J., Navigation, Vol. 25, pages 95-106, 1980.

7. Taschenbuch der Mathematik, Bronstein, I, and Semedjajew, K., Tuebner Verlagsgesellschaft Leipzig, 1960.

8. Using the Global Position Satellite System for Positioning and Navigation, Rhyne, T., Noe, P., and Painter, J., Altair Corporation.

9. Satellite Navigation, Klostermann, E., Lecture at the Carl-Cranz-Kurs, 1981.

Parameter	Start of Count	Unit
DTU - Date of use	Beginning of Year	Day
DTC - Date of collection of Almanac	Beginning of Year	Day
T - GPS - Time	Beginning of Day	Second
TC - Collection Time of Almanac	Beginning of week (0000 hours Sunday)	Second

The used time zone is Greenwich Mean Time (GMT)

TABLE 1. TIME PARAMETERS USED IN PROGRAMS

No. in Almanac	Keplerian Parameter	Name in Program and (GPS) - Name)
1	Eccentricity of ellipsoid	E (e)
2	Reference time for almanac	TOA (toa)
3	Orbit inclination	Di (i)
4	Drift rate of right ascension	OMD ($\dot{\Omega}$)
5	Square root of semi-major axis	RA ($\sqrt{A}$)
6	Right ascension of the orbit	OMO (Ω_0)
7	Argument of perigee	W (ω)
8	Mean anomaly	MO (Mo)
9	Semi-major axis	A
10	Cosine of orbit inclination angle	cos(i)
11	Sine of orbit inclination angle	sin(i)
12	Cosine of argument of perigee	cos(ω)
13	Sine of argument of perigee	sin(ω)
14	Mean motion	$\sqrt{\mu/A^3}$

TABLE 2. ORDER OF KEPLERIAN PARAMETERS

Transfer Files - These files are used to load programs which consist of several subroutines.

```
TEBGH   T=00004 IS ON CR00011 USING 00002 BLKS R=0000

0001    REL, %EBGH
0002    SEA, %ENU
0003    SEA, %EB12
0004    SEA, %EB03
0005    SEA, %HTRAN
0006    SEA, %NLHHT
0007    SEA, %INVHP
```

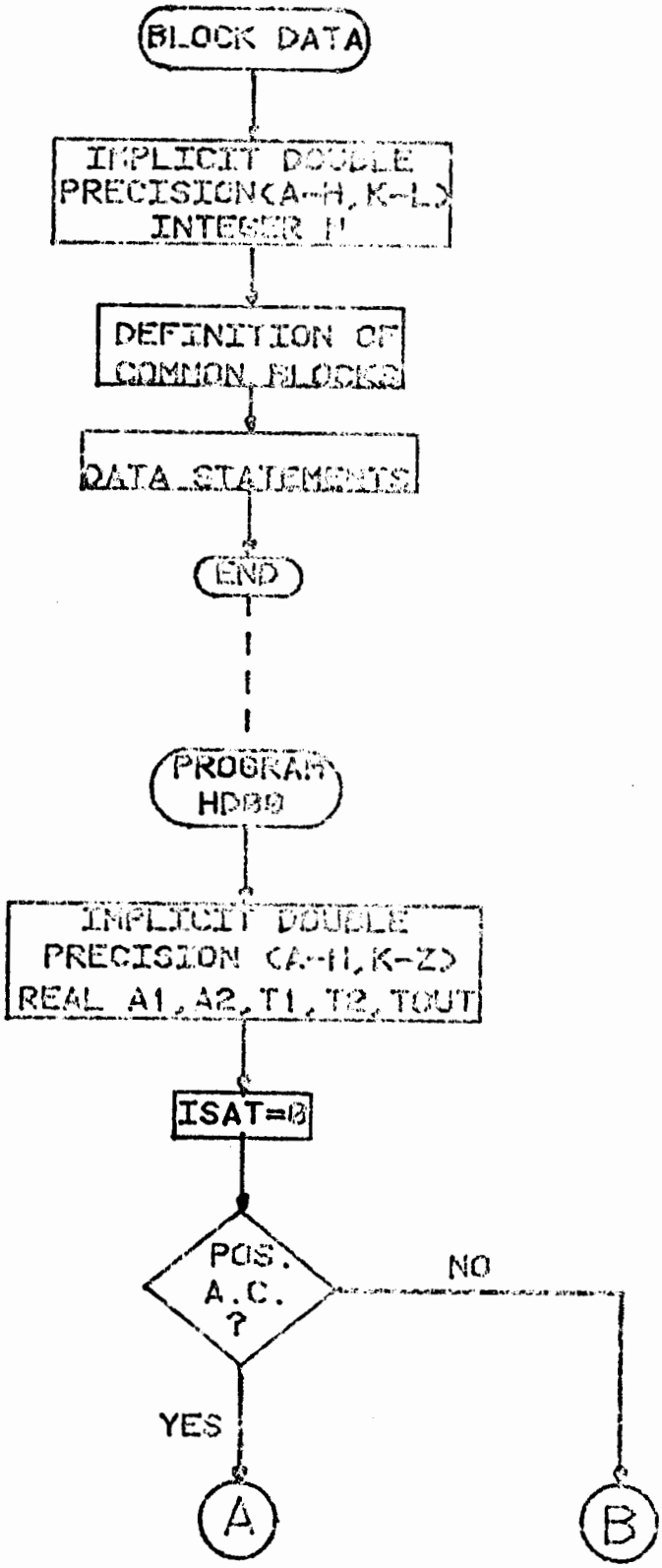
```
TEBGD1  T=00004 IS ON CR00002 USING 00002 BLKS R=0000

0001    REL, %EBGD1
0002    SEA, %EB09
0003    SEA, %MINVD
```

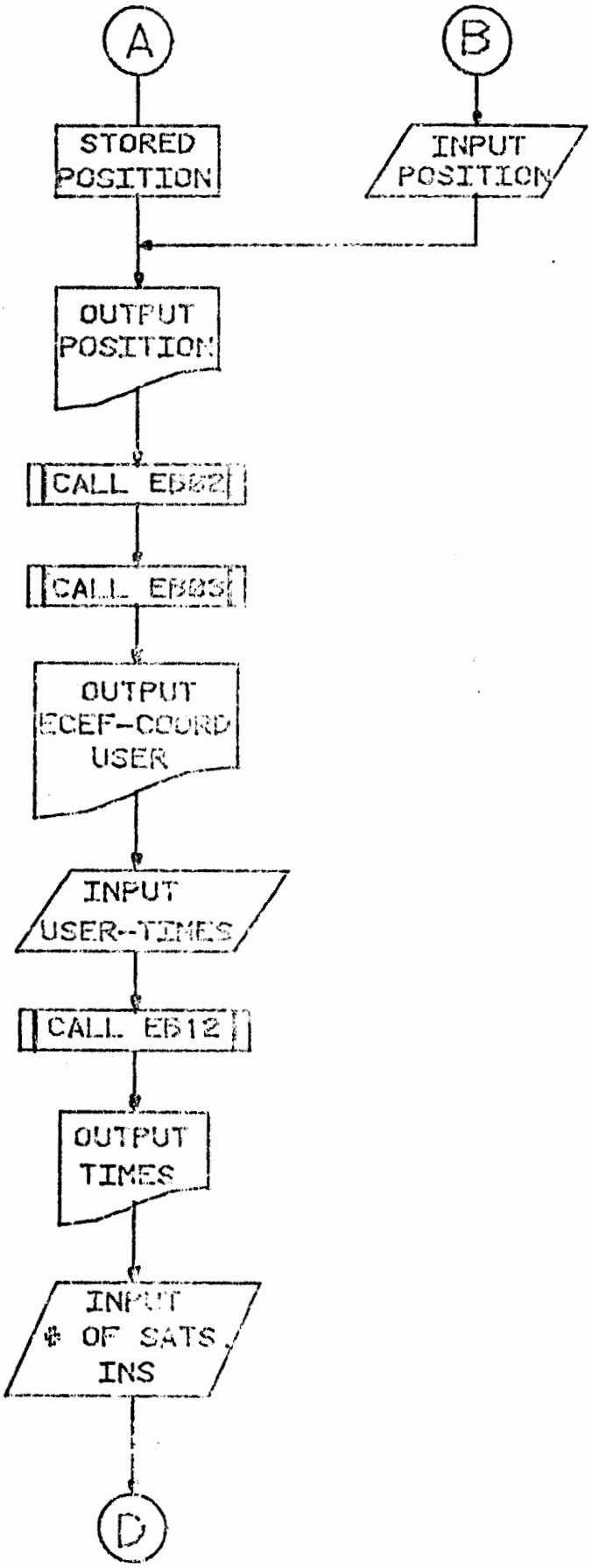
```
TPLHG   T=00004 IS ON CR00002 USING 00002 BLKS R=0000

0001   RE, %PLHG
0002   RE, %DLTBL
0003   SEA, %GPS
```

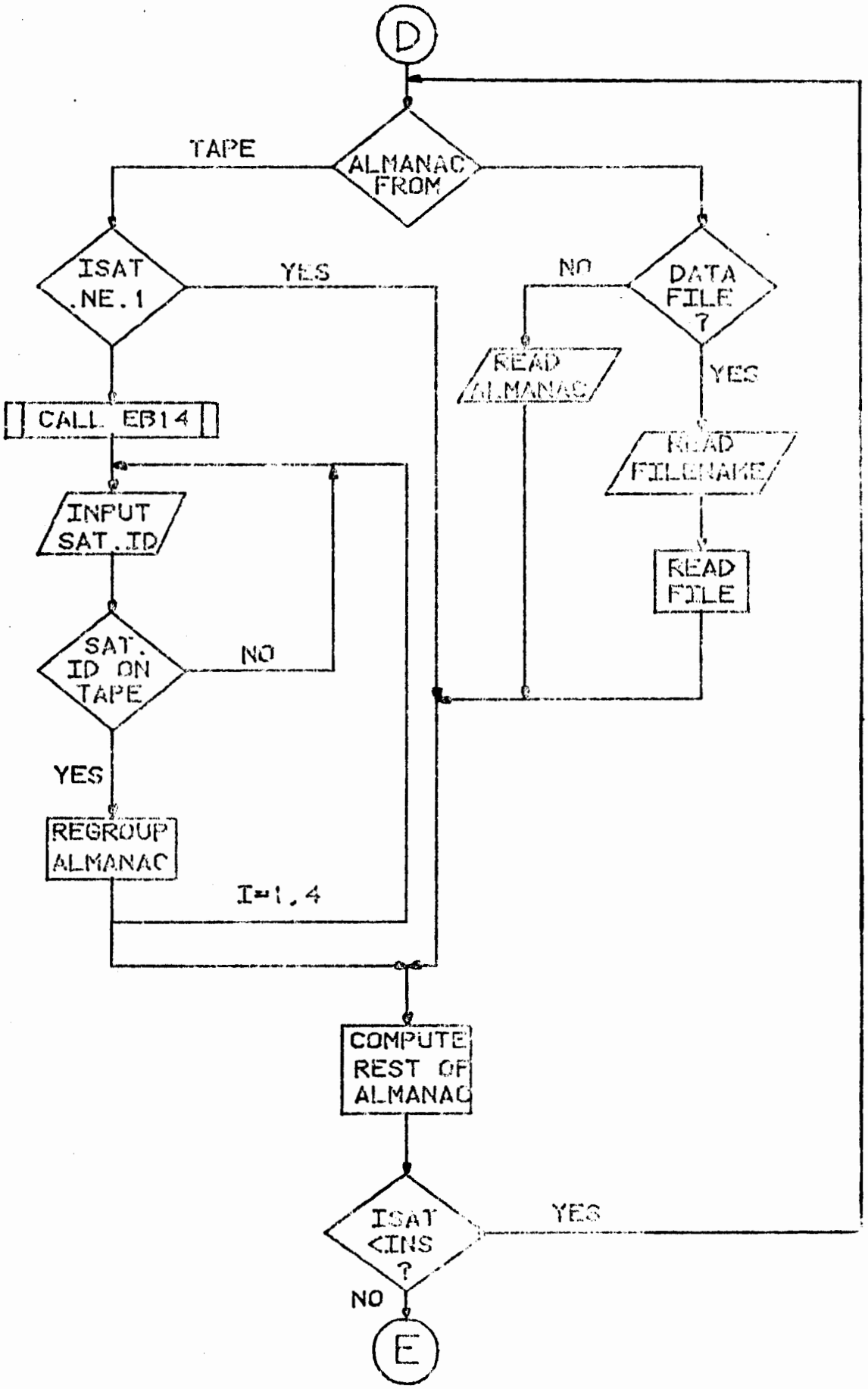
```
THD00   T=00004 IS ON CR00002 USING 00002 BLKS R=0000

0001    REA, %HD00
0002    SEA, %EB02
0003    SEA, %EB03
0004    SEA, %EB05
0005    SEA, %EB06
0006    SEA, %EB07
0007    SEA, %HD01
0008    SEA, %EB09
0009    SEA, %MINVD
0010    SEA, %EB12
0011    SEA, %EB14
0012    SEA, %DINTF
```

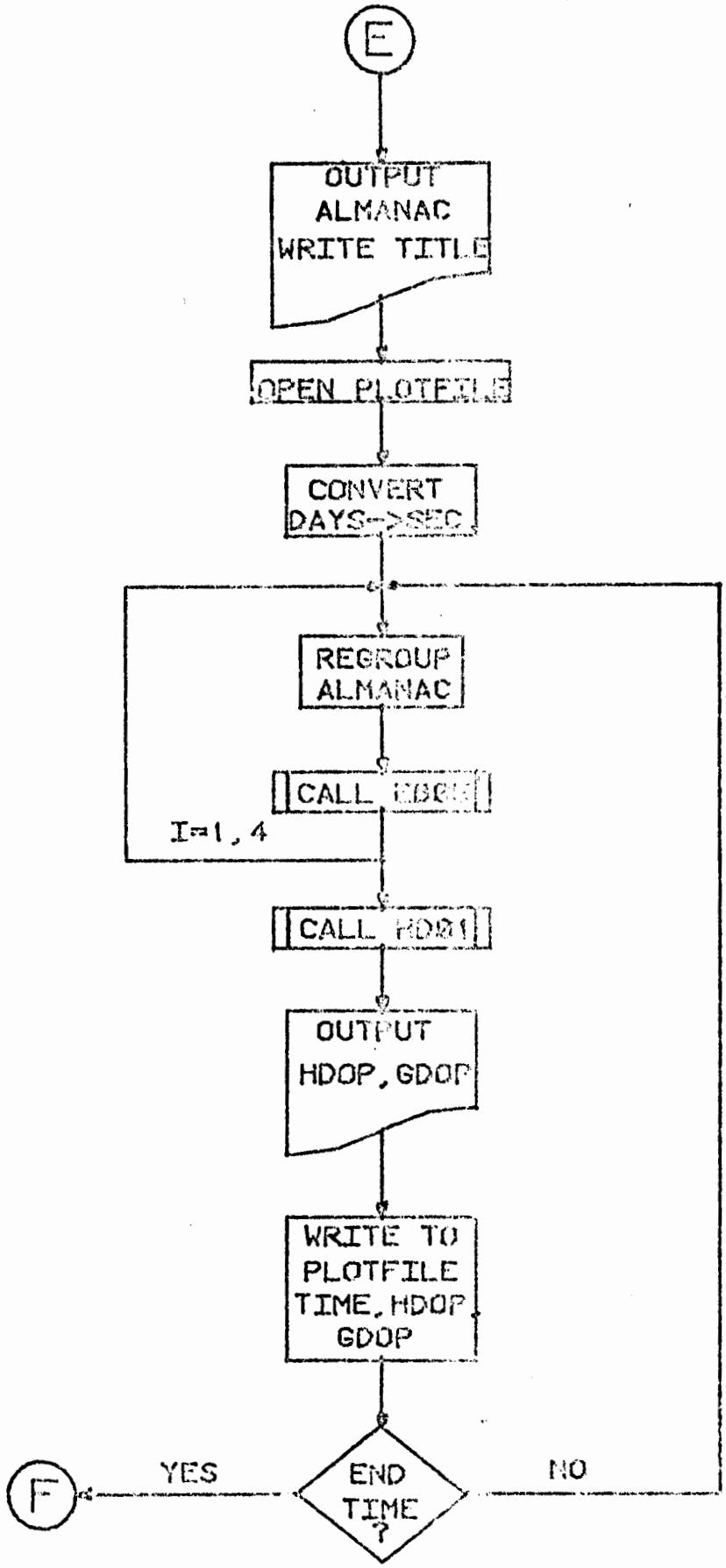
Flowcharts - These flowcharts were drawn on a Tektronix - minicomputer with a drafting software developed by a group of the Eglin AFB. Only new or significantly modified routines are included here.

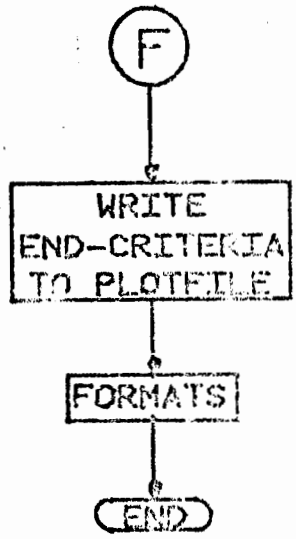
FLOWCHART HD00




A
B
STORED POSITION
INPUT POSITION
OUTPUT POSITION
CALL EB02
CALL EB03
OUTPUT ECEF-COORD USER
INPUT USER--TIMES
CALL EB12
OUTPUT TIMES
INPUT # OF SATS INS
D


D
ALMANAC FROM
TAPE
ISAT .NE. 1
YES
CALL EB14
INPUT SAT.ID
SAT. ID ON TAPE
NO
YES
REGROUP ALMANAC
I=1,4
NO
DATA FILE ?
READ ALMANAC
YES
READ FILENAME
READ FILE
COMPUTE REST OF ALMANAC
ISAT <INS ?
YES
NO
E


E
OUTPUT
ALMANAC
WRITE TITLE
OPEN PLOTFILE
CONVERT
DAYS->SEC
REGROUP
ALMANAC
CALL GDOP
I=1,4
CALL HDOP
OUTPUT
HDOP, GDOP
WRITE TO
PLOTFILE
TIME, HDOP,
GDOP
END
TIME
?
YES
NO
F



