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TRIP-TRAJECTORY INTEGRATION PROGRAM

BERNARD KAUFMAN

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GODDARD SPACE FLIGHT CENTER
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ABSTRACT

This document describes a numerical integration program (TRIP) based on Encke's method of integrating only the perturbations in the cartesian coordinates. The mathematical model can include Venus, Earth, Mars, Jupiter, the Moon and the Sun as either central or disturbing bodies. In addition, full oblateness potentials are included for the Earth and Moon and J_2 only for Mars. Modification to expand the oblateness models for the other planets is simple. Solar radiation pressure may also be included as an option in the input. The program uses the latest exported JPL double precision planetary ephemerides (DE 19)

TRIP has the option of calculating shadow times using penumbra and umbra; and printout may be obtained at specified times or, in the case of a planetary orbiter, at apoapsis or periapsis. Input data is very simple and there is a variety of coordinate systems for printout.

TRIP is available from the Goddard Program Library under number D00140. It is a 360/95 program and has proven over the years to be accurate and very fast.

CONTENTS

TRIP-TRAJECTORY INTEGRATION PROGRAM

INTRODUCTION

TRIP was developed in 1968 primarily to provide an accurate and fast trajectory program to replace the n-body numerical integration programs then in use for mission analysis at Goddard. These were primarily large and very slow programs such as the old JPL Space Program. A second and equally important objective was to make the input format simple enough to be used without extensive study of a manual.

TRIP was developed along modular lines so that it could be easily modified. It uses a fourth-order predictor-corrector numerical integration subroutine (described later) which because of the modularity may be easily replaced by any integration package. Many options have been added to TRIP since it was first developed; however, since Encke's method is used which requires rectification of the reference orbit, it was not considered advantageous to incorporate atmospheric drag.

Throughout the development of TRIP, its speed and simplicity have been maintained, making it a very useful as well as accurate, tool. It was most recently used for the launch window analysis for Imp-I.

TRIP is currently running on the IBM 360/95 and is available in the Goddard program library (number D00140).

DESCRIPTION OF SUBROUTINES

The functions of the subroutines used in TRIP are described briefly below. Many of them came from the Quick Look Mission Analysis Program developed by Philco-Ford (reference 1). A complete listing of TRIP appears in Appendix A.

MAIN - The driver for TRIP. Its primary function is to set up certain keys from the input data.

ADOT - (Reference 1) Obtains the angle between two vectors.

ARES - (Reference 2) Calculates the matrix necessary to transform coordinates from Earth mean equinox and equator of date to Mars mean equinox and equator of date.

ARKTNS - (Reference 1) Obtains the arctangent of y/x.

CROSS - (Reference 1) Finds the cross product of two 3-dimensional vectors

DERIV - Calculates the disturbing accelerations due to the presence of other bodies and, when required, calls other subroutines to calculate accelerations due to oblateness and solar radiation pressure. Performs rectification test.

DOT - (Reference 1) Finds the dot product of two vectors.

FNOL II - (Reference 3) Used for the numerical integration of a system of ordinary differential equations. A fourth-order Adams-Moulton predictor-corrector with a Runge-Kutta starter, FNOL II has the option of automatically varying the step size.

FNORM - (Reference 1) Finds the magnitude of a 3-dimensional vector.

GETACC - (Reference 4) Evaluates the disturbing acceleration due to oblateness of the Moon or Earth.

GETTAP - (Reference 5) Used to position the ephemeris data set and read the correct data record.

GHA - (Reference 1) Calculates the Greenwich hour angle.

GOTOR - (Reference 1) Solves Kepler's equation for incremental eccentric anomaly on a conic section given the incremental mean anomaly (time).

HARMON - Computes acceleration due to oblateness of Mars and is the driver for GETACC

INTR1 - (Reference 5) Sets up the call to READE to find position and velocity of the other bodies with respect to the central body.

ITER - Calculates times of entrances and exits from penumbra and umbra.

KONSTK - Defines all constants needed by TRIP.

M1 - (Reference 1) Multiplies a 3-dimensional vector by a 3×3 matrix.

MNA - (Reference 1) Provides the matrix to transform moon-centered coordinates in Earth's true equator and equinox to Moon-centered coordinates in the moon's true equator.

MULT - (Reference 1) Forms the product of two 3 × 3 matrices.

NUTAIT - (Reference 1) Calculates the matrix to relate coordinates in Earth's mean equator and equinox to the true equator and equinox.

ORB - (Reference 1) Transforms cartesian state vector to keplerian elements.

ORB2X - (Reference 1) Transforms keplerian elements to cartesian state vector.

OUT - Prints out various types of output as determined by keys set from input.

OUTX - (Reference 1) Prints out cartesian and spherical coordinates. Called from subroutine OUT.

OVRLAY - (Reference 1) Reads input data.

READE - (Reference 5) Reads, interpolates and translates ephemeris data from the JPL double-precision ephemeris system (DE-19).

ROTEQ - (Reference 1) Provides the matrix to transform from mean equator and equinox of 1950.0 to mean equator and equinox of date.

RVOUT - (Reference 1) Calculates spherical coordinates of position and velocity.

SHADOW - Driver for subroutine ITER. Sets up keys to be used in calculating shadow times.

SHIFTP - (Reference 1) Provides the cartesian state vector of a probe relative to all the bodies in the ephemeris.

SOLAR - Calculates the perturbing acceleration due to solar radiation pressure.

SPER - (Reference 1) Converts cartesian position to spherical coordinates.

STEPD - (Reference 1) Obtains the state vector of a probe which is separated from an initial state by a time or angle increment, assuming only two-body motion.

TCONIC - (Reference 1) Calculates time from periapsis corresponding to a given true anomaly on a conic section.

TERM - Contains termination logic for the numerical integrator. Determines when the proper conditions for termination have occurred.

TFRAC - (Reference 1) Provides the integral and fractional parts of the sum of two numbers.

TIMEC - (Reference 1) Computes whole and fractional days from January 1, 1950 at 0^{hr}.

TRAJ - The driver for