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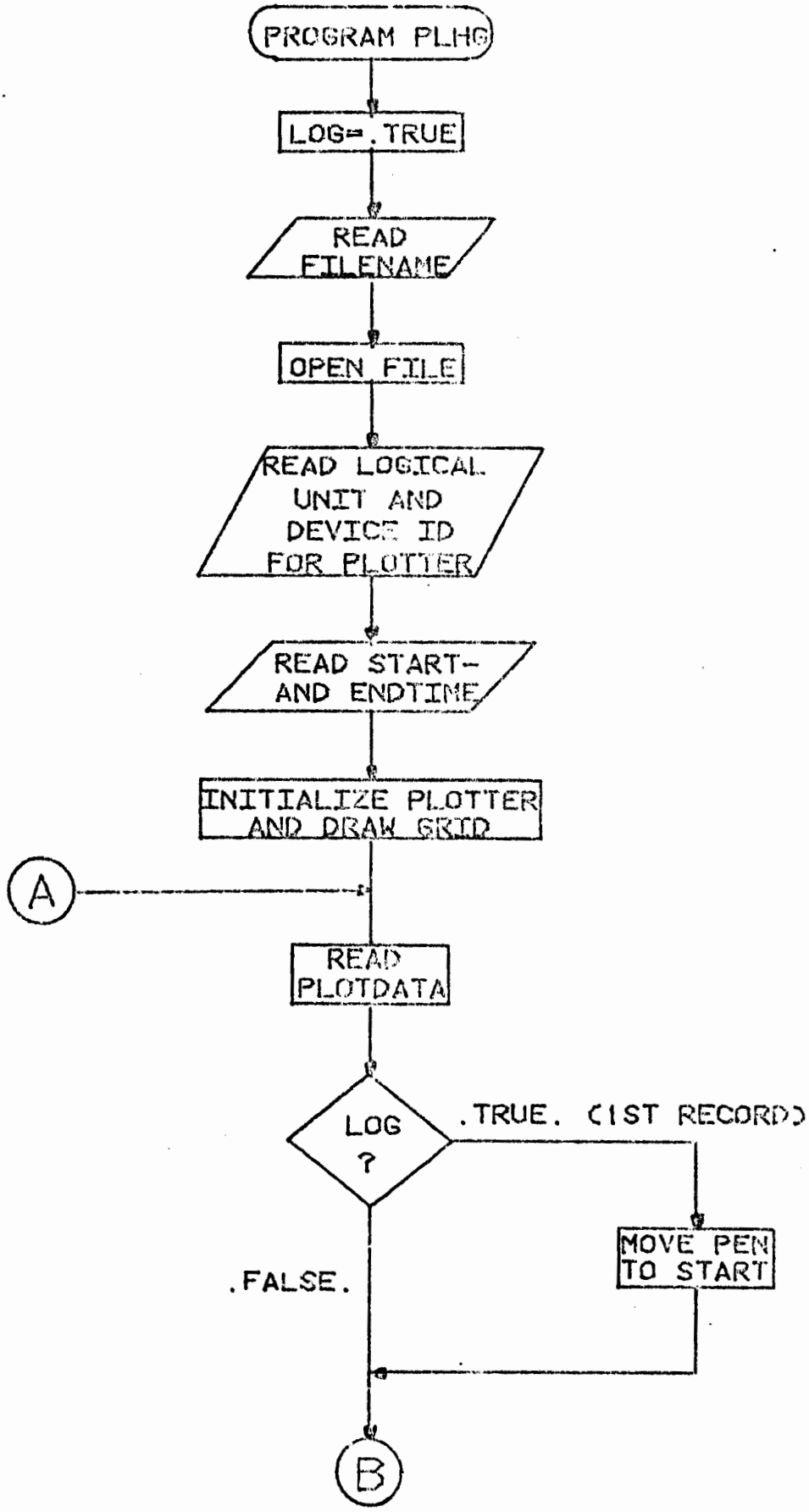
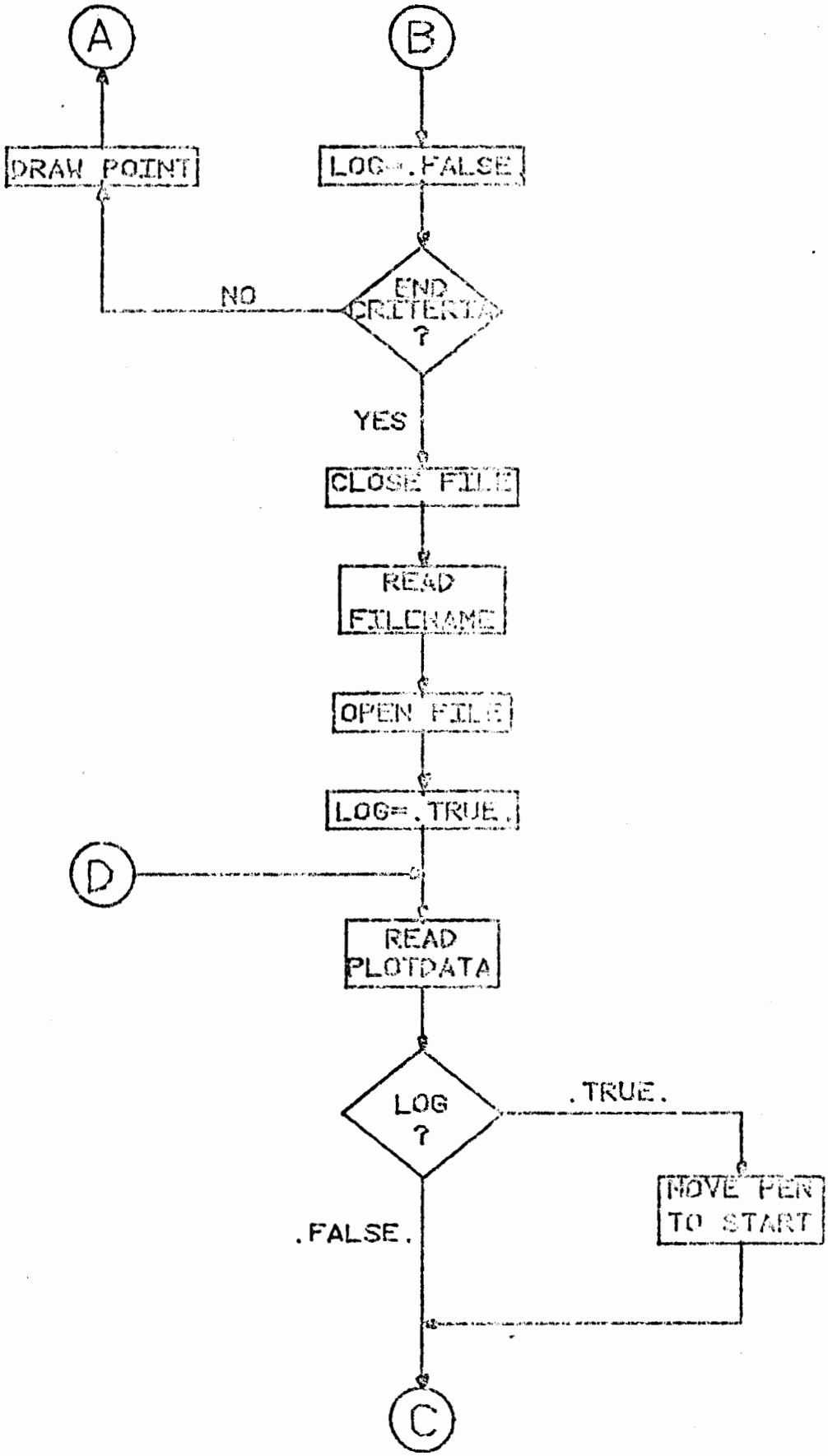
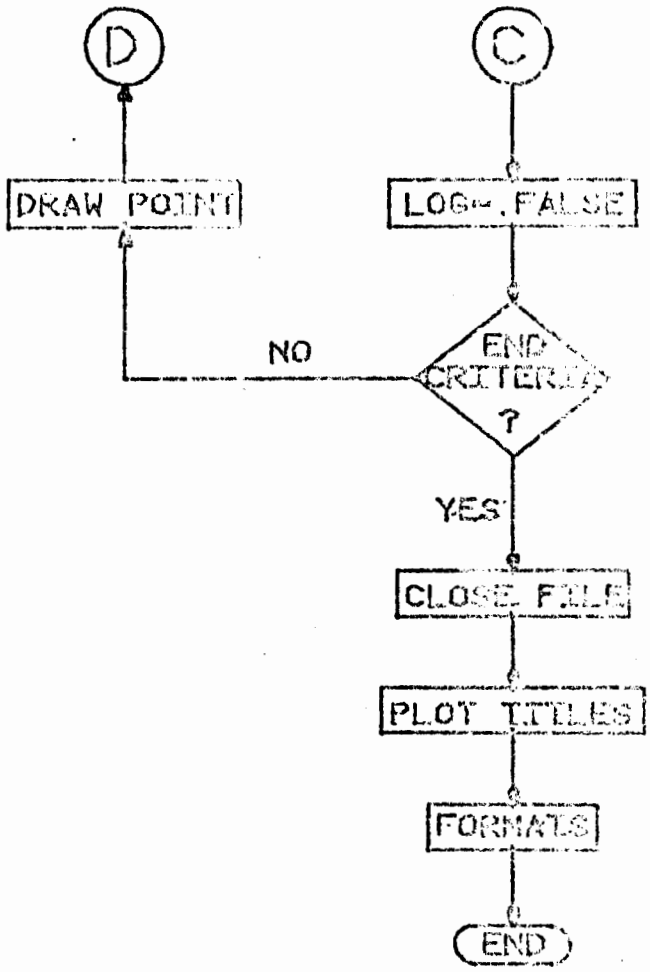
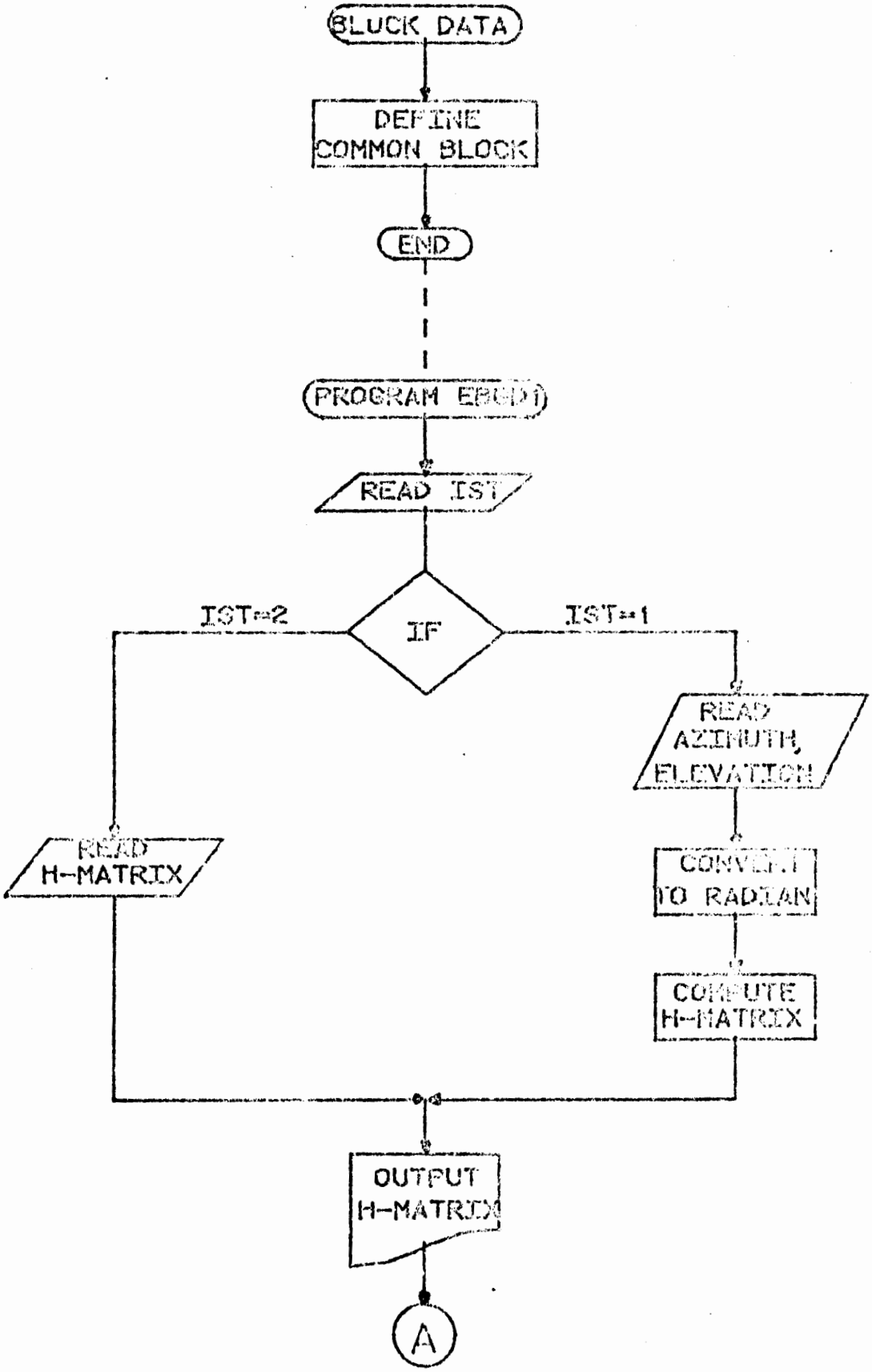
FLOWCHART PLHG

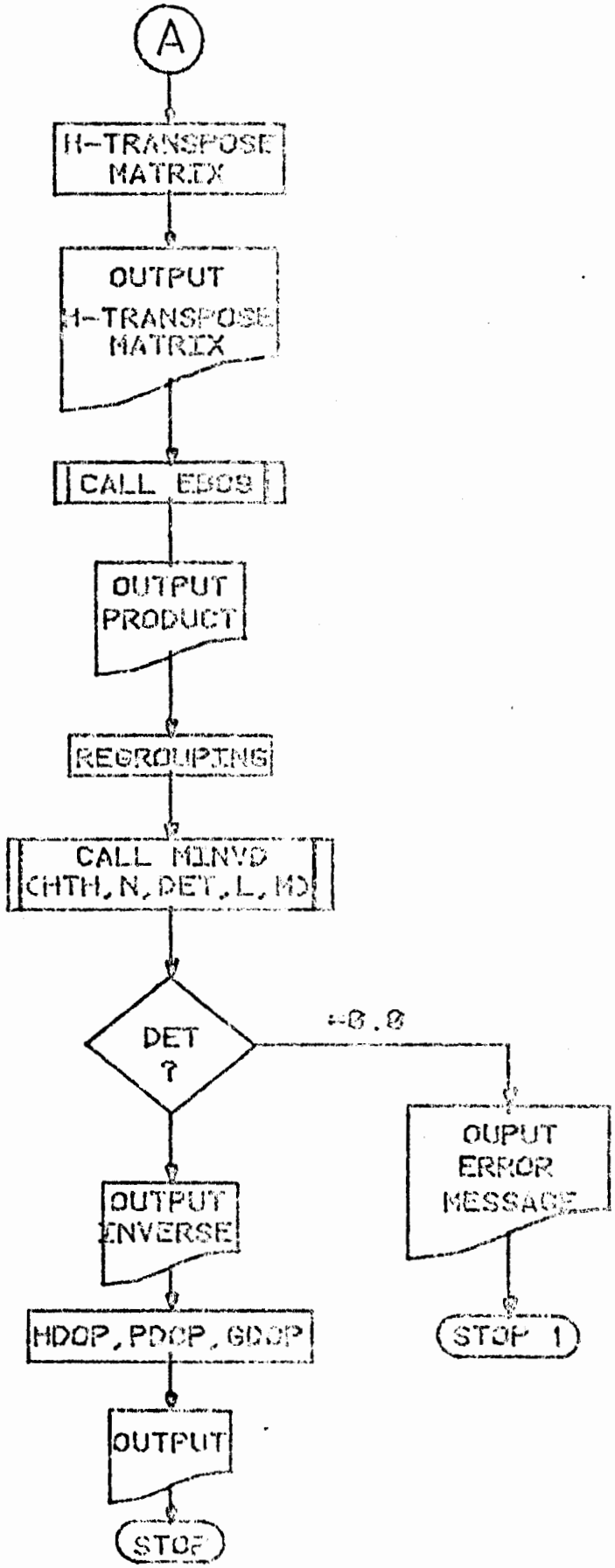



A
B
DRAW POINT
LOG=.FALSE.
NO
END CRITERIA ?
YES
CLOSE FILE
READ FILENAME
OPEN FILE
LOG=.TRUE.
D
READ PLOTDATA
LOG ?
.TRUE.
MOVE PEN TO START
.FALSE.
C

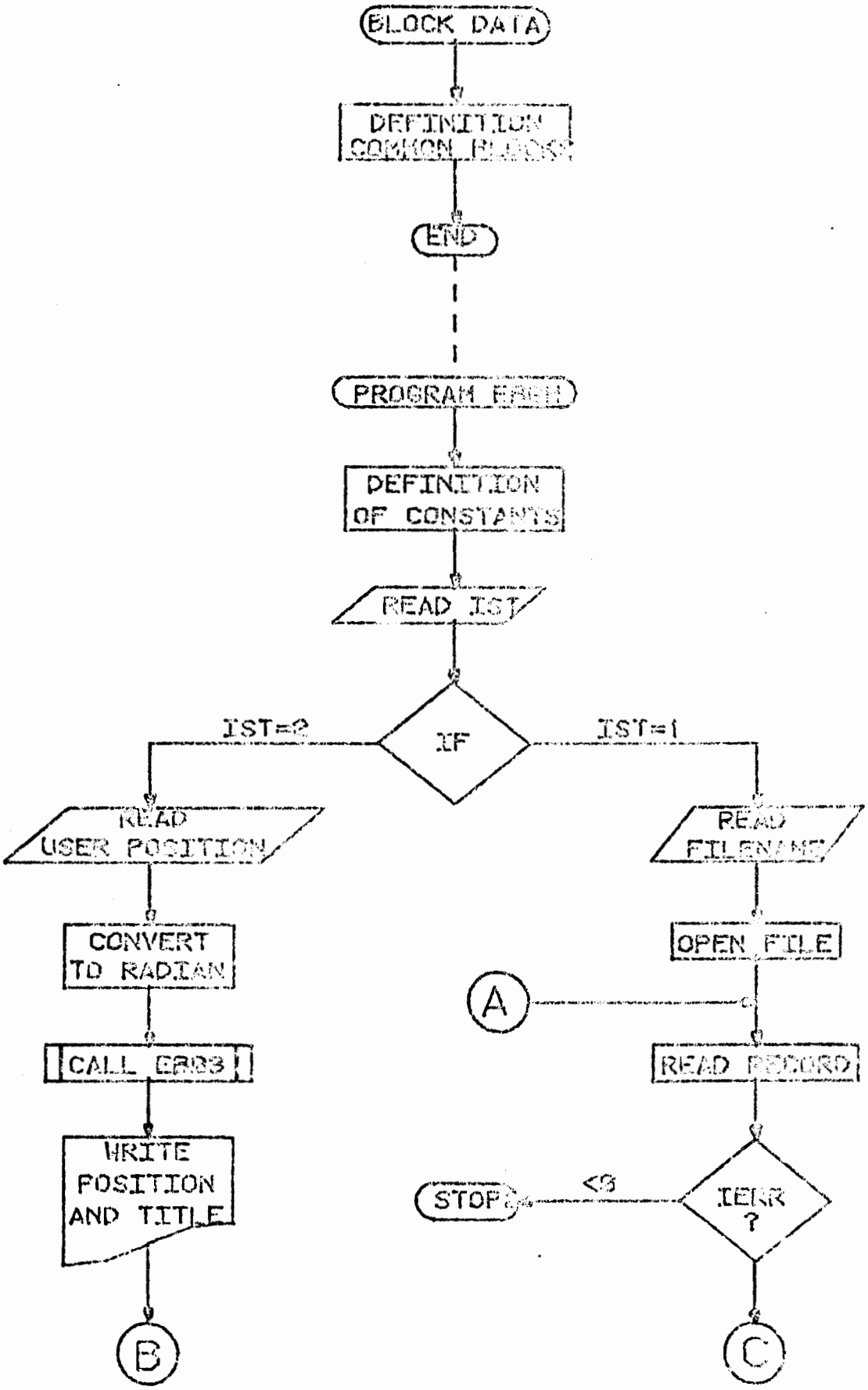

D
C
DRAW POINT
LOGI.FALSE
NO
END CRITERIA ?
YES
CLOSE FILE
PLOT TITLES
FORMATS
END

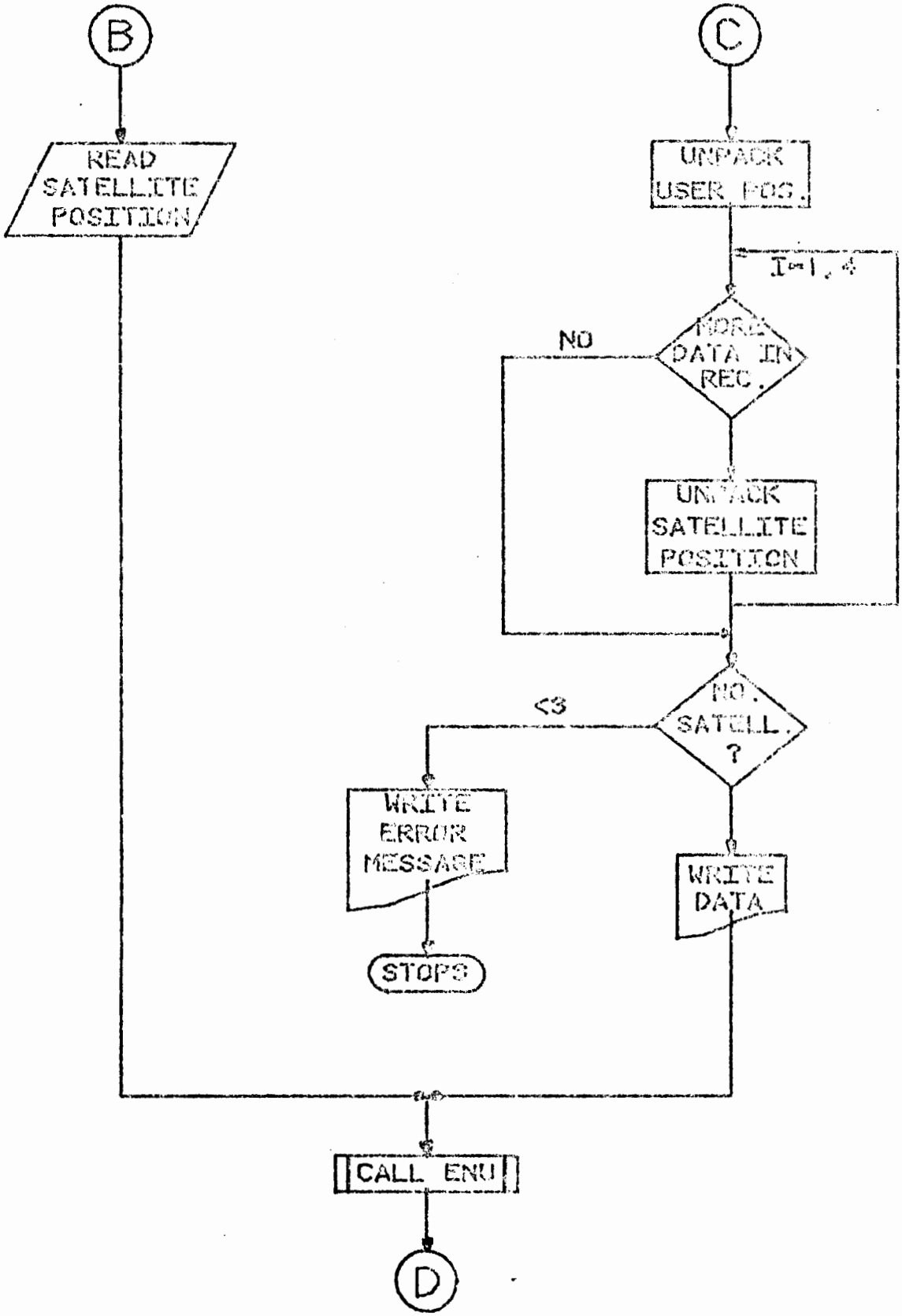
FLOWCHART EBGD1

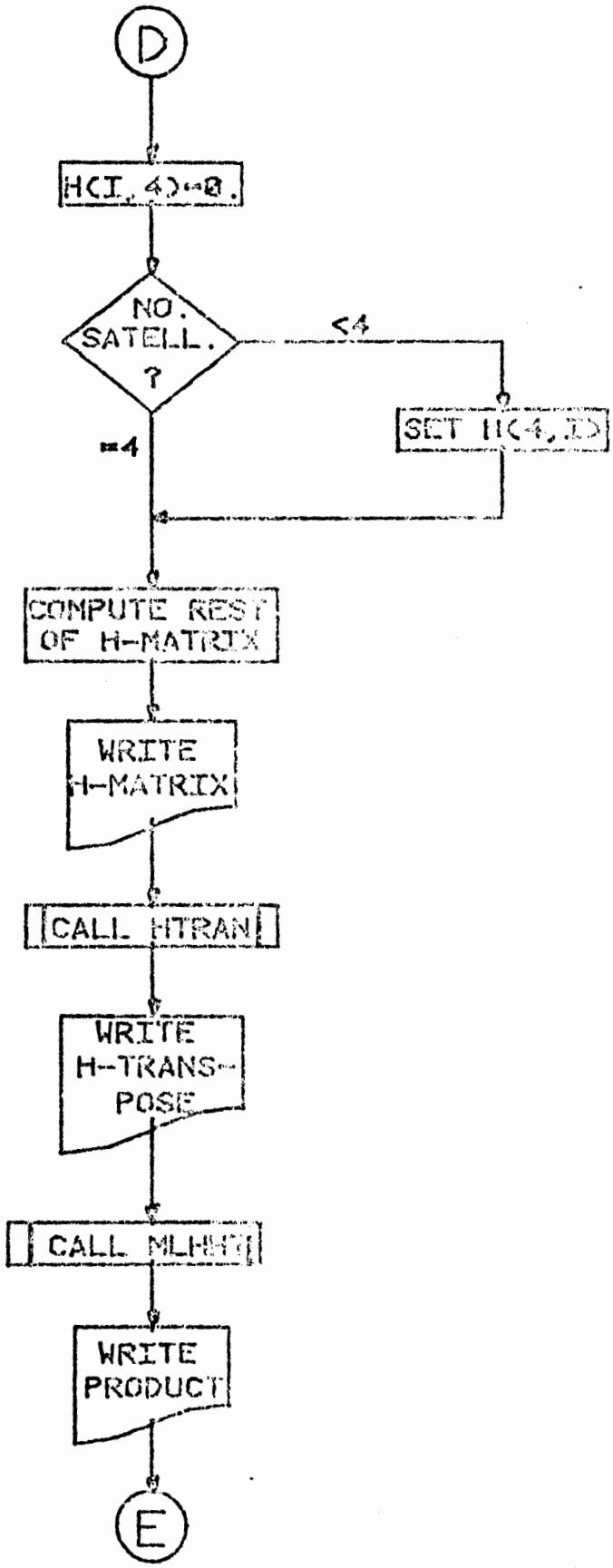


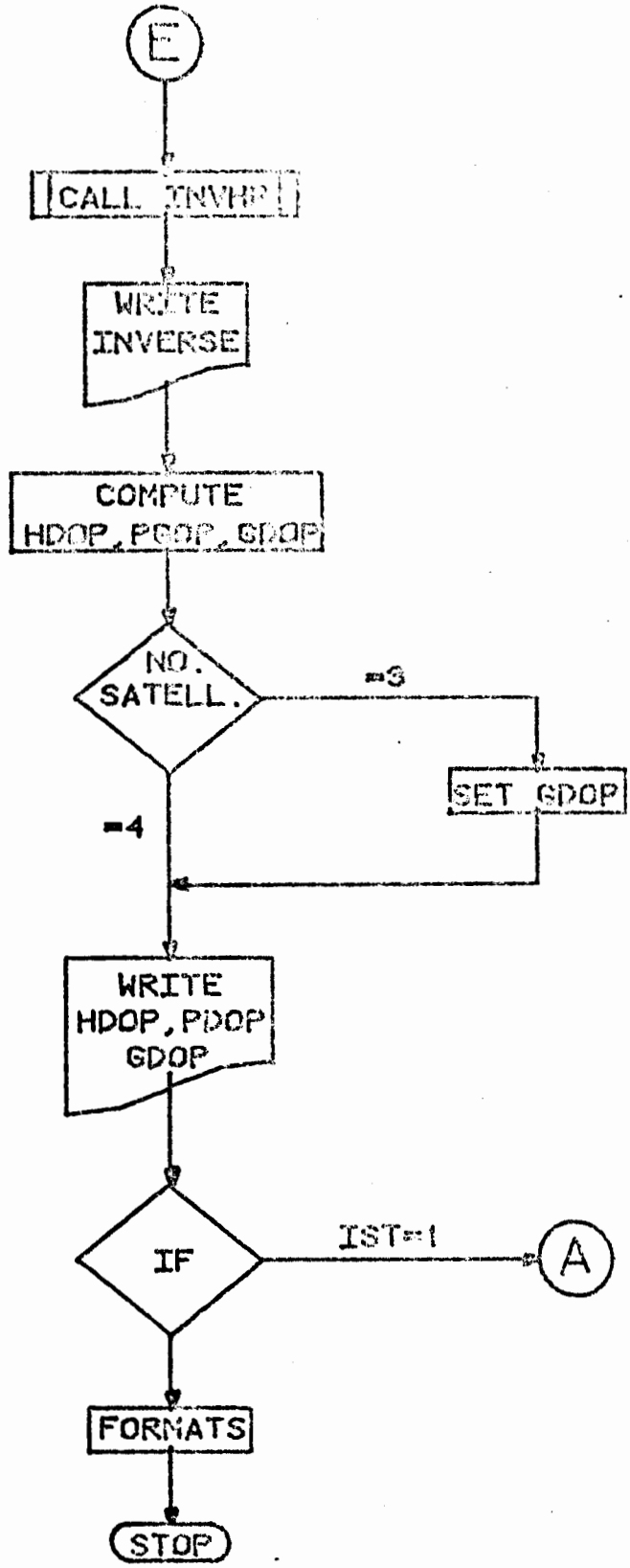

A
H-TRANSPOSE MATRIX
OUTPUT H-TRANSPOSE MATRIX
CALL EB09
OUTPUT PRODUCT
REGROUPING
CALL MINVD (HTH, N, DET, L, M)
DET ?
+0.0
OUPUT ERROR MESSAGE
STOP 1
OUTPUT INVERSE
HDOP, PDOP, GDOP
OUTPUT
STOP

FLOWCHART EBGH

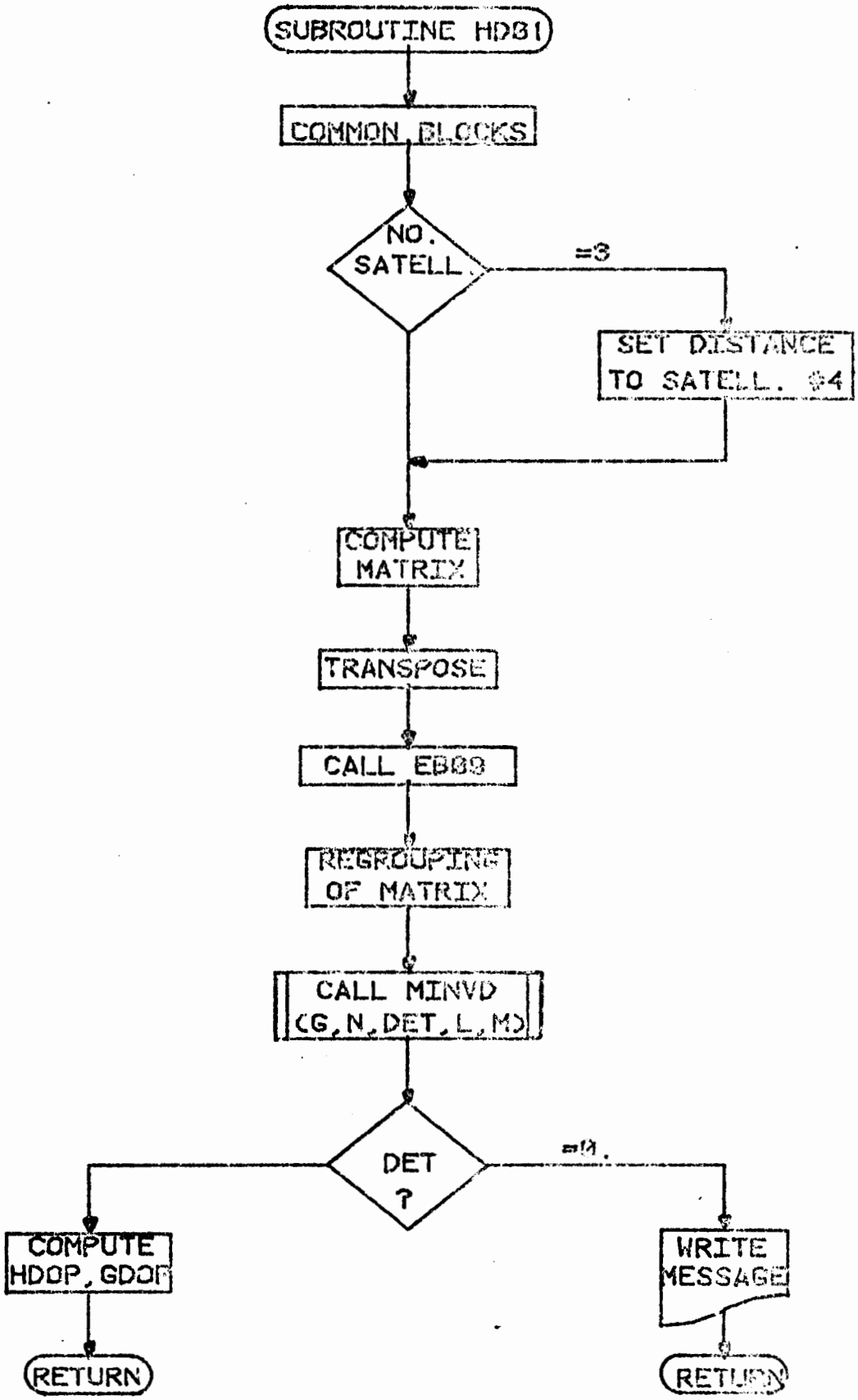



B
C
READ SATELLITE POSITION
UNPACK USER POS.
I=1,4
MORE DATA IN REC.
NO
UNPACK SATELLITE POSITION
NO. SATELL. ?
<3
WRITE ERROR MESSAGE
STOPS
WRITE DATA
CALL ENU
D

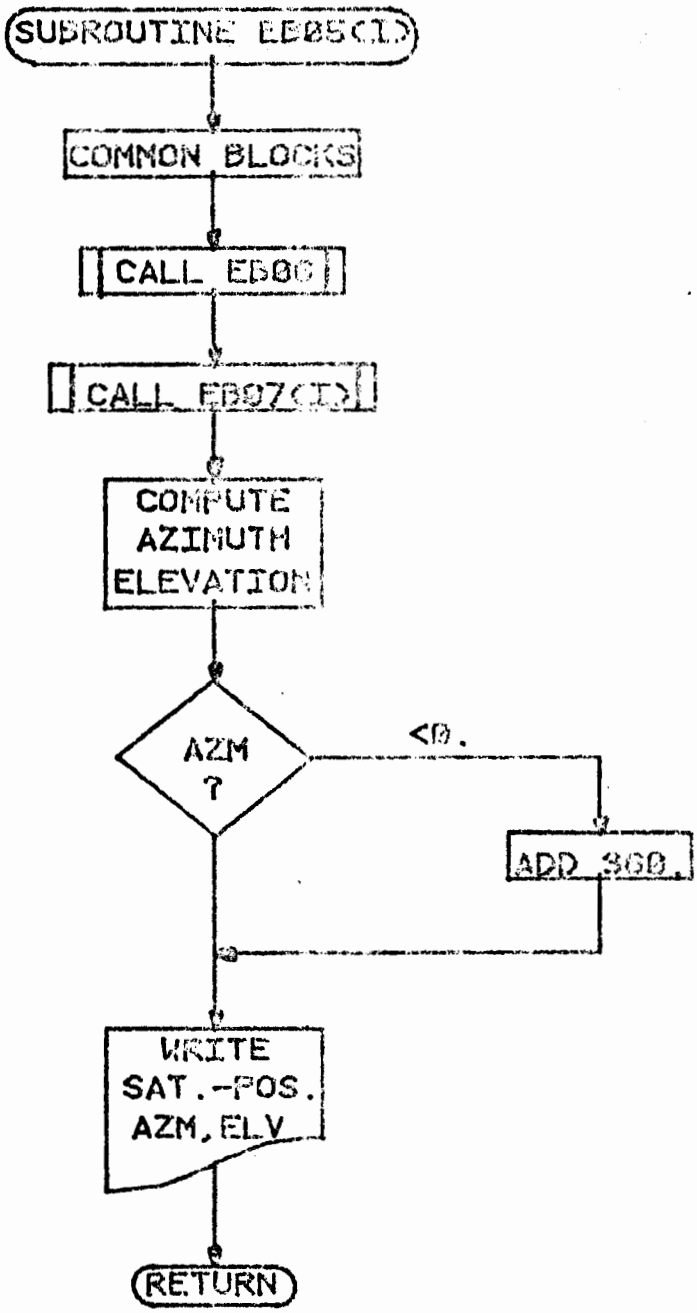

D
H(I,4)←0.
NO. SATELL. ?
<4
SET H(4,I)
=4
COMPUTE REST OF H-MATRIX
WRITE H-MATRIX
CALL HTRAN
WRITE H-TRANS-POSE
CALL MLHHT
WRITE PRODUCT
E


E
CALL INVHP
WRITE INVERSE
COMPUTE HDOP, PDOP, GDOP
NO. SATELL.
=3
SET GDOP
=4
WRITE HDOP, PDOP GDOP
IF
IST=1
A
FORMATS
STOP

FLOWCHART HD01



FLOWCHART EB05



APPENDIX C

PROGRAM LISTINGS

```
FTN4X,L,Y
C ************************
C *   FILENAME : &HD00    *
C ************************
      BLOCK DATA
      IMPLICIT DOUBLE PRECISION (A-H,K-Z)
      INTEGER N
      COMMON /CNST/PI,RTD,OMF,AE,E2,OMF2,SGC,ERATE,PI2
      COMMON/TIME/TDEL,TFIN
      COMMON/AZM/ELV(4),AZM(4)
      COMMON/POS/LAT,LON,ALT,R
      COMMON/NAC/TUY,TCY,TKC,DTC(4),DTU,TC,T
      COMMON/DB2/AD1(14)
      COMMON/DTX/U(4),D(4,4),RBAR(4)
      COMMON/SAT/S(4)
      COMMON/HDOP/HDOP,INS,GDOP
      COMMON/ELEV/E(3,3)
      COMMON/MAT/A(4,4),AT(4,4),AAT(4,4)
      COMMON/BLG/G(4,4),N
      COMMON/ALM/AD2(14,24),ID1(24)
      COMMON/EPH/C(7),K,S1(7)
      DATA PI/3.14159265D0/,RTD/57.2957795D0/,PI2/6.283185300/
      DATA OMF/.996647220D0/,AE/6.378135D6/
      DATA E2/6.694317778D-3/,OMF2/.993305683D0/
      DATA SGC/1.996499D7/,ERATE/7.292115147D-5/
      END
$FILES (1,1)
      PROGRAM HD00
C ***************************************************************
C *  ROUTINE COMPUTES FOR A PROMPTED TIME (DAY AND TIME INTERVALL  *
C * DURING THIS DAY) AND A PROMPTED USER POSITION THE POSITION OF  *
C * 4 GPS SATELLITES,THE AZIMUTH AND ELEVATION ANGLES, THE DISTANCE*
C * TO THE USER AND THE HDOP AND GDOP.                            *
C *  THE SATELLITE POSITIONS ARE COMPUTED FROM THE ALMANAC DATA BY *
C * A MODIFIED PROGRAM OF THE TEXAS A&M-UNIVERSITY.               *
C *  A PLOTFILE WITH A TIME TAGGED HDOP IS CREATED.               *
C *                                                               *
C * - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -*
C *                                                               *
C *   USED SUBROUTINES:     EB02                                  *
C *                         EB03                                  *
C *                         EB05                                  *
C *                         EB06                                  *
C *                         EB07                                  *
C *                         HD01                                  *
C *                         EB09                                  *
C *                         MINVD                                 *
C *                         EB12                                  *
C *                         EB14                                  *
C *                         DINTF                                 *
C *                                                               *
C * - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -*
C *                                                               *
C *  USED EARTH-REFERENCE-ELLIPSOID : WGS-72                      *
C *                                                               *
C *   IMPORTANT VARIABLES AND CONSTANTS :                         *
C *   INTEGER : IST,IST1,IST2       --> CONTROL-PARAMETERS        *
C *             I,II,J,I1,I2,I3     --> INDEX FOR DO-LOOPS        *
```

```
0059  C *              N                    --> SIZE OF MATRIX (USED IN      *
0060  C *                                       INVERSION SUBROUTINE)        *
0061  C *              INS                  --> NUMBER OF SATELLITES FOR     *
0062  C *                                       HDOP COMPUTATION             *
0063  C *              ISAT                 --> INDEX OF SATELLITES          *
0064  C *              ID (4)               --> PRN NO. OF USED SATELLITES   *
0065  C *              ID1 (24)             --> PRN NO. OF ALL SATELLITES    *
0066  C *              INAM (3)             --> NAME OF PLOTFILE             *
0067  C *                                                                    *
0068  C *   REAL     : A1,A2,T1,T2,TOUT     --> ONLY FOR OUTPUT,ALL REAL-    *
0069  C *                                       VARIABLES ARE NOT INVOLVED   *
0070  C *                                       IN ANY SIGNIFICANT COMPUTAT.*
0071  C *                                                                    *
0072  C *   DOUBLE PRECISION :                                               *
0073  C *              AD (14,4)            --> ALMANAC FOR 4 SATELLITES     *
0074  C *              AD1 (14)             --> ALMANAC JUST USED            *
0075  C *              AD2 (14,24)          --> ALMANAC FOR 24 SATELLITES    *
0076  C *              ALT                  --> ALTITUDE                     *
0077  C *              AE                   --> RADIUS OF EARTH              *
0078  C *              AZM (4)              --> AZIMUTH ANGLE OF SATELLITE   *
0079  C *              A(4,4),AT(4,4),      --> MATRIX,INVERTED MATRIX AND   *
0080  C *              AAT(4,4)                 MULTIPLICATION MATRIX.       *
0081  C *                                       A CONTAINS THE DIRECTION-    *
0082  C *                                       COSINES IN ENU COORDINATES   *
0083  C *              D(4,4)               --> DISTANCES FROM USER TO 4     *
0084  C *                                       SATELLITES IN ECEF COORD.    *
0085  C *              DTC(4)               --> DATE OF COLLECTION IN DAYS   *
0086  C *                                       FROM BEGINNING OF THE YEAR   *
0087  C *              DTU                  --> DATE OF USE IN DAYS (CONVER-*
0088  C *                                       TED INTO SECONDS) FROM       *
0089  C *                                       BEGINNING OF THE YEAR        *
0090  C *              E (3,3)              --> MATRIX CONTAINING SINES AND *
0091  C *                                       COSINES OF USER POSITION     *
0092  C *              E2                   --> SQUARE-ROOT OF THE EXCENTRI-*
0093  C *                                       CITY OF THE EARTH ELLIPSOID *
0094  C *              ELV (4)              --> ELEVATIONANGLE OF SATELLITES*
0095  C *              ERATE                --> EARTH ROTATION RATE          *
0096  C *              G (4,4)              --> MATRIX FOR INVERSION-SUBROU.*
0097  C *              GDOP                 --> GEOMETRIC DILUTION OF PRECI-*
0098  C *                                       SION                         *
0099  C *              HDOP                 --> HORIZONTAL DILUTION OF       *
0100  C *                                       PRECISION                    *
0101  C *              LAT                  --> LATITUDE                     *
0102  C *              LON                  --> LONGITUDE                    *
0103  C *              PI,PI2               --> PI(3.1415...) AND 2*PI       *
0104  C *              RTD                  --> RADIAN TO DEGREE CONVERSION *
0105  C *                                       FACTOR (180/PI)              *
0106  C *              RBAR                 --> LENGTH OF VECTOR USER-SATEL.*
0107  C *              S (4)                --> SATELLITE-POSITION IN ECEF   *
0108  C *              SGC                  --> SQUARE ROOT OF GRAVITATIONAL*
0109  C *                                       CONSTANT OF THE EARTH        *
0110  C *                      ALL TIMES IN GMT AND IN SECONDS               *
0111  C *              T                    --> GPS TIME                     *
0112  C *              TC                   --> COLLECTION TIME,START OF     *
0113  C *                                       COUNT AT BEGINNING OF EPOCH *
0114  C *              TCY                  --> TIME OF COLLECTION STARTING *
0115  C *                                       AT BEGINNING OF YEAR         *
0116  C *              TDEL                 --> TIME INCREMENT               *
0117  C *              TFIN                 --> END TIME                     *
0118  C *              TKC                  --> DIFFERENCE BETWEEN COLLEC-   *
```

```
C *                                        TIONTIME AND REFERENCETIME, *
C *                                        WRAPAROUNDS CONSIDERED      *
C *              TUY                   --> TIME OF USE                  *
C *              U (4)                 --> USER POSITION IN ECEF-COORD,*
C *                                                                    *
C ***********************************************************************
C
C
      IMPLICIT DOUBLE PRECISION(A-H,K-Z)
      REAL A1,A2,T2,T1,TOUT
      DIMENSION AD(14,4),ID(4),INAM(3)
      COMMON/TIME/TDEL,TFIN
      COMMON/AZM/ELV(4),AZM(4)
      COMMON/POS/LAT,LON,ALT,R
      COMMON/NAC/TUY,TCY,TKC,DTC(4),DTU,TC,T
      COMMON/CNST/PI,RTD,OMF,AE,E2,OMF2,SGC,ERATE,PI2
      COMMON/DB2/AD1(14)
      COMMON/DTX/U(4),D(4,4)
      COMMON/SAT/S(4)
      COMMON/ALM/AD2(14,24),ID1(24)
      COMMON/HDOP/HDOP,INS,GDOP
      ISAT=0
C ......................................................................
C                        INPUT
C
C **********  INPUT THE LATITUDE,LONGITUDE AND THE ALTITUDE **********
C          LON WEST AND LAT SOUTH ARE DENOTED BY A NEGATIVE VALUE
C
      WRITE (16,1)
1     FORMAT (//"   INPUT USER POSITION"
     1/          " ATLANTIC CITY (=1) OTHER POSITION (=2)"
     2/          " ANSWER :_")
      READ (16,98) IST
      IF(IST.EQ.2) GOTO 1001
C ----------------------
      LAT=0.395D2
      LON=-0.745D2
      ALT=0.1D3
      GOTO 1002
C ----------------------
1001  CONTINUE
      WRITE (16,2)
2     FORMAT (/"   USER POSITION IN DEGREES (FORMAT :G15.8)"
     1/          " LATITUDE          :_")
      READ (16,97) LAT
      WRITE (16,3)
3     FORMAT (" LONGITUDE         :_")
      READ (16,97) LON
      WRITE (16,4)
4     FORMAT (" ALTITUDE IN FEET :_")
      READ (16,97) ALT
1002  CONTINUE
C --------------------
      WRITE (6,50) LAT,LON,ALT
50    FORMAT (" PROGRAM   * H D 0 0 *"
     1/        " ---------------------"
     2//       " USER-POSITION :  "
     3/        "   LATITUDE :",G15.8," DEGREE"
     4/        "   LONGITUDE:",G15.8," DEGREE"
     5/        "   ALTITUDE :",G15.8," FEET")
```

```
0179        LAT=LAT/RTD
0180        LON=LON/RTD
0181        ALT=ALT/0.32809D1
0182  C
0183  C ********** EB02 COMPUTES E-MATRIX **********
0184  C
0185        CALL EB02
0186  C
0187  C ********** EB03 TAKES LAT, LON, AND ALT; **********
0188  C             IT RETURNS X,Y,Z IN U-VECTOR
0189  C
0190        CALL EB03
0191        WRITE (6,51) (U(I),I=1,3)
0192  51    FORMAT (/" ECEF-COORDINATES :",7X,"X",14X,"Y",14X,"Z"
0193       1/          "--------------------",3G15.8)
0194        U(4)=0.
0195  C
0196  C ********** READ USER TIME **********
0197  C
0198        WRITE (16,7)
0199  7     FORMAT (/" USER TIME (FORMAT : G15.8)"
0200       1/          "  STARTTIME (T),ENDTIME (TFIN) TIME INCREMENT (TDEL)"
0201       2/          " AND ALMANAC COLLECTION TIME (TC) IN SECONDS."
0202       3/          " START OF COUNT : T,TFIN,TDEL --> EVERY DAY AT 00:00"
0203       4/          "                  TC          --> BEGINNING OF EPOCH"
0204       5/          " TSTART=_")
0205        READ (16,97) T
0206        WRITE (16,8)
0207  8     FORMAT (" TFIN  =_")
0208        READ (16,97) TFIN
0209        WRITE (16,9)
0210  9     FORMAT (" TDEL  =_")
0211        READ (16,97) TDEL
0212        WRITE (16,32)
0213  32    FORMAT (" TC    =_")
0214        READ (16,97) TC
0215        WRITE (16,10)
0216  10    FORMAT (" DATE OF USE IN DAYS FROM JANUARY,FIRST :_")
0217        READ (16,97) DTU
0218        WRITE (16,31)
0219  31    FORMAT ( " 3 OR 4 SATELLITES FOR HDOP-COMPUTATION :_")
0220        READ (16,98) INS
0221  C --------------
0222        CALL EB12(T,T1)
0223        CALL EB12(TFIN,T2)
0224        WRITE (6,52) T,T1,TFIN,T2,TDEL,DTU
0225  52    FORMAT (//" USERTIMES :"
0226       1/          "   START (TSTART): ",G15.8," SEC. = ",F5.2," HOURS"
0227       2/          "   END (TFIN)    : ",G15.8," SEC. = ",F5.2," HOURS"
0228       3/          "   INCR. (TDEL)  : ",G15.8," SEC"
0229       4/          "   DATE (DTU)    : ",G15.8," DAYS")
0230  C
0231  C ********** READ ALMANACS **********
0232  C
0233        WRITE (16,12)
0234  12    FORMAT ( " ALMANAC-DATA FROM TAPE (=1) ? _")
0235        READ (16,98) IST1
0236  1000  CONTINUE
0237        ISAT=ISAT+1
0238        IF(IST1.EQ.1) GOTO 1009
```

```
0239          WRITE (16,13) ISAT
0240   13     FORMAT (/" OWN ALMANAC =1 OR DATA FROM FILE =2 FOR SV NO.",I2,"?"
0241         1/          " ANSWER :_")
0242          READ (16,98) IST
0243          IF(IST.EQ.1) GOTO 1005
0244   C ------------------
0245          WRITE (16,14)
0246   14     FORMAT (/" FILENAME :_")
0247          READ(16,92) INAM
0248          OPEN (2,FILE=INAM,FORM='FORMATTED')
0249          READ (2,96) DTC(ISAT),ID(ISAT)
0250          READ (2,91) (AD(I,ISAT),I=1,4)
0251          READ (2,91) (AD(I,ISAT),I=5,8)
0252          CLOSE(2)
0253          WRITE (16,15) ID(ISAT)
0254   15     FORMAT ( " SATELLITE ID = ",I2)
0255          GOTO 1010
0256   C ------------------
0257   1005   CONTINUE
0258          WRITE (16,16) ISAT
0259   16     FORMAT ( " ####### ALMANAC-DATA FOR SATELLITE ",I2,"#######"
0260         1/          " FORMAT :D12.4"
0261         2//         " DATE OF COLLECTION                    :_")
0262          READ (16,99) DTC(ISAT)
0263          WRITE (16,17)
0264   17     FORMAT (" EXCENTRICITY                        :_")
0265          READ (16,99) AD(1,ISAT)
0266          WRITE (16,18)
0267   18     FORMAT (" REFERENCE TIME                      :_")
0268          READ (16,99) AD(2,ISAT)
0269          WRITE (16,19)
0270   19     FORMAT (" ORBIT INCLINATION (IO)              :_")
0271          READ (16,99) AD(3,ISAT)
0272          WRITE (16,20)
0273   20     FORMAT (" DRIFT RATE OF (IO)                  :_")
0274          READ (16,99) AD(4,ISAT)
0275          WRITE (16,21)
0276   21     FORMAT (" SQARE ROOT OF GREAT HALF-AXIS       :_")
0277          READ (16,99) AD(5,ISAT)
0278          WRITE (16,22)
0279   22     FORMAT (" RIGHT ASCENSION OF ORBIT            :_")
0280          READ (16,99) AD(6,ISAT)
0281          WRITE (16,23)
0282   23     FORMAT (" ARGUMENT OF PERIGEE                 :_")
0283          READ (16,99) AD(7,ISAT)
0284          WRITE (16,24)
0285   24     FORMAT (" MEAN ANOMALY                        :_")
0286          READ (16,99) AD(8,ISAT)
0287          WRITE (16,25)
0288   25     FORMAT (" SATELLITE ID                        :_")
0289          READ (16,98) ID(ISAT)
0290          GOTO 1010
0291   C ------------
0292   1009   CONTINUE
0293          IF(ISAT.NE.1) GOTO 1010
0294          CALL EB14
0295          DO 107 I1=1,4
0296   1011   CONTINUE
0297          WRITE (16,26) I1
0298   26     FORMAT ( " ID OF SATELLITE (",I2,") : _")
```

```
      READ (16,98) ID(I1)
      DO 108 I2=1,24
      IF(ID(I1).NE.ID1(I2).AND.I2.LT.24) GOTO 108
      IF(ID(I1).EQ.ID1(I2)) GOTO 1012
      WRITE (16,27) ID(I1)
27    FORMAT ( " =====> SATELLITE ALMANAC OF SAT.(",I2,") NOT ON"
     1" TAPE !! <=====")
      GOTO 1011
108   CONTINUE
1012  CONTINUE
      DO 107 I3=1,8
      AD(I3,I1)=AD2(I3,I2)
      ID(I1)=ID1(I2)
107   CONTINUE
C --------------------
1010  CONTINUE
      AD(9,ISAT)=AD(5,ISAT)**2
      AD(10,ISAT)=COS(AD(3,ISAT))
      AD(11,ISAT)=SIN(AD(3,ISAT))
      AD(12,ISAT)=COS(AD(7,ISAT))
      AD(13,ISAT)=SIN(AD(7,ISAT))
      AD(14,ISAT)=SGC/(AD(5,ISAT)*AD(9,ISAT))
      IF(ISAT.LT.INS) GOTO 1000
C ..................................................................
C
C ********** OUTPUT ALMANAC **********
C
      A1=SNGL(DTC(1))
      A2=SNGL(TC)
      WRITE (6,53) A1,A2,(ID(I),I=1,4)
53    FORMAT (/"    USED ALMANACS          DTC= ",F5.0,"   TC= ",F7.0,
     1/          "    -------------- "
     2/          " SAT. ID : ",I3,19X,I3,19X,I3,19X,I3)
      WRITE (6,54) ((AD(I,J),J=1,4),I=1,14)
54    FORMAT (4(10X,D12.4,))
C ..................................................................
C                 CALCULATIONS AND OUTPUT
C
C ********** WRITE TITLE **********
C
      WRITE (6,61)
61    FORMAT (//" OUTPUT OF COMPUTATIONS "
     1/           " ---------------------- "
     2//         " ================================================ "
     2/          " ! THE PRINTOUT IS ARRANGED AS FOLLOWING EXAMPLE :  !"
     3/          " ! ----------------                                 !"
     4/          " ! TIME                                             !"
     5/          " !POSITION OF SATELLITES IN ECEF-COORDINATES (X,Y,Z)!"
     6/          " !AND ELEVATION AND AZIMUTH (3-4 LINES)             !"
     7/          " !- - - - - - - - - -                               !"
     8/          " !  HDOP AND GDOP                                  !"
     9/          " !------------------                                !"
     A/          " !    ALL VALUES ARE IN METER                       !"
     B/          " ================================================")
      WRITE (16,29)
29    FORMAT (" NAME OF PLOTFILE :_")
      READ (16,92) INAM
      OPEN(2,FILE=INAM,FORM='FORMATTED')
      WRITE (2,92) INAM
      WRITE (2,98) INS
```

```
0359  C
0360  C ----------  BEGINNING OF COMPUTATION-LOOP ----------------------->
0361  C
0362        DTU=(DTU-1.)*0.864D5
0363        TCY=(DTC(1)-1.)*0.864D5+DMOD(TC,0.864D5)
0364  1004  CONTINUE
0365        CALL EB12 (T,TOUT)
0366        WRITE (6,70)
0367        WRITE (6,62) TOUT
0368  62    FORMAT ( " TIME : ",F7.4," HOURS ")
0369        DO 102 I=1,INS
0370        DO 101 J=1,14
0371        AD1(J)=AD(J,I)
0372  101   CONTINUE
0373  C
0374  C ********** COMPUTATION OF POSITION,DISTANCE TO USER **********
0375  C             AND AZIMUTH AND ELEVATION OF SATELLITE(I)
0376  C
0377        II=I
0378        CALL EB05(II)
0379  102   CONTINUE
0380  C
0381  C ********** COMPUTATION OF INVERTED G-MATRIX,HDOP AND GDOP **********
0382  C
0383        CALL HD01
0384        WRITE (6,71)
0385        WRITE (6,63) HDOP,GDOP
0386  63    FORMAT (G15.8,5X,G15.8)
0387        A1=SNGL(HDOP)
0388        A2=SNGL(GDOP)
0389        TOUT=SNGL(T)/3600.
0390        WRITE (2,90) TOUT,A1,A2
0391        WRITE (6,70)
0392        T=T+TDEL
0393        IF (T.LE.TFIN) GOTO 1004
0394  C <-------------------  END OF COMPUTATION-LOOP----------------<--
0395  C
0396  C ********** WRITE END-CRITERIA TO PLOTFILE **********
0397  C
0398        TOUT=0.
0399        A1=0.
0400        A2=0.
0401        WRITE (2,90) TOUT,A1,A2
0402        CLOSE (2)
0403        STOP
0404  C
0405  C ********** FORMATS **********
0406  C
0407  70    FORMAT ( " ------------------------ ")
0408  71    FORMAT ( " - - - - - - - - - - - - - ")
0409  90    FORMAT (1X,3F12.6)
0410  91    FORMAT (4D18.8)
0411  92    FORMAT (3A2)
0412  93    FORMAT (I4)
0413  94    FORMAT (4E12.4)
0414  95    FORMAT (A4)
0415  96    FORMAT (G15.8,I3)
0416  97    FORMAT(G15.8)
0417  98    FORMAT(I2)
0418  99    FORMAT(D12.4)
```

```
0419          END
0420
```

```
&PLHG  T=00004 IS ON CR00011 USING 00018 BLKS R=0000

      FTN4X,L,Y
      $FILES (1,1)
            PROGRAM PLHG
      C ***************************************************************
      C *                  FILENAME :   &PLHG                         *
      C *                  ^^^^^^^^^^^^^^^^^^                         *
      C * PROGRAM PLOTS DATA FILES GENERATED BY THE PROGRAM "HD00"     *
      C * TO COMPARE THE HDOP'S COMPUTED FOR A SITUATION WITH FOUR     *
      C * SATELLITES (PLOTFILE 1) AND WITH THREE SATELLITES (PLOT-     *
      C * FILE 2).                                                     *
      C *                                                              *
      C * - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -*
      C *   USED SUBROUTINES : DLTBL,GPS  (PLOTLIBRARY)                *
      C *                                                              *
      C ***************************************************************
      C
            DIMENSION IGCB(192),INAM1(3),INAM2(3)
            LOGICAL LOG
      C
      C ********** READ NAME OF FILE,LOGICAL UNIT AND ID OF **********
      C                          DEVICE SUB
      C
            LOG=.TRUE.
            WRITE (16,1)
      1     FORMAT (" NAME OF PLOTFILE 1 :_")
            READ (16,92) INAM1
            OPEN (2,FILE=INAM1,FORM='FORMATTED')
            READ (2,92) INAM1
            READ (2,93) INS
            WRITE (16,3)
      3     FORMAT ( " LOGICAL UNIT (LU) AND ID OF DEVICE-SUBROUTINE"
           1/          "   LU =_")
            READ (16,93) LU
            WRITE (16,4)
      4     FORMAT ( "   ID =_")
            READ (16,93) ID
      C
      C ********** INITIALIZE PLOTTER AND DRAW GRID **********
      C
            WRITE (16,5)
      5     FORMAT ( " START-AND ENDTIME IN HOURS."
           1/          " TSTART :_")
            READ (16,94) TSTART
            WRITE (16,6)
      6     FORMAT ( " TEND   :_")
            READ (16,94) TEND
            CALL PLOTR (IGCB,ID,1,LU)
            CALL SETAR (IGCB)
            CALL FRAME (IGCB)
            CALL VIEWP (IGCB,30.,90.,20.,60.)
            CALL WINDW (IGCB,TSTART,TEND,0.,20.)
            CALL FXD (IGCB,2)
            CALL LGRID (IGCB,-0.25,5.,0.,0.,1.,1.,1.)
      C
      C ********** DATA INPUT FROM FILES AND PLOT **********
      C
            CALL LINE (IGCB,0)
      1000  CONTINUE
```

```
0059          READ (2,95) TOUT,HDOP,GDOP
0060          IF(LOG) CALL MOVE (IGCB,TOUT,HDOP)
0061          LOG=.FALSE.
0062          IF(TOUT.LT.0.01.AND.HDOP.LT.0.01) GOTO 1001
0063          CALL DRAW(IGCB,TOUT,HDOP)
0064          GOTO 1000
0065   1001   CONTINUE
0066          CLOSE(2)
0067   C ---------------------
0068          WRITE (16,2)
0069   2      FORMAT ( " NAME OF PLOTFILE 2 :_")
0070          READ (16,92) INAM2
0071          OPEN (3,FILE=INAM2,FORM='FORMATTED')
0072          READ (3,92) INAM2
0073          READ (3,93) INS2
0074          CALL LINE(IGCB,1)
0075          LOG=.TRUE.
0076   1002   CONTINUE
0077          READ (3,95) TOUT,HDOP,GDOP
0078          IF(LOG) CALL MOVE (IGCB,TOUT,HDOP)
0079          LOG=.FALSE.
0080          IF(TOUT.LT.0.01.AND.HDOP.LT.0.01) GOTO 1003
0081          CALL DRAW (IGCB,TOUT,HDOP)
0082          GOTO 1002
0083   1003   CONTINUE
0084          CLOSE (3)
0085   C
0086   C ********** PLACE TITLES AND OTHER INFORMATION ***********
0087   C
0088          CALL VIEWP (IGCB,10.,100.,10.,90.)
0089          CALL WINDW (IGCB,10.,100.,10.,90.)
0090          CALL MOVE (IGCB,55.,80.)
0091          CALL CPLOT (IGCB,-11.,0.,0)
0092          CALL LABEL (IGCB)
0093          WRITE (LU,7)
0094   7      FORMAT ("GRAPH OF HDOP VS. TIME")
0095          CALL MOVE  (IGCB,55.,10.)
0096          CALL CPLOT (IGCB,-8.,0.,0)
0097          CALL LABEL (IGCB)
0098          WRITE (LU,8)
0099   8      FORMAT ("GMT-TIME IN HOURS")
0100          CALL MOVE (IGCB,1.,50.)
0101          CALL LABEL (IGCB)
0102          WRITE (LU,9)
0103   9      FORMAT ("HDOP")
0104          CALL LINE (IGCB,0)
0105          CALL MOVE (IGCB,30.,70.)
0106          CALL DRAWI (IGCB,15.,0.)
0107          CALL MOVEI (IGCB,2.,0.)
0108          CALL CPLOT (IGCB,0.,-0.25,0)
0109          CALL LABEL (IGCB,)
0110          WRITE (LU,10)
0111   10     FORMAT ("4 SAT.")
0112          CALL LINE (IGCB,1)
0113          CALL MOVE (IGCB,65.,70.)
0114          CALL DRAWI (IGCB,15.,0.)
0115          CALL MOVEI (IGCB,2.,0.)
0116          CALL CPLOT (IGCB,0.,-0.25,0)
0117          CALL LABEL (IGCB)
0118          WRITE (LU,11)
```

```
11      FORMAT ("3 SAT.")
        CALL PLOTR (IGCB,ID,0)
C
C ********** FORMATS **********
C
92      FORMAT (3A2)
93      FORMAT (I2)
94      FORMAT (F8.6)
95      FORMAT (1X,3F12.6)
        CALL PLOTR (IGCB,ID,0)
        STOP
        END
```

```
&EBGD1 T=00004 IS ON CR00011 USING 00018 BLKS R=0000

FTN4X,L,Y
C ************************
C *   FILENAME : &EBGD1   *
C ************************
      BLOCK DATA
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      COMMON/MAT/HT(4,4),H(4,4),HTH(4,4)
      END
      PROGRAM EBGD1
C ******************************************************************
C *  ROUTINE TO CALCULATE GDOP WITH INSERTED H-MATRIX OR WITH      *
C * AZIMUTH- AND ELEVATIONANGLE.                                   *
C *                                                                *
C * - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - *
C *   USED SUBROUTINES : EB09                                      *
C *                      MINVD                                     *
C * - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - *
C *     MICHAEL J. MAGROGAN  CO-OP  ACT-100D  FEBRUARY 1981        *
C *     ERHARD BUCHBERGER           ACT-100B  APRIL 1982           *
C******************************************************************
C
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION AZ(4),EL(4),HPROD(4,4),L(4),M(4)
      COMMON/MAT/HT(4,4),H(4,4),HTH(4,4)
      N=4
      RTD=57.2957795
C ..................................................................
C                          INPUT
C
C ********** INPUT H-MATRIX OR ANGLES **********
C
      WRITE (6,17)
17    FORMAT ( " PROGRAM *EBGD1*"
     1/        " ^^^^^^^^^^^^^^^^")
      WRITE (16,9)
9     FORMAT ( " SELECT INPUT :"
     1/        " H-MATRIX=1    ANGLES=2"
     2/        " ANSWER   :_")
      READ (16,91) IST
      IF(IST.EQ.2) GOTO 1002
C -----------------
      DO 100 I=1,4
      DO 100 J=1,4
      WRITE (16,10) I,J
10    FORMAT ( " ELEMENT (",I2,",",I2,") :_")
      READ (16,90) H(I,J)
100   CONTINUE
      GOTO 1003
C -----------------
1002  CONTINUE
      WRITE (6,15)
15    FORMAT (//" AZIMUTH        ELEVATION")
      DO 103 I=1,4
      WRITE (16,13) I
13    FORMAT ( " AZIMUTH(",I2,")   :_")
      READ (16,90) AZ(I)
      WRITE (16,14) I
14    FORMAT ( " ELEVATION(",I2,") :_")
```

```
      READ (16,90) EL(I)
      WRITE (6,16) AZ(I),EL(I)
16    FORMAT (2D12.4)
      AZ(I)=AZ(I)/RTD
      EL(I)=EL(I)/RTD
      H(I,1)=COS(EL(I))*COS(AZ(I))
      H(I,2)=COS(EL(I))*SIN(AZ(I))
      H(I,3)=SIN(EL(I))
      H(I,4)=1.
103   CONTINUE
C ------------------
1003  CONTINUE
      WRITE (6,4)
4     FORMAT (//" H-MATRIX")
      WRITE (6,5) ((H(I,J),J=1,4),I=1,4)
5     FORMAT (4D16.8)
C ..................................................................
C                          COMPUTATONS
C
C ********** COMPUTE THE TRANSPOSE OF THE H MATRIX **********
C
      DO 101 I=1,4
      DO 101 J=1,4
      HT(I,J)=H(J,I)
101   CONTINUE
      WRITE (6,6)
6     FORMAT (/" H-TRANSPOSE-MATRIX ")
      WRITE (6,5) ((HT(I,J),J=1,4),I=1,4)
C
C ********** CALL EB09 TO MULTIPLY THE H AND H TRANSPOSE **********
C                              MATRIX
C
      CALL EB09
      WRITE (6,7)
7     FORMAT (/" HT*H-MATRIX ")
      WRITE (6,5) ((HTH(I,J),J=1,4),I=1,4)
C
C ********** CALL MINVD TO COMPUTE THE INVERSE OF THE H AND **********
C                          H TRANSPOSE PRODUCT MATRIX
C
      DO 102 I=1,4
      DO 102 J=1,4
      HPROD(I,J)=HTH(I,J)
102   CONTINUE
      CALL MINVD (HPROD,N,DET,L,M)
      IF(DET.LT.1.0D-5) GOTO 1000
      WRITE (6,8)
8     FORMAT (/" INVERTED HT*H-MATRIX ")
      WRITE (6,5) ((HPROD(I,J),J=1,4),I=1,4)
C
C ********** THE TRACE OF THE MATRIX IS THE SUM OF ITS **********
C                                ELEMENTS
C
      TRACEZ=HPROD(1,1)+HPROD(2,2)
      HDOPV=DSQRT(TRACEZ)
      TRACEZ=TRACEZ+HPROD(3,3)+HPROD(4,4)
      GDOPV=DSQRT(TRACEZ)
      GOTO 1001
C -----------------------
1000  CONTINUE
```

```
      WRITE (16,1) DET
1     FORMAT ( " DETERMINANT OF MATRIX : ",D16.8)
      WRITE (6,12)
      WRITE (16,12)
12    FORMAT ( " +****************************************** "
     1/         " *HT*H-MATRIX IS SINGULAR (DETERMINANT=0.)* "
     2/         " +****************************************** ")
      STOP1
C ----------------------
1001  CONTINUE
      HDOP=SNGL(HDOPV)
      GDOP=SNGL(GDOPV)
      WRITE (16,11) HDOP,GDOP
      WRITE (6,11) HDOP,GDOP
11    FORMAT ( " HDOP = ",F15.8," GDOP = ",F15.8)
C
C ********** FORMATS **********
C
90    FORMAT (D16.8)
91    FORMAT (I2)
      STOP
      END
```

```
%EBGH  T=00004 IS ON CR00011 USING 00024 BLKS R=0000

0001  FTN4X,L,Y
0002  C ************************
0003  C *   FILENAME : %EBGH   *
0004  C ************************
0005        BLOCK DATA
0006        DOUBLE PRECISION ENUP,XP,YP,ZP,H,HT,HPROD,HDOPV,GDOPV
0007        DOUBLE PRECISION PI,RTD,OMF,AE,E2,OMF2,U,LAT,LON,ALT
0008        DOUBLE PRECISION XS,YS,ZS,TRACEZ,X,Y,Z,NORM
0009        DOUBLE PRECISION SGC,ERATE,XY
0010        COMMON/COORD/ENUP(3,3),XP,YP,ZP,H(4,4),HT(4,4),HPROD(4,4),
0011       1LSAT(4),XS(4),YS(4),ZS(4),HDOPV,GDOPV
0012        COMMON/CNST/PI,RTD,OMF,AE,E2,OMF2,SGC,ERATE
0013        COMMON/DTX/U(4)
0014        COMMON/POS/LAT,LON,ALT,XY
0015        END
0016        PROGRAM EBGH
0017  C ***************************************************************
0018  C *   ROUTINE TO CALCULATE HDOP,PDOP AND GDOP WITH PROMPTED      *
0019  C * USER- AND SATELLITE-POSITIONS.                               *
0020  C *   INPUT IS POSSIBLE OVER THE KEYBOARD OR FROM A DATAFILE.    *
0021  C *                                                              *
0022  C * - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -*
0023  C *   THE ORIGINAL PROGRAM WAS MADE BY MICHAEL J. MAGROGAN,CO-OP,*
0024  C * ACT 100B, ALSO THE SUBROUTINES "ENU","HTRAN","MLHHT","INVHP",*
0025  C *                                                              *
0026  C *   FURTHER USED SUBROUTINES : EB03,EB12                       *
0027  C *                                                              *
0028  C * - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -*
0029  C *   THE COMMON-BLOCKS ARE DEFINED TO FIT THE PROGRAM "HD00".   *
0030  C *                                                              *
0031  C ***************************************************************
0032  C
0033        DIMENSION IBUF(69),IDCB(144),NAME(3),ISATV(4)
0034        COMMON /COORD/ ENUP(3,3),XP,YP,ZP,H(4,4),HT(4,4),HPROD(4,4),
0035       +LSAT(4),XS(4),YS(4),ZS(4),HDOPV,GDOPV
0036        COMMON/CNST/PI,RTD,OMF,AE,E2,OMF2
0037        COMMON/DTX/U(4)
0038        COMMON/POS/LAT,LON,ALT
0039        DOUBLE PRECISION ENUP,XP,YP,ZP,H,HT,HPROD,HDOPV,GDOPV,PDOPV
0040        DOUBLE PRECISION PI,RTD,OMF,AE,E2,OMF2,U,LAT,LON,ALT
0041        DOUBLE PRECISION XS,YS,ZS,TRACEZ,X,Y,Z,NORM,TIME,BUF(15)
0042        EQUIVALENCE (IBUF,TIME),(IBUF(5),BUF),(IBUF(65),ISATV)
0043        REAL LAT1,LON1
0044  C
0045  C ********** DEFINITION OF CONSTANTS **********
0046  C
0047        RTD=57.2957795D0
0048        AE=6.378135D6
0049        E2=6.694317778D-3
0050        OMF2=0.993305683D0
0051  C
0052  C ********** THIS PROGRAM NEEDS AIRPLANE POSITION(XP,YP,ZP) **********
0053  C   AND FOUR SATELLITE POSITIONS (XS(1-4),YS(1-4),ZS(1-4)) AS INPUTS
0054  C
0055        WRITE (16,10)
0056  10    FORMAT ( " COORDINATES INPUT FROM FILE (=1) ?  :_")
0057        READ (16,92) IST
0058        IF(IST.EQ.1) GOTO 1000
```

```
0059  C ..................................................................
0060  C                    INPUT OVER KEYBOARD
0061  C
0062  C ********** USER POSITION **********
0063  C
0064        WRITE (16,1)
0065  1     FORMAT ( " INPUT USER POSITION IN GEOGR. COORDINATES (ALTITUDE
0066       1 IN FEET)"
0067       2/         " LATITUDE :_")
0068        READ (16,91) LAT1
0069        WRITE (16,2)
0070  2     FORMAT ( " LONGITUDE:_")
0071        READ (16,91) LON1
0072        WRITE (16,3)
0073  3     FORMAT ( " ALTITUDE :_")
0074        READ (16,91) ALT1
0075        LAT=DBLE(LAT1)/RTD
0076        LON=DBLE(LON1)/RTD
0077        ALT=DBLE(ALT1)/0.32809D1
0078  C
0079  C ********** COMPUTE ECEF-COORDINATES WITH SUBR. EB03 **********
0080  C
0081        CALL EB03
0082        XP=U(1)
0083        YP=U(2)
0084        ZP=U(3)
0085        WRITE (6,4) LAT1,LON1,ALT1,XP,YP,ZP
0086  4     FORMAT ( " PROGRAM *EBGH*        VERSION A"
0087       1/         " ---------------"
0088       2//        " USER-COORDINATES :"
0089       3/         " LAT =",G15.8,"  LON =",G15.8,"  ALT =",G15.8,
0090       4/         " XP  =",G15.8,"  YP  =",G15.8,"  ZP  =",G15.8)
0091  C
0092  C ********** SATELLITE-POSITION **********
0093  C
0094        WRITE (16,15)
0095  15    FORMAT ( " HOW MANY SATELLITES ?  :_")
0096        READ (16,92) NSAT
0097        IST2=1
0098        WRITE (16,5)
0099  5     FORMAT ( " INPUT SATELLITE-POSITION IN ECEF.")
0100        DO 101 I=1,NSAT
0101        WRITE (16,6)I
0102  6     FORMAT ( " XS(",I2,") =_")
0103        READ (16,90) XS(I)
0104        WRITE (16,7) I
0105  7     FORMAT ( " YS(",I2,") =_")
0106        READ (16,90) YS(I)
0107        WRITE (16,8) I
0108  8     FORMAT ( " ZS(",I2,") =_")
0109        READ (16,90) ZS(I)
0110        WRITE (6,9) I,XS(I),YS(I),ZS(I)
0111  9     FORMAT ( " SAT.NO :",I2," XS =",D16.8," YS =",D16.8," ZS ="
0112       1,D16.8)
0113  101   CONTINUE
0114        GOTO 1001
0115  C ..................................................................
0116  C
0117  C                        INPUT FROM FILE
0118  C
```

```
0119  C   BECAUSE OF RESTRICTION IN THE SUBROUTINES THE SYSTEM HAS TO BE
0120  C  ALTIMETER AIDED.
0121  C
0122  1000  CONTINUE
0123        WRITE (16,11)
0124  11    FORMAT ( " FILENAME :_")
0125        READ (16,93) NAME
0126        CALL OPEN (IDCB,IERR,NAME,0,0)
0127        IF(IERR.LT.0) STOP1
0128        WRITE (6,12) NAME
0129  12    FORMAT ( " PROGRAM *EBGH*      VERSION B"
0130       1/          "^^^^^^^^^^^^^^^^"
0131       2//         " FILENAME : ",3A2,/)
0132        NUM=1
0133        NSAT=4
0134        WRITE (16,16)
0135  16    FORMAT ( " SYSTEM ALTIMETER AIDED (=1) ?  :_")
0136        READ (16,92) IST2
0137  1002  CONTINUE
0138        CALL READF (IDCB,IERR,IBUF,068,LEN,NUM)
0139        IF(IERR.LT.0) STOP2
0140        XP=BUF(1)
0141        YP=BUF(2)
0142        ZP=BUF(3)
0143        I=0
0144        DO 102 K=1,4
0145        IF(ISATV(K).EQ.0) GOTO 102
0146        I=I+1
0147        ISATV(I)=ISATV(K)
0148        XS(I)=BUF(K+3)
0149        YS(I)=BUF(K+7)
0150        ZS(I)=BUF(K+11)
0151  102   CONTINUE
0152        IF(I-3) 1004,1005,1006
0153  C ----------------------
0154  1004  WRITE (16,22)
0155  22    FORMAT ( " ****************************"
0156       1/          " +ONLY TWO SATELLITES IN FILE*"
0157       2/          " ****************************")
0158        STOP3
0159  C -----------------------
0160  1005  NSAT=3
0161  1006  CONTINUE
0162        CALL EB12(TIME,TOUT)
0163        WRITE (6,13) NUM,TIME,TOUT,XP,YP,ZP
0164  13    FORMAT ( " RECORD-NO. : ",I3,
0165       1/          " TIME        : ",D14.6," SEC. ==> ",F8.4," HOURS GMT"
0166       2/          " USERPOSITION  --->  ",3D16.8,
0167       3/          " SATELLITE-POSITIONS :"
0168       4/,10X,"XS",14X,"YS",14X,"ZS")
0169        WRITE (6,14) ((ISATV(I),XS(I),YS(I),ZS(I)),I=1,NSAT)
0170  14    FORMAT (I3,3D16.8)
0171  C ..................................................................
0172  C                              COMPUTATIONS
0173  C
0174  C ********** CALL ENU TO FILL ENUP MATRIX **********
0175  C
0176  1001  CONTINUE
0177        CALL ENU
0178  C
```

```
C *********** FILL COLUMN 4 OF H MATRIX WITH 1'S. **********
C
      DO 40 I=1,4
       H(I,4)=1.D0
   40 CONTINUE
      IF(NSAT.EQ.4) GOTO 1003
      IF(IST2.NE.1) GOTO 1003
      H(4,1)=0.
      H(4,2)=0.
      H(4,3)=-1.
      H(4,4)=0.
1003  CONTINUE
      DO 50 I=1,NSAT
C
C ********** SATELLITE POSITION VECTOR MINUS AIRPLANE **********
C                          POSITION VECTOR
C
        X=XS(I)-XP
        Y=YS(I)-YP
        Z=ZS(I)-ZP
C
C ********** MAGNITUDE OF THE VECTOR BETWEEN THE SATELLITE **********
C                           AND THE AIRPLANE
C
        NORM=DSQRT(X**2+Y**2+Z**2)
C
C *********** UNIT VECTOR FROM THE VECTOR BETWEEN THE ***********
C                  SATELLITE AND THE AIRPLANE
C
      X=X/NORM
      Y=Y/NORM
      Z=Z/NORM
C
C ********** CONVERT FROM ECEF COORDINATES TO ENU COOR- **********
C           DINATES USING ENUP-MATRIX AND FILL UP H-MATRIX
C
      H(I,1)=ENUP(1,1)*X+ENUP(1,2)*Y+ENUP(1,3)*Z
      H(I,2)=ENUP(2,1)*X+ENUP(2,2)*Y+ENUP(2,3)*Z
      H(I,3)=ENUP(3,1)*X+ENUP(3,2)*Y+ENUP(3,3)*Z
   50 CONTINUE
      WRITE (6,17)
17    FORMAT (/" H-MATRIX")
      WRITE (6,94) ((H(I,J),J=1,4),I=1,4)
C
C ********** CALL HTRAN TO COMPUTE THE TRANSPOSE OF **********
C                       THE H-MATRIX
C
      CALL HTRAN
      WRITE (6,18)
18    FORMAT (/" H-TRANSPOSE-MATRIX")
      WRITE (6,94) ((HT(I,J),J=1,4),I=1,4)
C
C ********** CALL MLHHT TO MULTIPLY THE H AND H **********
C                   TRANSPOSE MATRIX
      CALL MLHHT
      WRITE (6,19)
19    FORMAT (/" HT*H-MATRIX")
      WRITE (6,94) ((HPROD(I,J),J=1,4),I=1,4)
C
C ********** CALL INVHP TO COMPUTE THE INVERSE OF THE H AND **********
```

```
C                          HTRANSPOSE PRODUCT MATRIX
C
      CALL INVHP
      WRITE (6,20)
20    FORMAT (/" INVERTED H*HT-MATRIX")
      WRITE (6,94) ((HPROD(I,J),J=1,4),I=1,4)
C
C ********** THE TRACE OF THE MATRIX IS THE SUM OF ITS ***********
C                            DIAGONAL ELEMENTS
C
      TRACEZ=HPROD(1,1)+HPROD(2,2)
      HDOPV=DSQRT(TRACEZ)
      PDOPV=DSQRT(TRACEZ+HPROD(3,3))
      TRACEZ=TRACEZ+HPROD(3,3)+HPROD(4,4)
      GDOPV=DSQRT(TRACEZ)
      HDOP=SNGL(HDOPV)
      PDOP=SNGL(PDOPV)
      GDOP=SNGL(GDOPV)
      IF(NSAT.EQ.3.AND.IST2.NE.1) GDOP=1.E20
      WRITE (6,21) HDOP,PDOP,GDOP
      WRITE (16,21) HDOP,PDOP,GDOP
21    FORMAT ( " HDOP = ",F10.5," PDOP = ",F10.5," GDOP = ",F10.5,//)
      NUM=NUM+1
      IF(IST.EQ.1) GOTO 1002
C
C ********** FORMATS **********
C
90    FORMAT (D16.8)
91    FORMAT (F15.8)
92    FORMAT (I2)
93    FORMAT (3A2)
94    FORMAT (4D16.8)
      STOP
      END
```

```
&EB02  T=00004 IS ON CR00011 USING 00012 BLKS R=0000

FTN4X,L,Y
C ***************************************************
C *          FILENAME : &EB02                       *
C *                                                 *
C *        PROGRAM COMPUTES THE E-MATRIX            *
C ***************************************************
C
      SUBROUTINE EB02
      IMPLICIT DOUBLE PRECISION (A-H,K-Z)
      COMMON/ELEV/E(3,3)
      COMMON/POS/LAT,LON,ALT,R
C ------------------
      SN=DSIN(LON)
      CN=DCOS(LON)
      ST=DSIN(LAT)
      CT=DCOS(LAT)
      E(1,1)=-SN
      E(1,2)=CN
      E(1,3)=0.0
      E(2,1)=-CN*ST
      E(2,2)=-SN*ST
      E(2,3)=CT
      E(3,1)=CN*CT
      E(3,2)=SN*CT
      E(3,3)=ST
      RETURN
      END
```

```
&EB03  T=00004 IS ON CR00011 USING 00012 BLKS R=0000

FTN4X,L,Y
C ***************************************************
C *                FILENAME :  &EB03                *
C *                                                 *
C * COMPUTES THE USER-POSITION IN ECEF-COORDINATES *
C * (TU-VECTOR=U-VECTOR (IN MAINPROGRAM) )          *
C *                                                 *
C ***************************************************
C
      SUBROUTINE EB03
      IMPLICIT DOUBLE PRECISION(A-Z)
      COMMON/CNST/PI,RTD,OMF,AE,E2,OMF2,SGC,ERATE
      COMMON/DTX/TU(4)
      COMMON/POS/LAT,LON,ALT,XY
C ------------------
      SLAT=DSIN(LAT)
      XY=AE/DSQRT(1.E0-E2*SLAT*SLAT)
      TU(3)=(XY*OMF2+ALT)*SLAT
      XY=(XY+ALT)*DCOS(LAT)
      TU(1)=XY*DCOS(LON)
      TU(2)=XY*DSIN(LON)
      RETURN
      END
```

&EB05 T=00004 IS ON CR00011 USING 00012 BLKS R=0000

```
FTN4X,L,Y
C ***************************************************************
C *                  FILENAME :  &EB05                          *
C *                                                             *
C *      COMPUTES ELEVATION AND AZIMUTH OF SATELLITES AND IN    *
C *   SUB. "EB06" THE POSITION AND IN SUB. "EB07" THE DISTANCE  *
C *   USER-SATELLITE.                                           *
C *                                                             *
C ***************************************************************
C
      SUBROUTINE EB05 (I)
      IMPLICIT DOUBLE PRECISION (A-H,K-Z)
      DIMENSION Y(4,3)
      COMMON/ELEV/E(3,3)
      COMMON/SAT/S(4)
      COMMON/AZM/ELV(4),AZM(4)
      COMMON/CNST/PI,RTD,OMF,AE,E2,OMF2,SGC,ERATE
      COMMON/DTX/U(4),D(4,4),RBAR(4)
C ---------------------
      CALL EB06
      CALL EB07(I)
      DO 100 II=1,3
      Y(I,II)=0.D0
      DO 100 III=1,3
      Y(I,II)=Y(I,II)+S(III)*E(II,III)
100   CONTINUE
C
C ********** COMPUTATION OF ELEVATION AND AZIMUTH OF **********
C                      SATELLITES AND OUTPUT
C
      Y(I,3)=Y(I,3)-AE
      SY=DSQRT(Y(I,1)*Y(I,1)+Y(I,2)*Y(I,2))
      ELV(I)=DATAN2(Y(I,3),SY)*RTD
      AZM(I)=DATAN2(Y(I,1),Y(I,2))*RTD
      IF(AZM(I).LT.0.) AZM(I)=AZM(I)+360.0
      WRITE (6,1) (S(J),J=1,3),ELV(I),AZM(I)
1     FORMAT (5(2X,D12.4))
      RETURN
      END
```

```
&EB06  T=00004 IS ON CR00011 USING 00018 BLKS P=0000

FTN4X,L,Y
C ***********************************************
C *                 FILENAME :  &EB06            *
C *                                              *
C * COMPUTES THE ACTUAL POSITION OF THE SATELLITE  *
C * IN ECEF-COORDINATES ( S-VECTOR = X,Y,Z )       *
C *                                              *
C ***********************************************
C
      SUBROUTINE EB06
      IMPLICIT DOUBLE PRECISION (A-Z)
      INTEGER I
      COMMON/NAC/TUY,TCY,TKC,DTC(4),DTU,TC,T
      COMMON/CNST/PI,RTD,OMF,AE,E2,OMF2,SGC,ERATE,PI2
      COMMON/SAT/X,Y,Z,MK
      COMMON/DB2/ECC,TOE,INOT,NRATE,SRAD,OMED,OME,MNOT,R,CINO,
     *SINO,COME,SOME,C
C -------------------------
      A=TC-TOE
      TUY=DTU+T
      IF(A.GT.-0.3024D6.AND.A.LT.3024D6) TKC=A
      IF(A.LT.-0.3024D6) TKC=A+0.6048D6
      IF(A.GT.0.3024D6) TKC=A-0.6048D6
      TK=TUY-TCY+TKC
      OGA=OMEO+(NRATE-ERATE)*TK-ERATE*TOE
      MK=MNOT+C*TK
    6 IF(MK.GE.-PI2)GO TO 7
      MK=MK+PI2
      GO TO 6
    7 IF(MK.LE.PI2)GO TO 8
      MK=MK-PI2
      GO TO 7
    8 EK=MK+ECC*DSIN(MK)
      DO 100 I=1,4
      COSE=DCOS(EK)
      SINE=DSIN(EK)
      TK=1.-ECC*COSE
100   EK=EK-(EK-MK-ECC*SINE)/TK
      COSE=(COSE-ECC)/TK
      SINE=DSQRT(1.-ECC*ECC)*SINE/TK
      EK=COSE*COME-SINE*SOME
      MK=SINE*COME+COSE*SOME
      SINE=2.*MK*EK
      COSE=2.*EK*EK-1.
      RK=TK*R
      X=RK*EK
      Y=RK*MK
      Z=Y*SINO
      EK=CINO*Y
      SINE=DSIN(OGA)
      COSE=DCOS(OGA)
      Y=X*SINE+EK*COSE
      X=X*COSE-EK*SINE
      RETURN
      END
```

```
&EB07  T=00004 IS ON CR00011 USING 00012 BLKS R=0000

0001  FTN4X,L,Y
0002  C ***************************************************
0003  C *              FILENAME : &EB07                   *
0004  C *                                                 *
0005  C *     COMPUTES DISTANCES TO SATTELLITE            *
0006  C *                                                 *
0007  C ***************************************************
0008  C
0009        SUBROUTINE EB07(I)
0010        IMPLICIT DOUBLE PRECISION (A-H,K-Z)
0011        COMMON/SAT/S(4)
0012        COMMON/DTX/U(4),D(4,4),R(4)
0013  C -----------------------
0014        R(I)=0.
0015        DO 100 J=1,3
0016        D(I,J)=S(J)-U(J)
0017        R(I)=D(I,J)*D(I,J)+R(I)
0018  100   CONTINUE
0019        R(I)=DSQRT(R(I))
0020        D(I,4)=1.0
0021        RETURN
0022        END
```

```
&EB09  T=00004 IS ON CR00011 USING 00012 BLKS R=0000

FTN4X,L,Y
C ***************************************************
C *                FILENAME : &EB09                 *
C *                                                 *
C * MULTIPLICATES TWO MATRICES --> H*G=A            *
C *                                                 *
C ***************************************************
C
      SUBROUTINE EB09
      IMPLICIT DOUBLE PRECISION (A-H,L-Z)
      COMMON/MAT/G(4,4),H(4,4),A(4,4)
C -------------------
      DO 100 I=1,4
      DO 100 J=1,4
      TEMP=0.0D0
      DO 101 K=1,4
      TEMP=TEMP+H(I,K)*G(K,J)
101   CONTINUE
      A(I,J)=TEMP
100   CONTINUE
      RETURN
      END
```

```
&EB12  T=00004 IS ON CR00011 USING 00012 BLKS R=0000

FTN4X,L,Y
C ***********************************************
C *                FILENAME : &EB12              *
C *                                              *
C * ROUTINE TO CONVERT SECONDS TO HOURS MIN SEC. *
C *                                              *
C ***********************************************
C
      SUBROUTINE EB12 (TMIN,THR)
      IMPLICIT DOUBLE PRECISION (A-Z)
      REAL THR
      INTEGER*4 HR,MIN,SEC
C ----------------------
      THR=(SNGL(TMIN)/3600.0)+.00005
      HR=INT(THR)
      THR=(THR-HR)*60
      MIN=INT(THR)
      THR=(THR-MIN)*60
      SEC=INT(THR)
      THR=HR+(MIN*.01)+(SEC*.0001)+.00005
      RETURN
      END
```

```
&EB14  T=00004 IS ON CR00011 USING 00024 BLKS R=0000

FTN4,L,Y
C ***********************************************
C *              FILENAME : &EB14                *
C * READS ALMANAC-DATA FROM DATA-TAPE,CONVERTS IT  *
C * INTO DOUBLE PRECISION AND CREATES ARRAY WITH   *
C * DATA FOR MAINPROGRAM.                          *
C *                                                *
C ***********************************************
C
      SUBROUTINE EB14
      DOUBLE PRECISION AD,A,B,C,DTC
      COMMON/ALM/AD(14,24),ID1(24)
      COMMON/NAC/A,B,C,DTC
      DIMENSION IALMAC(12,24),ISVPRN(24),ID(24)
      INTEGER ALMAC(24,24),IAR(2),IBUF(310),IDARY(24)
      EQUIVALENCE(IBUF(16),IALMAC)
      REAL OMD,OMO,MO
      INTEGER H
      DATA PI/3.14159265/,ISVPRN/4,7,6,8,5,9,18*0/
C
C  ISTAD IS THE STARTING ADDRESS OF ALMANAC DATA AND IWCNT IS THE NUMBER
C  OF WORDS IN THE ALMANAC DATA.
C
      DATA ISTAD/172700B/,IWCNT/310/,LU8/8/
C
C  CALL EXEC TO READ IN ALMANAC DATA.
C
100   CALL EXEC(1,LU8,IBUF,IWCNT)
      CALL ABREG(IERR,NWRD)
      IF(NWRD .NE. 288) GO TO 100
      DO 40 J=1,24
          DO 50 I=1,12
          I2=2*I
          I1=I2-1
          ITMP=IALMAC(I,J)
          ALMAC(I1,J)=IAND(ITMP,377B)
          ALMAC(I2,J)=ISHFT(ITMP,-8)
50        CONTINUE
40    CONTINUE
      WRITE(16,120)
      READ(16,*)DTC
C
C  GET SATELLITE ID(PRN NUMBER) FROM ALMANAC DATA.
C
      DO 10 J=1,24
          DO 20 I=1,24
          ID(I)=ALMAC(1,I)
C
C  TEST TO SEE IF SATELLITE IS IN PRN NUMBER ORDER.
C
          IF(ID(I).EQ. 0)GO TO 20
          IF(ID(I).EQ. ISVPRN(J))GO TO 30
20        CONTINUE
      GO TO 10
C
C  GET ECENTRICITY OF SATELLITE ORBIT FROM ALMANAC DATA.
C
30    IAR(2)=IOR(ISHFT(ALMAC(2,I),8),ALMAC(3,I))
```

```
0059          IDARY(J)=ID
0060          IAR(1)=0
0061          ID1(J)=ID(I)
0062    C
0063    C  ECENTRICITY IS SCALED BY A FACTOR OF 2**-21.
0064    C
0065          E=DINTF(IAR)*4.7683716E-7
0066    C
0067    C  GET TIME OF APPLICABILITY OF THE ALMANAC PARAMETERS.
0068    C
0069          IAR(2)=ALMAC(4,I)
0070          IAR(1)=0
0071    C
0072    C  TOA(SECONDS) IS SCALED BY A FACTOR OF 2**12.
0073    C
0074          TOA=DINTF(IAR)*4096.0
0075    C
0076    C  GET SATELLITE ORBIT INCLINATION FROM ALMANAC DATA.
0077    C
0078          IAR(2)=IOR(ISHFT(ALMAC(5,I),8),ALMAC(6,I))
0079          IAR(1)=0
0080          IF(IAR(2) .LT. 0) IAR(1)=-1
0081    C
0082    C  DI(SEMICIRCLES) IS SCALED BY A FACTOR OF 2**-19 INCREMENTED
0083    C  BY 1/3 AND MULTIPLIED BY PI TO YIELD RADIANS.
0084    C
0085          DI=((DINTF(IAR)*1.9073486E-6)+(1.0/3.0))*PI
0086    C
0087    C  GET DRIFT RATE OF LONGITUDE OF ASCENDING NODE OF THE ORBIT
0088    C  FROM ALMANAC DATA.
0089    C
0090          IAR(1)=0
0091          IAR(2)=IOR(ISHFT(ALMAC(7,I),8),ALMAC(8,I))
0092          IF(IAR(2) .LT. 0) IAR(1)=-1
0093    C
0094    C  OMD (SEMICIRCLES/SEC) IS SCALED BY A FACTOR OF 2**-38 AND
0095    C  MULTIPLIED BY PI TO YIELD RADIANS/SEC.
0096    C
0097          OMD=DINTF(IAR)*PI*3.6379788E-12
0098    C
0099    C  GET HEALTH WORD FROM ALMANAC DATA.
0100    C
0101          H=ALMAC(9,I)
0102    C
0103    C  GET THE SQUARE ROOT OF THE SEMI-MAJOR AXIS OF THE ORBIT
0104    C  FROM ALMANAC DATA.
0105    C
0106          IAR(1)=ALMAC(10,I)
0107          IAR(2)=IOR(ISHFT(ALMAC(11,I),8),ALMAC(12,I))
0108    C
0109    C  RA(METERS) IS SCALED BY A FACTOR OF 2**-11.
0110    C
0111          RA=DINTF(IAR)*4.8828125E-4
0112    C
0113    C  GET THE RIGHT ASCENSION OF THE ORBIT FROM ALMANAC DATA.
0114    C
0115          IAR(2)=IOR(ISHFT(ALMAC(14,I),8),ALMAC(15,I))
0116          IAR(1)=ALMAC(13,I)
0117          IF(IAND(ALMAC(13,I),200B).NE.0)IAR(1)=IOR(IAR(1),177400B)
0118    C
```

```
C  OMO(SEMICIRCLES)IS SCALED BY A FACTOR OF 2**-23 AND
C  MULTIPLIED BY PI TO YIELD RADIANS.
C
      OMO=DINTF(IAR)*PI*1.1920929E-7
C
C  GET THE ARGUMENT OF PERIGEE FROM ALMANAC DATA.
C
      IAR(1)=ALMAC(16,I)
      IAR(2)=IOR(ISHFT(ALMAC(17,I),8),ALMAC(18,I))
      IF(IAND(IAR(1),200B).NE.0)IAR(1)=IOR(IAR(1),177400B)
C
C  W(SEMICIRCLES) IS SCALED BY A FACTOR OF 2**-23 AND
C  MULTIPLIED BY PI TO YIELD RADIANS.
C
      W=DINTF(IAR)*PI*1.1920929E-7
C
C  GET MEAN ANOMALY AT TOA FROM ALMANAC DATA.
C
      IAR(1)=ALMAC(19,I)
      IF(IAND(IAR(1),200B).NE.0)IAR(1)=IOR(IAR(1),177400B)
      IAR(2)=IOR(ISHFT(ALMAC(20,I),8),ALMAC(21,I))
C
C  MO(SEMICIRCLES) IS SCALED BY A FACTOR OF 2**-23 AND
C  MULTIPLIED BY PI TO YIELD RADIANS.
C
      MO=DINTF(IAR)*PI*1.1920929E-7
      AD(1,J)=DBLE(E)
      AD(2,J)=DBLE(TOA)
      AD(3,J)=DBLE(DI)
      AD(4,J)=DBLE(OMD)
      AD(5,J)=DBLE(RA)
      AD(6,J)=DBLE(OMO)
      AD(7,J)=DBLE(W)
      AD(8,J)=DBLE(MO)
10    CONTINUE
      RETURN
120   FORMAT(" ENTER COLLECTION DATE FOR ALMANAC DATA(NTH DAY)_")
      END
```

```
&HD01  T=00004 IS ON CR00011 USING 00018 BLKS R=0000

      FTN4X,L,Y
      C ***************************************************
      C *                FILENAME : &HD01                 *
      C *                                                 *
      C * COMPUTES THE G-MATRIX,INVERTES AND TRANSPONES   *
      C * IT AND COMPUTES THE HDOP AND GDOP.              *
      C *  FORMULAS FROM : MILLIKEN/ZOLLER                *
      C *                  "NAVSTAR OPERATION"            *
      C *                                                 *
      C ***************************************************
      C
            SUBROUTINE HD01
            IMPLICIT DOUBLE PRECISION (A-H,K-M,O-Z)
            DIMENSION IL(4),IM(4)
            COMMON/POS/LAT,LON,ALT
            COMMON/DTX/U(4),D(4,4)
            COMMON/CNST/PI,RTD
            COMMON/BLG/G(4,4),N              !  FOR MATRIXINVERSION
            COMMON/MAT/A(4,4),AT(4,4),AAT(4,4)
            COMMON/HDOP/HDOP,INS,GDOP
            N=4
      C
      C ********** COMPUTATION OF A (=G) **********
      C
            A1=DSIN(LON)
            A2=DCOS(LON)
            A3=DSIN(LAT)
            A4=DCOS(LAT)
            IF(INS.EQ.4) GOTO 1000
            DO 102 I=1,4
            D(4,I)=U(I)
      102   CONTINUE
      1000  CONTINUE
            DO 100 I=1,4
            A5=1./DSQRT(D(I,1)*D(I,1)+D(I,2)*D(I,2)+D(I,3)*D(I,3))
            A(I,1)=(-D(I,1)*A1+D(I,2)*A2)*A5
            A(I,2)=(-D(I,1)*A3*A2-D(I,2)*A3*A1+D(I,3)*A4)*A5
            A(I,3)=(D(I,1)*A4*A2+D(I,2)*A4*A1+D(I,3)*A3)*A5
            A(I,4)=1.
      100   CONTINUE
      C
      C ********** MATRIX-TRANSPONATION **********
      C
            DO 101 I=1,4
            DO 101 J=1,4
            AT(I,J)=A(J,I)
      101   CONTINUE
      C
      C ********** MULTIPLICATION OF MATRIZES (AT*A)=AAT **********
      C
            CALL EB09
      C
      C ********** INVERSION OF AAT AND COMPUTATION OF HDOP **********
      C
            DO 103 I=1,4
            DO 103 J=1,4
            G(I,J)=AAT(I,J)
      103   CONTINUE
```

```
      CALL MINVD(G,N,DET,IL,IM)
      IF(DET.EQ.0.0D0) GOTO 1001
      HDOP=DSQRT(G(1,1)+G(2,2))
      GDOP=DSQRT(G(1,1)+G(2,2)+G(3,3)+G(4,4))
      RETURN
 1001 CONTINUE
      WRITE (6,1)
      WRITE (16,1)
 1    FORMAT ( " ****************** "
     1/         " +MATRIX SINGULAR* "
     2/         " ****************** ")
      RETURN
      END
```

```
&MINVD T=00003 IS ON CR00011 USING 00024 BLKS R=0000

0001  FTN4X,L,Y
0002  C
0003  C     ..............................................................
0004  C
0005  C        SUBROUTINE MINVD          HP-VERSION
0006  C
0007  C        PURPOSE
0008  C           INVERT A MATRIX
0009  C
0010  C        USAGE
0011  C           CALL MINVD(A,N,D,L,M)
0012  C
0013  C        DESCRIPTION OF PARAMETERS
0014  C           A - INPUT MATRIX, DESTROYED IN COMPUTATION AND REPLACED BY
0015  C               RESULTANT INVERSE.
0016  C           N - ORDER OF MATRIX A
0017  C           D - RESULTANT DETERMINANT
0018  C           L - WORK VECTOR OF LENGTH N
0019  C           M - WORK VECTOR OF LENGTH N
0020  C
0021  C        REMARKS
0022  C           MATRIX A MUST BE A GENERAL MATRIX
0023  C
0024  C        SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
0025  C           NONE
0026  C
0027  C        METHOD
0028  C           THE STANDARD GAUSS-JORDAN METHOD IS USED. THE DETERMINANT
0029  C           IS ALSO CALCULATED. A DETERMINANT OF ZERO INDICATES THAT
0030  C           THE MATRIX IS SINGULAR.
0031  C
0032  C     ..............................................................
0033  C
0034        SUBROUTINE MINVD(A,N,D,L,M)
0035        IMPLICIT DOUBLE PRECISION (A-H,O-T,V-Z)
0036        IMPLICIT REAL*4 (U)
0037        DIMENSION A(1),L(1),M(1)
0038  C
0039  C        SEARCH FOR LARGEST ELEMENT
0040  C
0041        D=1.0D0
0042        NK=-N
0043        DO 80 K=1,N
0044        NK=NK+N
0045        L(K)=K
0046        M(K)=K
0047        KK=NK+K
0048        BIGA=A(KK)
0049        DO 20 J=K,N
0050        IZ=N*(J-1)
0051        DO 20 I=K,N
0052        IJ=IZ+I
0053     10 IF(DABS(BIGA)-DABS(A(IJ))) 15,20,20
0054     15 BIGA=A(IJ)
0055        L(K)=I
0056        M(K)=J
0057     20 CONTINUE
0058  C
```

```
C          INTERCHANGE ROWS
C
      J=L(K)
      IF(J-K) 35,35,25
   25 KI=K-N
      DO 30 I=1,N
      KI=KI+N
      HOLD=-A(KI)
      JI=KI-K+J
      A(KI)=A(JI)
   30 A(JI) =HOLD
C
C          INTERCHANGE COLUMNS
C
   35 I=M(K)
      IF(I-K) 45,45,38
   38 JP=N*(I-1)
      DO 40 J=1,N
      JK=NK+J
      JI=JP+J
      HOLD=-A(JK)
      A(JK)=A(JI)
   40 A(JI) =HOLD
C
C          DIVIDE COLUMN BY MINUS PIVOT (VALUE OF PIVOT ELEMENT IS
C          CONTAINED IN BIGA)
C
   45 IF(BIGA) 48,46,48
   46 D=0.0D0
      RETURN
   48 DO 55 I=1,N
      IF(I-K) 50,55,50
   50 IK=NK+I
      A(IK)=A(IK)/(-BIGA)
   55 CONTINUE
C
C          REDUCE MATRIX
C
      DO 65 I=1,N
      IK=NK+I
      HOLD=A(IK)
      IJ=I-N
      DO 65 J=1,N
      IJ=IJ+N
      IF(I-K) 60,65,60
   60 IF(J-K) 62,65,62
   62 KJ=IJ-I+K
      A(IJ)=HOLD*A(KJ)+A(IJ)
   65 CONTINUE
C
C          DIVIDE ROW BY PIVOT
C
      KJ=K-N
      DO 75 J=1,N
      KJ=KJ+N
      IF(J-K) 70,75,70
   70 A(KJ)=A(KJ)/BIGA
   75 CONTINUE
C
C          PRODUCT OF PIVOTS
```

```
C
      D=D*BIGA
C
C        REPLACE PIVOT BY RECIPROCAL
C
      A(KK)=1.0D0/BIGA
   80 CONTINUE
C
C        FINAL ROW AND COLUMN INTERCHANGE
C
      K=N
  100 K=(K-1)
      IF(K) 150,150,105
  105 I=L(K)
      IF(I-K) 120,120,108
  108 JQ=N*(K-1)
      JR=N*(I-1)
      DO 110 J=1,N
      JK=JQ+J
      HOLD=A(JK)
      JI=JR+J
      A(JK)=-A(JI)
  110 A(JI) =HOLD
  120 J=M(K)
      IF(J-K) 100,100,125
  125 KI=K-N
      DO 130 I=1,N
      KI=KI+N
      HOLD=A(KI)
      JI=KI-K+J
      A(KI)=-A(JI)
  130 A(JI) =HOLD
      GO TO 100
  150 RETURN
      END
```

```
&DINTF T=00004 IS ON CR00013 USING 00003 BLKS R=0000

0001  ASMB,L
0002        NAM   DINTF
0003        ENT   DINTF
0004        EXT   .FLTD
0005  DINTF NOP
0006        ISZ   DINTF
0007        LDA   DINTF,I
0008        STA   IBF
0009        ISZ   DINTF
0010        DLD   IBF,I
0011        AND   B377
0012        JSB   .FLTD
0013        JMP   DINTF,I
0014  IBF   BSS   1
0015  B377  OCT   377
0016        END
```

```
&ENU   T=00003 IS ON CR00002 USING 00023 BLKS R=0000

0001  FTN4,M,Y
0002  C*********************************************************************
0003  C                                                                    *
0004  C        THIS SUBROUTINE FILLS THE ENUP MATRIX.                      *
0005  C                                                                    *
0006  C        MICHAEL J. MAGROGAN  CO-OP  ACT-100D  FEBRUARY 1981         *
0007  C                                                                    *
0008  C*********************************************************************
0009        SUBROUTINE ENU
0010  C  THIS SUBROUTINE IS PASSED AIRCRAFT POSITION(XP,YP,ZP) FROM THE MAIN
0011  C  PROGRAM(GDOP) AND RETURNS THE FILLED ENUP MATRIX.
0012        COMMON /COORD/ ENUP(3,3),XP,YP,ZP,H(4,4),HT(4,4),HPROD(4,4),
0013       +LSAT(4),XS(4),YS(4),ZS(4),HDOPV,GDOPV
0014        DOUBLE PRECISION ENUP,XP,YP,ZP,H,HT,HPROD,XS,YS,ZS,HDOPV,GDOPV
0015        DOUBLE PRECISION WP,TANPHI,COSLAM,SINLAM,COSPHI,SINPHI,ESQU
0016        DATA ESQU/0.00669431778D0/
0017  C  CALCULATE THE TERMS NEEDED TO FILL ENUP MATRIX.
0018        WP=DSQRT(XP**2+YP**2)
0019        TANPHI=ZP/WP
0020        COSLAM=XP/WP
0021        SINLAM=YP/WP
0022        TANPHI=TANPHI/(1.D0-ESQU)
0023        COSPHI=1.D0/DSQRT(1.D0+TANPHI**2)
0024        SINPHI=COSPHI*TANPHI
0025  C  FILL ENUP MATRIX.
0026        ENUP(1,1)=-SINLAM
0027        ENUP(1,2)=COSLAM
0028        ENUP(1,3)=0.D0
0029        ENUP(2,1)=-SINPHI*COSLAM
0030        ENUP(2,2)=-SINPHI*SINLAM
0031        ENUP(2,3)=COSPHI
0032        ENUP(3,1)=COSPHI*COSLAM
0033        ENUP(3,2)=COSPHI*SINLAM
0034        ENUP(3,3)=SINPHI
0035        RETURN
0036        END
```

&HTRAN T=00003 IS ON CR00002 USING 00007 BLKS R=0000

```
FTN4,L,Y
C*********************************************************************
C                                                                    *
C        THIS SUBROUTINE COMPUTES THE TRANSPOSE OF THE H MATRIX.     *
C                                                                    *
C        MICHAEL J. MAGROGAN  CO-OP  ACT-100D  FEBRUARY 1981         *
C                                                                    *
C*********************************************************************
      SUBROUTINE HTRAN
C  THIS SUBROUTINE IS PASSED THE H MATRIX FROM THE MAIN PROGRAM(GDOP)
C  AND RETURNS THE TRANSPOSE OF THE H MATRIX(HT).
      COMMON /COORD/ ENUP(3,3),XP,YP,ZP,H(4,4),HT(4,4),HPROD(4,4),
     +LSAT(4),XS(4),YS(4),ZS(4),HDOPV,GDOPV
      DOUBLE PRECISION ENUP,XP,YP,ZP,H,HT,HPROD,XS,YS,ZS,HDOPV,GDOPV
C  COMPUTE THE TRANSPOSE OF THE H MATRIX.
      DO 10 I=1,4
        DO 20 J=1,4
          HT(I,J)=H(J,I)
   20 CONTINUE
   10 CONTINUE
      RETURN
      END
```

&MLHHT T=00003 IS ON CR00002 USING 00024 BLKS R=0000

```
FTN4,L,Y
C*****************************************************************
C                                                                 *
C        THIS SUBROUTINE MULTILLIES THE H AND H TRANSPOSE MATRICES *
C                                                                 *
C        MICHAEL J. MAGROGAN CO-OP ACT-100D FEB 1981              *
C                                                                 *
C*****************************************************************
      SUBROUTINE MLHHT
C THIS SUBROUTINE IS PASSED THE H AND H TRANSPOSE MATRICES FROM THE
C NAIN PROGRAM (GDOP) AND RETURNS THE PRODUCT MATRIX (HPROD)
      COMMON/COORD/ENUP(3,3),XP,YP,ZP,H(4,4),HT(4,4),HPROD(4,4),
     +LSAT(4),XS(4),YS(4),ZS(4),HDOPV,GDOPV
      DOUBLE PRECISION ENUP,XP,YP,ZP,H,HT,HPROD,XS,YS,ZS,HDOPV,GDOPV
C MULTIPLY THE H AND HT MATRICES
      DO 10 I=1,4
      DO 10 J=1,4
      HPROD(I,J)=0.D0
      DO 10 K=1,4
      HPROD(I,J)=HPROD(I,J)+HT(I,K)*H(K,J)
10    CONTINUE
      RETURN
      END
```

&INVHP T=00003 IS ON CR00002 USING 00024 BLKS R=0000

```
FTN4,L,Y
C*****************************************************************
C                                                                 *
C       THIS SUBROUTINE WAS WRITTEN BY CHE S. WONG IT IS IN HIS   *
C       PAPER "A GPS ALMANAC", HE CALLS THIS SUBROUTINE "MATI".   *
C                                                                 *
C                                                                 *
C       MICHAEL J. MAGROGAN  CO-OP  ACT-100D  FEBRUARY 1981       *
C                                                                 *
C*****************************************************************
      SUBROUTINE INVHP
C  'INVHPR' INVERTS THE H PRODUCT MATRIX AND SUBSTITUTES THE
C  RESULTS BACK INTO THE H PRODUCT MATRIX.
C
C  THIS SUBROUTINE IS PASSED THE H PRODUCT MATRIX(HPROD) FROM THE
C  MAIN PROGRAM(GDOP) AND RETURNS THE MATRIX INVERSE OF THE H
C  PRODUCT MATRIX(HPROD).
      COMMON /COORD/ENUP(3,3),XP,YP,ZP,H(4,4),HT(4,4),HPROD(4,4),
     +LSAT(4),XS(4),YS(4),ZS(4),HDOPV,GDOPV,DET
      DOUBLE PRECISION ENUP,XP,YP,ZP,H,HT,HPROD,XS,YS,ZS,HDOPV,GDOPV
      DOUBLE PRECISION PIVOT,ONE,ZERO,T,DET
      DIMENSION INDEX(4,2),IPVOT(4),PIVOT(4)
      DATA ONE/1.D0/,ZERO/0.D0/
      DET=1.D0
C  CLEAR IPVOT VECTOR.
      DO 10 I=1,4
        IPVOT(I)=0
   10 CONTINUE
C  FOLLOWING 12 STATEMENTS SEARCH FOR PIVOT ELEMENT.
      DO 20 I=1,4
        T=ZERO
        DO 30 J=1,4
          IF(IPVOT(J)-1) 31,30,31
   31     DO 40 K=1,4
            IF(IPVOT(K)-1) 41,40,91
   41       IF(DABS(T)-DABS(HPROD(J,K))) 42,40,40
   42       IROW=J
            ICOL=K
            T=HPROD(J,K)
   40 CONTINUE
   30 CONTINUE
        IPVOT(ICOL)=IPVOT(ICOL)+1
C  FOLLOWING 15 STATEMENTS PUT PIVOT ELEMENT ON DIAGONAL.
        IF(IROW-ICOL) 43,51,43
   43   DET=-DET
          DO 50 L=1,4
            T=HPROD(IROW,L)
            HPROD(IROW,L)=HPROD(ICOL,L)
   50       HPROD(ICOL,L)=T
   51   INDEX(I,1)=IROW
        INDEX(I,2)=ICOL
        PIVOT(I)=HPROD(ICOL,ICOL)
        DET=DET*PIVOT(I)
C  THE FOLLOWING 6 STATEMENTS DIVIDE PIVOT ROW
C  BY PIVOT ELEMENT.
        HPROD(ICOL,ICOL)=ONE
          DO 60 L=1,4
   60       HPROD(ICOL,L)=HPROD(ICOL,L)/PIVOT(I)
```

```
C  FOLLWOING 10 STATEMENTS TO REDUCE NON-PIVOT ROWS.
            DO 20 LI=1,4
              IF(LI-ICOL) 21,20,21
   21         T=HPROD(LI,ICOL)
              HPROD(LI,ICOL)=ZERO
              DO 70 L=1,4
   70           HPROD(LI,L)=HPROD(LI,L)-HPROD(ICOL,L)*T
   20 CONTINUE
C  FOLLOWING 11 STATEMENTS TO INTERCHANGE COLUMNS.
      DO 80 I=1,4
      L=4-I+1
      IF(INDEX(L,1)-INDEX(L,2))81,80,81
81    JROW=INDEX(L,1)
      JCOL=INDEX(L,2)
      DO90K=1,4
      T=HPROD(K,JROW)
          HPROD(K,JROW)=HPROD(K,JCOL)
          HPROD(K,JCOL)=T
   90 CONTINUE
   80 CONTINUE
   91 RETURN
      END
```

APPENDIX D

EXAMPLES OF DATA FILES

Almanac Files

```
A557    T=00004 IS ON CR00002 USING 00002 BLKS R=0000

0001     57.000000        5
0002       0.23045540D-02     0.33177600D+06     0.11124156D+01    -0.61945435D-08
0003       0.51536416D+04     0.56938994D+00    -0.20916948D+01     0.69497383D+00
0004


A657    T=00004 IS ON CR00002 USING 00002 BLKS R=0000

0001     57.000000        6
0002       0.15506744D-02     0.33177600D+06     0.11071186D+01     0.64574115D-08
0003       0.51536494D+04    -0.15504746D+01     0.20494380D+01    -0.10743284D+01
0004


A857    T=00004 IS ON CR00002 USING 00002 BLKS R=0000

0001     57.000000        8
0002       0.22068024D-02     0.33177600D+06     0.11034214D+01    -0.63431207D-08
0003       0.51536484D+04     0.56528795D+00    -0.19833443D+00     0.35664302D+00
0004


A957    T=00004 IS ON CR00002 USING 00002 BLKS R=0000

0001     57.000000        9
0002       0.81076622D-02     0.33177600D+06     0.11036611D+01    -0.65031278D-08
0003       0.51536670D+04    -0.15456643D+01     0.13524077D+01    -0.11417092D+01
0004
```

URE File

```
U557    T=00004 IS ON CR00002 USING 00024 BLKS R=0000

0001   11
0002      .1050E+02    .1200E+01
0003      .1075E+02    .1330E+01
0004      .1100E+02    .2600E+00
0005      .1125E+02   -.5000E+00
0006      .1150E+02   -.6700E+00
0007      .1175E+02   -.8400E+00
0008      .1200E+02   -.1080E+01
0009      .1225E+02   -.8000E+00
0010      .1250E+02   -.2500E+00
0011      .1275E+02   -.8700E+00
0012      .1300E+02   -.9000E+00
```

```
PROGRAM *EBGH*        VERSION A     EXAMPLES OF PROGRAM OUTPUT
^^^^^^^^^^^^^^

USER-COORDINATES :
LAT =  39.500000       LON = -74.500000       ALT =  100.00000
XP  =  1317011.6       YP  = -4748990.4       ZP  =  4035321.8
SAT.NO : 1 XS =  -.18330000D+08 YS =  -.19150000D+08 ZS =   .21860000D+07
SAT.NO : 2 XS =  -.28430000D+07 YS =  -.21740000D+08 ZS =   .14930000D+08
SAT.NO : 3 XS =   .97110000D+07 YS =  -.72340000D+07 ZS =   .23660000D+08
SAT.NO : 4 XS =  -.10730000D+08 YS =  -.59120000D+07 ZS =   .23340000D+08

H-MATRIX
 -.93250784D+00  -.28302801D+00   .22433071D+00   .10000000D+01
 -.41485437D+00  -.63121006D-01   .90769576D+00   .10000000D+01
  .34551315D+00   .56740932D+00   .74744052D+00   .10000000D+01
 -.52313791D+00   .71235238D+00   .46784699D+00   .10000000D+01

H-TRANSPOSE-MATRIX
 -.93250784D+00  -.41485437D+00   .34551315D+00  -.52313791D+00
 -.28302801D+00  -.63121006D-01   .56740932D+00   .71235238D+00
  .22433071D+00   .90769576D+00   .74744052D+00   .46784699D+00
  .10000000D+01   .10000000D+01   .10000000D+01   .10000000D+01

HT*H-MATRIX
  .14347276D+01   .11350071D+00  -.57224967D+00  -.15249870D+01
  .11350071D+00   .91348837D+00   .63659009D+00   .93361268D+00
 -.57224967D+00   .63659009D+00   .16517840D+01   .23473140D+01
 -.15249870D+01   .93361268D+00   .23473140D+01   .40000000D+01

INVERTED H*HT-MATRIX
  .36502949D+01  -.19983312D+01  -.36472862D+01   .39984113D+01
 -.19983312D+01   .25934803D+01   .15117074D+01  -.22542968D+01
 -.36472862D+01   .15117074D+01   .74466003D+01  -.61132306D+01
  .39984113D+01  -.22542968D+01  -.61132306D+01   .58879592D+01
HDOP =    2.49875 PDOP =    3.70005 GDOP =    4.42474


PROGRAM *EBGH*        VERSION A
^^^^^^^^^^^^^^

USER-COORDINATES :
LAT =  39.500000       LON = -74.500000       ALT =  100.00000
XP  =  1317011.6       YP  = -4748990.4       ZP  =  4035321.8
SAT.NO : 1 XS =  -.18330000D+08 YS =  -.19150000D+08 ZS =   .21860000D+07
SAT.NO : 2 XS =  -.28430000D+07 YS =  -.21740000D+08 ZS =   .14930000D+08
SAT.NO : 3 XS =   .97110000D+07 YS =  -.72340000D+07 ZS =   .23660000D+08

H-MATRIX
 -.93250784D+00  -.28302801D+00   .22433071D+00   .10000000D+01
 -.41485437D+00  -.63121006D-01   .90769576D+00   .10000000D+01
  .34551315D+00   .56740932D+00   .74744052D+00   .10000000D+01
  .00000000D+00   .00000000D+00  -.10000000D+01   .00000000D+00

H-TRANSPOSE-MATRIX
 -.93250784D+00  -.41485437D+00   .34551315D+00   .00000000D+00
 -.28302801D+00  -.63121006D-01   .56740932D+00   .00000000D+00
  .22433071D+00   .90769576D+00   .74744052D+00  -.10000000D+01
  .10000000D+01   .10000000D+01   .10000000D+01   .00000000D+00

HT*H-MATRIX
```

```
 .11610544D+01    .48615925D+00  -.32750117D+00  -.10018491D+01
 .48615925D+00    .40604245D+00   .30331817D+00   .22126030D+00
-.32750117D+00    .30331817D+00   .24329032D+01   .18794670D+01
-.10018491D+01    .22126030D+00   .18794670D+01   .30000000D+01

INVERTED H*HT-MATRIX
 .54713155D+02  -.77387582D+02  -.29281686D+01   .25813506D+02
-.77387582D+02   .11217536D+03   .37852890D+01  -.36488319D+02
-.29281686D+01   .37852890D+01   .10000000D+01  -.18835280D+01
 .25813506D+02  -.36488319D+02  -.18835280D+01   .12824894D+02
HDOP =    12.91853 PDOP =    12.95718 GDOP =    13.44297
```

```
PROGRAM *EBGH*       VERSION B
**************

FILENAME : !2/23/

RECORD-NO. :    1
TIME        :     .240295D+05 SEC. ==>    6.4029 HOURS GMT
USERPOSITION  --->      .13124184D+07  -.47538986D+07    .40310172D+07
SATELLITE-POSITIONS :
          XS                YS                ZS
 6  -.27384016D+07  -.24919635D+08   .86777768D+07
 9  -.99460549D+07  -.12005477D+08   .21292195D+08
 8   .14541746D+08  -.34133485D+07   .22000845D+08

H-MATRIX
 -.43966564D+00  -.38309360D+00   .81236286D+00   .10000000D+01
 -.58508400D+00   .49393319D+00   .64320037D+00   .10000000D+01
  .58641386D+00   .55738190D+00   .58774502D+00   .10000000D+01
  .00000000D+00   .00000000D+00  -.10000000D+01   .00000000D+00

H-TRANSPOSE-MATRIX
 -.43966564D+00  -.58508400D+00   .58641386D+00   .00000000D+00
 -.38309360D+00   .49393319D+00   .55738190D+00   .00000000D+00
  .81236286D+00   .64320037D+00   .58774502D+00  -.10000000D+01
  .10000000D+01   .10000000D+01   .10000000D+01   .00000000D+00

HT*H-MATRIX
  .87951037D+00   .20629715D+00  -.38883246D+00  -.43833579D+00
  .20629715D+00   .70140529D+00   .33408543D+00   .66822149D+00
 -.38883246D+00   .33408543D+00   .24190843D+01   .20433082D+01
 -.43833579D+00   .66822149D+00   .20433082D+01   .30000000D+01

INVERTED H*HT-MATRIX
  .15438569D+01  -.84117185D+00   .36562251D-01   .38803629D+00
 -.84117185D+00   .23159976D+01   .19894412D+00  -.77427307D+00
  .36562251D-01   .19894412D+00   .10000000D+01  -.72007348D+00
  .38803629D+00  -.77427307D+00  -.72007348D+00   .10529361D+01
HDOP =    1.96465 PDOP =    2.20451 GDOP =    2.43162


RECORD-NO. :    2
TIME        :     .241645D+05 SEC. ==>    6.4244 HOURS GMT
USERPOSITION  --->      .13137653D+07  -.47567960D+07    .40272182D+07
SATELLITE-POSITIONS :
          XS                YS                ZS
 6  -.27577762D+07  -.25088535D+08   .81721616D+07
 9  -.99341777D+07  -.12380684D+08   .21084965D+08
 8   .14774962D+08  -.32576402D+07   .21870541D+08

H-MATRIX
 -.44157237D+00  -.40434632D+00   .80094812D+00   .10000000D+01
 -.59021561D+00   .47760913D+00   .65079571D+00   .10000000D+01
  .59703183D+00   .55484459D+00   .57939665D+00   .10000000D+01
  .00000000D+00   .00000000D+00  -.10000000D+01   .00000000D+00

H-TRANSPOSE-MATRIX
 -.44157237D+00  -.59021561D+00   .59703183D+00   .00000000D+00
 -.40434632D+00   .47760913D+00   .55484459D+00   .00000000D+00
  .80094812D+00   .65079571D+00   .57939665D+00  -.10000000D+01
  .10000000D+01   .10000000D+01   .10000000D+01   .00000000D+00
```

```
HT*H-MATRIX
  .89978762D+00   .22791568D+00  -.39186811D+00  -.43475615D+00
  .22791568D+00   .69945895D+00   .30844064D+00   .62810740D+00
 -.39186811D+00   .30844064D+00   .24007534D+01   .20311405D+01
 -.43475615D+00   .62810740D+00   .20311405D+01   .30000000D+01

INVERTED H*HT-MATRIX
  .15228542D+01  -.84519400D+00   .48530776D-01   .36479000D+00
 -.84519400D+00   .22720379D+01   .17842872D+00  -.71898363D+00
  .48530776D-01   .17842872D+00   .10000000D+01  -.70737127D+00
  .36479000D+00  -.71898363D+00  -.70737127D+00   .10156547D+01
HDOP =    1.94805 PDOP =    2.18972 GDOP =    2.41051


RECORD-NO. :   3
TIME       :    .242855D+05 SEC. ==>   6.4445 HOURS GMT
USERPOSITION  --->     .13146833D+07  -.47595232D+07   .40237264D+07
SATELLITE-POSITIONS :
         XS              YS              ZS
 6  -.27734586D+07  -.25213739D+08   .77753730D+07
 9  -.99268982D+07  -.12705524D+08   .20897338D+08
 8   .15109884D+08  -.30452386D+07   .21672668D+08

H-MATRIX
 -.44289760D+00  -.42060457D+00   .79179133D+00   .10000000D+01
 -.59473423D+00   .46314714D+00   .65710419D+00   .10000000D+01
  .61219330D+00   .55030335D+00   .56779009D+00   .10000000D+01
  .00000000D+00   .00000000D+00  -.10000000D+01   .00000000D+00

H-TRANSPOSE-MATRIX
 -.44289760D+00  -.59473423D+00   .61219330D+00   .00000000D+00
 -.42060457D+00   .46314714D+00   .55030335D+00   .00000000D+00
  .79179133D+00   .65710419D+00   .56779009D+00  -.10000000D+01
  .10000000D+01   .10000000D+01   .10000000D+01   .00000000D+00

HT*H-MATRIX
  .92464773D+00   .24772732D+00  -.39388755D+00  -.42543853D+00
  .24772732D+00   .69424725D+00   .28376167D+00   .59284592D+00
 -.39388755D+00   .28376167D+00   .23811050D+01   .20166856D+01
 -.42543853D+00   .59284592D+00   .20166856D+01   .30000000D+01

INVERTED H*HT-MATRIX
  .14885525D+01  -.84347279D+00   .62223630D-01   .33595049D+00
 -.84347279D+00   .22502180D+01   .16309441D+00  -.67392952D+00
  .62223630D-01   .16309441D+00   .10000000D+01  -.69563438D+00
  .33595049D+00  -.67392952D+00  -.69563438D+00   .98177950D+00
HDOP =    1.93359 PDOP =    2.17687 GDOP =    2.39177


RECORD-NO. :   4
TIME       :    .244363D+05 SEC. ==>   6.4717 HOURS GMT
USERPOSITION  --->     .13116254D+07  -.47538321D+07   .40296685D+07
SATELLITE-POSITIONS :
         XS              YS              ZS
 6  -.27913019D+07  -.25319994D+08   .74149243D+07
 9  -.99219754D+07  -.13107162D+08   .20654291D+08
 8   .15474265D+08  -.28247174D+07   .21444534D+08

H-MATRIX
```

```
 -.44368457D+00  -.43720261D+00   .78230293D+00   .10000000D+01
 -.60048559D+00   .44268187D+00   .66592028D+00   .10000000D+01
  .62875741D+00   .54316541D+00   .55644898D+00   .10000000D+01
  .00000000D+00   .00000000D+00  -.10000000D+01   .00000000D+00

H-TRANSPOSE-MATRIX
 -.44368457D+00  -.60048559D+00   .62875741D+00   .00000000D+00
 -.43720261D+00   .44268187D+00   .54316541D+00   .00000000D+00
  .78230293D+00   .66592028D+00   .55644898D+00  -.10000000D+01
  .10000000D+01   .10000000D+01   .10000000D+01   .00000000D+00

HT*H-MATRIX
  .95277482D+00   .26967525D+00  -.39709986D+00  -.41541275D+00
  .26967525D+00   .68214202D+00   .25500978D+00   .54864466D+00
 -.39709986D+00   .25500978D+00   .23650832D+01   .20046722D+01
 -.41541275D+00   .54864466D+00   .20046722D+01   .30000000D+01

INVERTED H*HT-MATRIX
  .14554206D+01  -.84986195D+00   .77120096D-01   .30542400D+00
 -.84986195D+00   .22516961D+01   .14601366D+00  -.62704469D+00
  .77120096D-01   .14601366D+00   .10000000D+01  -.68424838D+00
  .30542400D+00  -.62704469D+00  -.68424838D+00   .94753181D+00
HDOP =     1.92539 PDOP =     2.16959 GDOP =     2.37795


RECORD-NO. :    5
TIME       :     .245579D+05 SEC. ==>   6.4918 HOURS GMT
USERPOSITION  --->      .13157679D+07  -.47542795D+07   .40295002D+07
SATELLITE-POSITIONS :
          XS                YS                ZS
 6  -.28158738D+07  -.25466048D+08   .68916140D+07
 9  -.99226391D+07  -.13435843D+08   .20444894D+08
 8   .15755228D+08  -.26559606D+07   .21261766D+08

H-MATRIX
 -.44603845D+00  -.45832357D+00   .76875823D+00   .10000000D+01
 -.60568836D+00   .42700231D+00   .67142433D+00   .10000000D+01
  .64110224D+00   .53800090D+00   .54730518D+00   .10000000D+01
  .00000000D+00   .00000000D+00  -.10000000D+01   .00000000D+00

H-TRANSPOSE-MATRIX
 -.44603845D+00  -.60568836D+00   .64110224D+00   .00000000D+00
 -.45832357D+00   .42700231D+00   .53800090D+00   .00000000D+00
  .76875823D+00   .67142433D+00   .54730518D+00  -.10000000D+01
  .10000000D+01   .10000000D+01   .10000000D+01   .00000000D+00

HT*H-MATRIX
  .97682077D+00   .29071318D+00  -.39869106D+00  -.41062457D+00
  .29071318D+00   .68183643D+00   .22881041D+00   .50667964D+00
 -.39869106D+00   .22881041D+00   .23413428D+01   .19874877D+01
 -.41062457D+00   .50667964D+00   .19874877D+01   .30000000D+01

INVERTED H*HT-MATRIX
  .14299077D+01  -.84764592D+00   .88344820D-01   .28035198D+00
 -.84764592D+00   .22115435D+01   .12587245D+00  -.57292608D+00
  .88344820D-01   .12587245D+00   .10000000D+01  -.67166273D+00
  .28035198D+00  -.57292608D+00  -.67166273D+00   .91344361D+00
HDOP =     1.90826 PDOP =     2.15440 GDOP =     2.35688
```

```
PROGRAM *EBGD1*
^^^^^^^^^^^^^^^


H-MATRIX
  .10000000D+01   .00000000D+00   .00000000D+00   .10000000D+01
 -.50000000D+00   .86602500D+00   .00000000D+00   .10000000D+01
 -.50000000D+00  -.86602500D+00   .00000000D+00   .10000000D+01
  .00000000D+00   .00000000D+00   .10000000D+01   .10000000D+01

H-TRANSPOSE-MATRIX
  .10000000D+01  -.50000000D+00  -.50000000D+00   .00000000D+00
  .00000000D+00   .86602500D+00  -.86602500D+00   .00000000D+00
  .00000000D+00   .00000000D+00   .00000000D+00   .10000000D+01
  .10000000D+01   .10000000D+01   .10000000D+01   .10000000D+01

HT*H-MATRIX
  .20000000D+01   .50000000D+00   .50000000D+00   .10000000D+01
  .50000000D+00   .19999993D+01   .50000070D+00   .10000000D+01
  .50000000D+00   .50000070D+00   .19999993D+01   .10000000D+01
  .10000000D+01   .10000000D+01   .10000000D+01   .20000000D+01

INVERTED HT*H-MATRIX
  .66666667D+00  -.34694470D-17   .00000000D+00  -.33333333D+00
 -.34694470D-17   .66666698D+00  -.31083362D-06  -.33333333D+00
  .00000000D+00  -.31083362D-06   .66666698D+00  -.33333333D+00
 -.33333333D+00  -.33333333D+00  -.33333333D+00   .10000000D+01
HDOP =       1.15470076 GDOP =       1.73205090
PROGRAM *EBGD1*
^^^^^^^^^^^^^^^


H-MATRIX
  .10000000D+01   .00000000D+00   .00000000D+00   .10000000D+01
 -.50000000D+00   .86600000D+00   .00000000D+00   .10000000D+01
 -.50000000D+00  -.86600000D+00   .00000000D+00   .10000000D+01
  .10000000D+01   .00000000D+00   .00000000D+00   .10000000D+01

H-TRANSPOSE-MATRIX
  .10000000D+01  -.50000000D+00  -.50000000D+00   .10000000D+01
  .00000000D+00   .86600000D+00  -.86600000D+00   .00000000D+00
  .00000000D+00   .00000000D+00   .00000000D+00   .00000000D+00
  .10000000D+01   .10000000D+01   .10000000D+01   .10000000D+01

HT*H-MATRIX
  .20000000D+01   .50000000D+00   .50000000D+00   .20000000D+01
  .50000000D+00   .19999560D+01   .50004400D+00   .50000000D+00
  .50000000D+00   .50004400D+00   .19999560D+01   .50000000D+00
  .20000000D+01   .50000000D+00   .50000000D+00   .20000000D+01
*****************************************
*HT*H-MATRIX IS SINGULAR (DETERMINANT=0.)*
*****************************************
PROGRAM *EBGD1*
^^^^^^^^^^^^^^


AZIMUTH         ELEVATION
  .0000D+00    .1000D+02
  .2400D+03    .1000D+02
  .1200D+03    .1000D+02
```

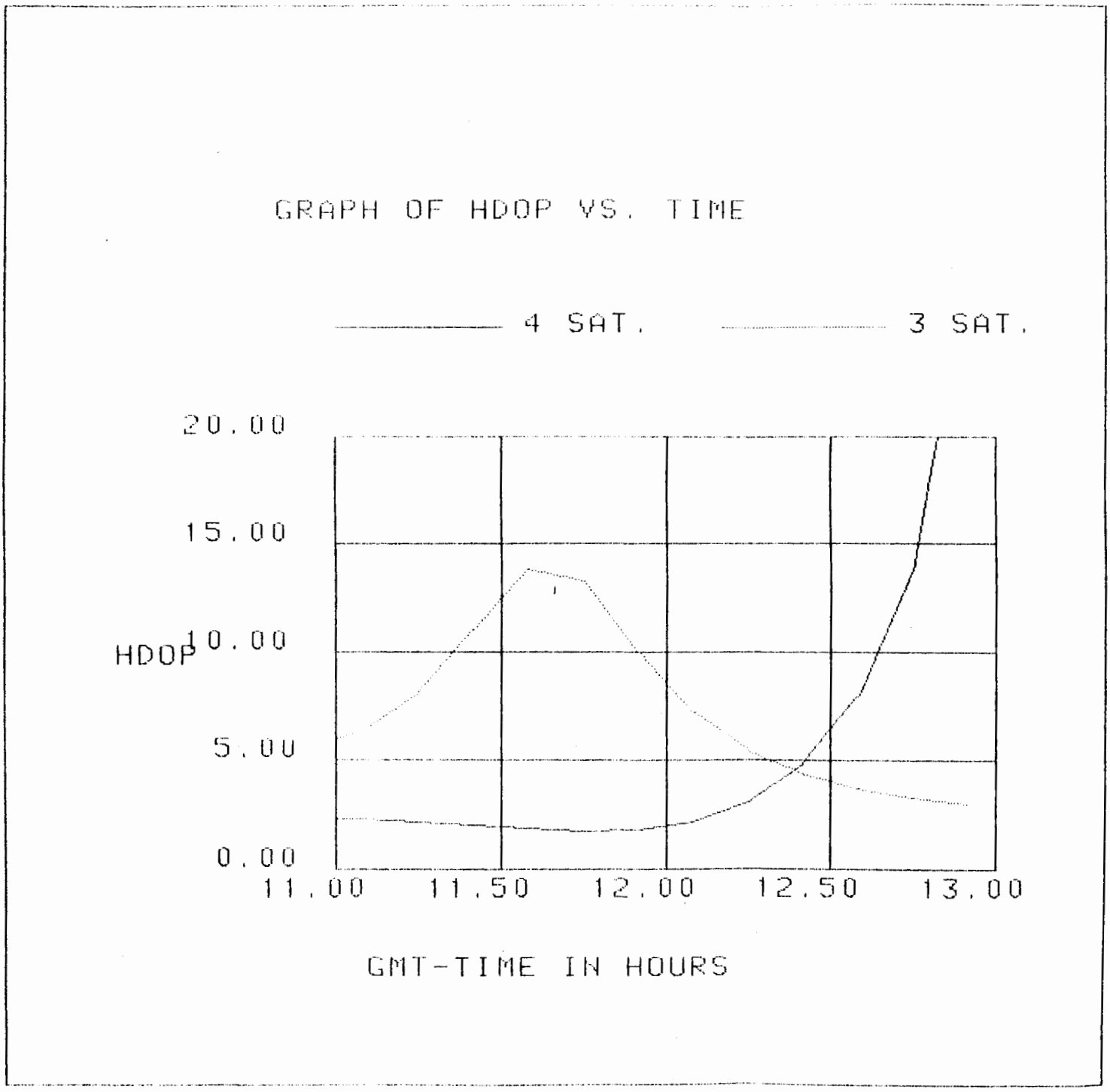
```
  .0000D+00    .9000D+02


H-MATRIX
  .98480775D+00    .00000000D+00    .17364819D+00    .10000000D+01
 -.49240368D+00   -.85286864D+00    .17364819D+00    .10000000D+01
 -.49240397D+00    .85286847D+00    .17364819D+00    .10000000D+01
 -.86246497D-07    .00000000D+00    .10000000D+01    .10000000D+01

H-TRANSPOSE-MATRIX
  .98480775D+00   -.49240368D+00   -.49240397D+00   -.86246497D-07
  .00000000D+00   -.85286864D+00    .85286847D+00    .00000000D+00
  .17364819D+00    .17364819D+00    .17364819D+00    .10000000D+01
  .10000000D+01    .10000000D+01    .10000000D+01    .10000000D+01

HT*H-MATRIX
  .20000000D+01    .54523073D+00    .54523044D+00    .11736481D+01
  .54523073D+00    .20000000D+01    .54523044D+00    .11736482D+01
  .54523044D+00    .54523044D+00    .20000000D+01    .11736482D+01
  .11736481D+01    .11736482D+01    .11736482D+01    .20000000D+01

INVERTED HT*H-MATRIX
  .78369263D+00    .96298448D-01    .96298605D-01   -.57291028D+00
  .96298448D-01    .78369273D+00    .96298655D-01   -.57291041D+00
  .96298605D-01    .96298655D-01    .78369277D+00   -.57291052D+00
 -.57291028D+00   -.57291041D+00   -.57291052D+00    .15085929D+01
HDOP =       1.25195265 GDOP =       1.96460462
```

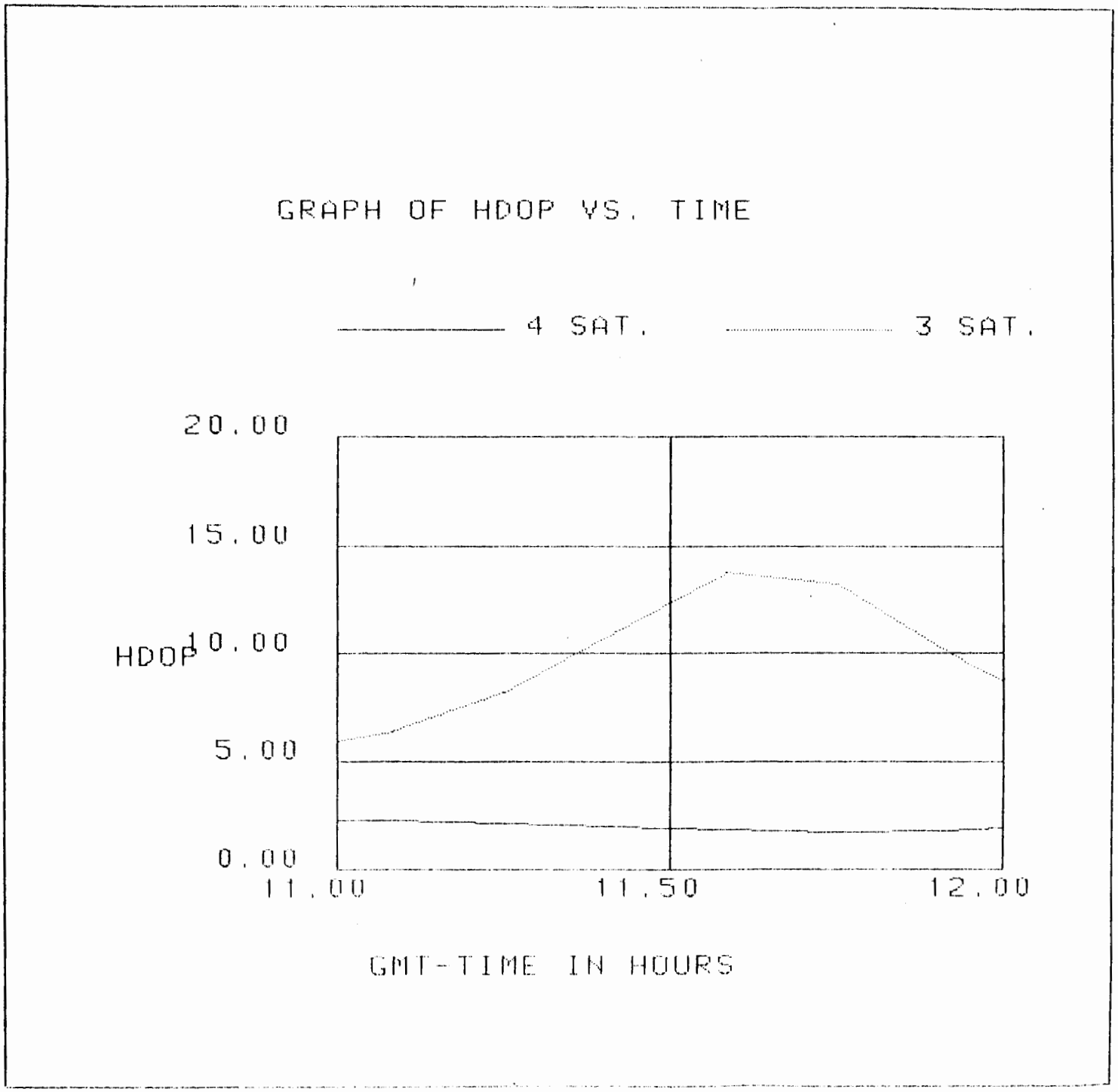
```
PROGRAM   * H D O O *
---------------------

USER-POSITION :
  LATITUDE :  39.500000     DEGREE
  LONGITUDE: -74.500000     DEGREE
  ALTITUDE :  100.00000     FEET

ECEF-COORDINATES :        X              Y              Z
------------------  1317011.6     -4748990.4     4035321.8


USERTIMES :
  START (TSTART):   38700.000     SEC. = 10.45 HOURS
  END (TFIN)    :   46800.000     SEC. = 13.00 HOURS
  INCR. (TDEL)  :   600.00000     SEC
  DATE (DTU)    :   57.000000     DAYS

   USED ALMANACS          DTC=   57.   TC=  20000.
   -------------
SAT. ID :   5                     6                     8                     9
            .2305D-02             .1551D-02             .2207D-02             .8108D-02
            .3318D+06             .3318D+06             .3318D+06             .3318D+06
            .1112D+01             .1107D+01             .1103D+01             .1104D+01
           -.6195D-08            -.6457D-08            -.6343D-08            -.6503D-08
            .5154D+04             .5154D+04             .5154D+04             .5154D+04
            .5694D+00            -.1550D+01             .5653D+00            -.1546D+01
           -.2092D+01             .2049D+01            -.1983D+00             .1352D+01
            .6950D+00            -.1074D+01             .3566D+00            -.1142D+01
            .2656D+08             .2656D+08             .2656D+08             .2656D+08
            .4425D+00             .4472D+00             .4505D+00             .4503D+00
            .8968D+00             .8944D+00             .8928D+00             .8929D+00
           -.4977D+00            -.4606D+00             .9804D+00             .2167D+00
           -.8674D+00             .8876D+00            -.1970D+00             .9762D+00
            .1459D-03             .1459D-03             .1459D-03             .1459D-03


OUTPUT OF COMPUTATIONS
----------------------

=================================================
! THE PRINTOUT IS ARRANGED AS FOLLOWING EXAMPLE :  !
! ----------------                                 !
! TIME                                             !
!POSITION OF SATELLITES IN ECEF-COORDINATES (X,Y,Z)!
!AND ELEVATION AND AZIMUTH (3-4 LINES)             !
!- - - - - - - - -                                 !
!  HDOP AND GDOP                                   !
!------------------                                !
!    ALL VALUES ARE IN METER                       !
=================================================
-----------------------
TIME : 10.4501 HOURS
   -.1833D+08    -.1915D+08     .2186D+07     .1294D+02     .2531D+03
   -.2843D+07    -.2174D+08     .1493D+08     .6517D+02     .2612D+03
    .9711D+07    -.7234D+07     .2366D+08     .4839D+02     .3139D+02
   -.1073D+08    -.5912D+07     .2334D+08     .2789D+02     .3237D+03
- - - - - - - - - - - - -
 2.4984615          4.4243006
-----------------------
-----------------------
TIME : 10.5500 HOURS
   -.1824D+08    -.1889D+08     .4249D+07     .1588D+02     .2571D+03
   -.2728D+07    -.2281D+08     .1326D+08     .6319D+02     .2493D+03
    .1104D+08    -.6041D+07     .2341D+08     .4477D+02     .3586D+02
   -.1039D+08    -.7676D+07     .2298D+08     .3173D+02     .3208D+03
- - - - - - - - - - - - -
 2.3736091          4.5147265
-----------------------
-----------------------
TIME : 11.0500 HOURS
   -.1803D+08    -.1853D+08     .6279D+07     .1877D+02     .2612D+03
   -.2686D+07    -.2376D+08     .1148D+08     .6012D+02     .2396D+03
    .1241D+08    -.4931D+07     .2299D+08     .4126D+02     .4015D+02
   -.1015D+08    -.9419D+07     .2245D+08     .3530D+02     .3172D+03
- - - - - - - - - - - - -
 2.2600505          4.7088703
-----------------------
```

```
-----------------------
TIME : 11.1500 HOURS
   -.1767D+08    -.1809D+08     .8261D+07     .2161D+02     .2655D+03
   -.2706D+07    -.2457D+08     .9620D+07     .5628D+02     .2320D+03
    .1380D+08    -.3914D+07     .2239D+08     .3785D+02     .4434D+02
   -.9994D+07    -.1112D+08     .2174D+08     .3851D+02     .3128D+03
- - - - - - - - - - - -
 2.1423699          5.0271648
-----------------------
-----------------------
TIME : 11.2500 HOURS
   -.1718D+08    -.1759D+08     .1018D+08     .2439D+02     .2700D+03
   -.2774D+07    -.2524D+08     .7684D+07     .5195D+02     .2261D+03
    .1519D+08    -.2997D+07     .2162D+08     .3456D+02     .4844D+02
   -.9927D+07    -.1277D+08     .2086D+08     .4124D+02     .3075D+03
- - - - - - - - - - - -
 2.0113983          5.5042133
-----------------------
-----------------------
TIME : 11.3500 HOURS
   -.1654D+08    -.1704D+08     .1202D+08     .2712D+02     .2746D+03
   -.2879D+07    -.2576D+08     .5688D+07     .4732D+02     .2215D+03
    .1657D+08    -.2183D+07     .2069D+08     .3136D+02     .5249D+02
   -.9944D+07    -.1435D+08     .1981D+08     .4337D+02     .3014D+03
- - - - - - - - - - - -
 1.8709018          6.1925626
-----------------------
-----------------------
TIME : 11.4501 HOURS
   -.1575D+08    -.1645D+08     .1377D+08     .2981D+02     .2793D+03
   -.3005D+07    -.2611D+08     .3649D+07     .4253D+02     .2179D+03
    .1793D+08    -.1478D+07     .1960D+08     .2827D+02     .5651D+02
   -.1004D+08    -.1584D+08     .1862D+08     .4478D+02     .2946D+03
- - - - - - - - - - - -
 1.7567730          7.1692332
-----------------------
-----------------------
TIME : 11.5500 HOURS
   -.1483D+08    -.1584D+08     .1542D+08     .3245D+02     .2843D+03
   -.3138D+07    -.2631D+08     .1582D+07     .3767D+02     .2150D+03
    .1924D+08    -.8800D+06     .1836D+08     .2525D+02     .6050D+02
   -.1019D+08    -.1722D+08     .1727D+08     .4538D+02     .2873D+03
- - - - - - - - - - - -
 1.7786423          8.5484359
-----------------------
-----------------------
TIME : 12.0500 HOURS
   -.1376D+08    -.1523D+08     .1695D+08     .3506D+02     .2893D+03
   -.3262D+07    -.2634D+08    -.4972D+06     .3282D+02     .2125D+03
    .2049D+08    -.3895D+06     .1698D+08     .2232D+02     .6447D+02
   -.1041D+08    -.1849D+08     .1580D+08     .4513D+02     .2800D+03
- - - - - - - - - - - -
 2.1462068          10.507829
-----------------------
-----------------------
TIME : 12.1500 HOURS
   -.1257D+08    -.1463D+08     .1835D+08     .3763D+02     .2946D+03
   -.3364D+07    -.2621D+08    -.2573D+07     .2801D+02     .2104D+03
    .2166D+08    -.2539D+04     .1547D+08     .1946D+02     .6842D+02
   -.1067D+08    -.1963D+08     .1420D+08     .4407D+02     .2727D+03
- - - - - - - - - - - -
 3.0898991          13.345598
-----------------------
-----------------------
TIME : 12.2500 HOURS
   -.1125D+08    -.1406D+08     .1961D+08     .4018D+02     .3000D+03
   -.3427D+07    -.2592D+08    -.4628D+07     .2329D+02     .2085D+03
    .2273D+08     .2861D+06     .1384D+08     .1665D+02     .7236D+02
   -.1096D+08    -.2063D+08     .1249D+08     .4226D+02     .2659D+03
- - - - - - - - - - - -
 4.8538946          17.615520
-----------------------
-----------------------
TIME : 12.3500 HOURS
   -.9819D+07    -.1353D+08     .2072D+08     .4269D+02     .3056D+03
   -.3439D+07    -.2548D+08    -.6649D+07     .1868D+02     .2067D+03
    .2370D+08     .4837D+06     .1211D+08     .1390D+02     .7627D+02
   -.1127D+08    -.2148D+08     .1069D+08     .3982D+02     .2597D+03
- - - - - - - - - - - -
 7.9541551          24.494625
-----------------------
```

```
PROGRAM   * H D O O *
---------------------

USER-POSITION :
  LATITUDE :  39.500000     DEGREE
  LONGITUDE: -74.500000     DEGREE
  ALTITUDE :  100.00000     FEET

ECEF-COORDINATES :       X              Y              Z
------------------  1317011.6     -4748990.4     4035321.8


USERTIMES :
  START (TSTART):   38700.000     SEC. = 10.45 HOURS
  END (TFIN)    :   46800.000     SEC. = 13.00 HOURS
  INCR. (TDEL)  :   600.00000     SEC
  DATE (DTU)    :   57.000000     DAYS

   USED ALMANACS          DTC=   57.   TC=  20000.
   -------------
SAT. ID :   5                     6                     9                     0
            .2305D-02             .1551D-02             .8108D-02             .0000D+00
            .3318D+06             .3318D+06             .3318D+06             .0000D+00
            .1112D+01             .1107D+01             .1104D+01             .0000D+00
           -.6195D-08            -.6457D-08            -.6503D-08             .0000D+00
            .5154D+04             .5154D+04             .5154D+04             .0000D+00
            .5694D+00            -.1550D+01            -.1546D+01             .0000D+00
           -.2092D+01             .2049D+01             .1352D+01             .0000D+00
            .6950D+00            -.1074D+01            -.1142D+01             .0000D+00
            .2656D+08             .2656D+08             .2656D+08             .0000D+00
            .4425D+00             .4472D+00             .4503D+00             .0000D+00
            .8968D+00             .8944D+00             .8929D+00             .0000D+00
           -.4977D+00            -.4606D+00             .2167D+00             .0000D+00
           -.8674D+00             .8876D+00             .9762D+00             .0000D+00
            .1459D-03             .1459D-03             .1459D-03             .0000D+00


OUTPUT OF COMPUTATIONS
----------------------

=================================================
! THE PRINTOUT IS ARRANGED AS FOLLOWING EXAMPLE :  !
! ---------------                                 !
! TIME                                            !
!POSITION OF SATELLITES IN ECEF-COORDINATES (X,Y,Z)!
!AND ELEVATION AND AZIMUTH (3-4 LINES)            !
!- - - - - - - - -                                !
!  HDOP AND GDOP                                  !
!-----------------                                !
!    ALL VALUES ARE IN METER                      !
=================================================
-----------------------
TIME : 10.4501 HOURS
   -.1833D+08    -.1915D+08     .2186D+07     .1294D+02     .2531D+03
   -.2843D+07    -.2174D+08     .1493D+08     .6517D+02     .2612D+03
   -.1073D+08    -.5912D+07     .2334D+08     .2789D+02     .3237D+03
- - - - - - - - - - - - -
 4.7632762          8.3858993
-----------------------
-----------------------
TIME : 10.5500 HOURS
   -.1824D+08    -.1889D+08     .4249D+07     .1588D+02     .2571D+03
   -.2728D+07    -.2281D+08     .1326D+08     .6319D+02     .2493D+03
   -.1039D+08    -.7676D+07     .2298D+08     .3173D+02     .3208D+03
- - - - - - - - - - - - -
 5.3833744          10.201813
-----------------------
-----------------------
TIME : 11.0500 HOURS
   -.1803D+08    -.1853D+08     .6279D+07     .1877D+02     .2612D+03
   -.2686D+07    -.2376D+08     .1148D+08     .6012D+02     .2396D+03
   -.1015D+08    -.9419D+07     .2245D+08     .3530D+02     .3172D+03
- - - - - - - - - - - - -
 6.4216688          13.226424
-----------------------
```

```
-----------------------
TIME : 11.1500 HOURS
   -.1767D+08    -.1809D+08     .8261D+07     .2161D+02     .2655D+03
   -.2706D+07    -.2457D+08     .9620D+07     .5628D+02     .2320D+03
   -.9994D+07    -.1112D+08     .2174D+08     .3851D+02     .3128D+03
- - - - - - - - - - - -
 8.1927780          18.405895
-----------------------
-----------------------
TIME : 11.2500 HOURS
   -.1718D+08    -.1759D+08     .1018D+08     .2439D+02     .2700D+03
   -.2774D+07    -.2524D+08     .7684D+07     .5195D+02     .2261D+03
   -.9927D+07    -.1277D+08     .2086D+08     .4124D+02     .3075D+03
- - - - - - - - - - - -
 11.009826          26.657326
-----------------------
-----------------------
TIME : 11.3500 HOURS
   -.1654D+08    -.1704D+08     .1202D+08     .2712D+02     .2746D+03
   -.2879D+07    -.2576D+08     .5688D+07     .4732D+02     .2215D+03
   -.9944D+07    -.1435D+08     .1981D+08     .4337D+02     .3014D+03
- - - - - - - - - - - -
 13.818422          34.879208
-----------------------
-----------------------
TIME : 11.4501 HOURS
   -.1575D+08    -.1645D+08     .1377D+08     .2981D+02     .2793D+03
   -.3005D+07    -.2611D+08     .3649D+07     .4253D+02     .2179D+03
   -.1004D+08    -.1584D+08     .1862D+08     .4478D+02     .2946D+03
- - - - - - - - - - - -
 13.244735          33.416337
-----------------------
-----------------------
TIME : 11.5500 HOURS
   -.1483D+08    -.1584D+08     .1542D+08     .3245D+02     .2843D+03
   -.3138D+07    -.2631D+08     .1582D+07     .3767D+02     .2150D+03
   -.1019D+08    -.1722D+08     .1727D+08     .4538D+02     .2873D+03
- - - - - - - - - - - -
 9.9871434          24.453441
-----------------------
-----------------------
TIME : 12.0500 HOURS
   -.1376D+08    -.1523D+08     .1695D+08     .3506D+02     .2893D+03
   -.3262D+07    -.2634D+08    -.4972D+06     .3282D+02     .2125D+03
   -.1041D+08    -.1849D+08     .1580D+08     .4513D+02     .2800D+03
- - - - - - - - - - - -
 7.1913427          16.689341
-----------------------
-----------------------
TIME : 12.1500 HOURS
   -.1257D+08    -.1463D+08     .1835D+08     .3763D+02     .2946D+03
   -.3364D+07    -.2621D+08    -.2573D+07     .2801D+02     .2104D+03
   -.1067D+08    -.1963D+08     .1420D+08     .4407D+02     .2727D+03
- - - - - - - - - - - -
 5.4283696          12.201738
-----------------------
-----------------------
TIME : 12.2500 HOURS
   -.1125D+08    -.1406D+08     .1961D+08     .4018D+02     .3000D+03
   -.3427D+07    -.2592D+08    -.4628D+07     .2329D+02     .2085D+03
   -.1096D+08    -.2063D+08     .1249D+08     .4226D+02     .2659D+03
- - - - - - - - - - - -
 4.3584985          9.3746357
-----------------------
-----------------------
TIME : 12.3500 HOUR
   -.9819D+07    -.1353D+08     .2072D+08     .4269D+02     .3056D+03
   -.3439D+07    -.2548D+08    -.6649D+07     .1868D+02     .2067D+03
   -.1127D+08    -.1480D+08     .1069D+08     .3982D+02     .2597D+03
- - - - - - - - - - - -
 3.6957639          7.5990681
-----------------------
-----------------------
TIME : 12.4501
   -.8289D+07    -.1305D+08     .2167D+08     .4518D+02     .3114D+03
   -.3386D+07    -.2489D+08    -.8618D+07     .1419D+02     .2049D+03
   -.1158D+08    -.2218D+08     .8800D+07     .3688D+02     .2542D+03
- - - - - - - - - - - -
 3.2771483          6.4295319
-----------------------
```


GRAPH OF HDOP VS. TIME
4 SAT.
3 SAT.
20.00
15.00
10.00
5.00
0.00
HDOP
11.00
11.50
12.00
12.50
13.00
GMT-TIME IN HOURS


GRAPH OF HDOP VS. TIME
4 SAT.
3 SAT.
20.00
15.00
10.00
5.00
0.00
HDOP
11.00
11.50
12.00
GMT-TIME IN HOURS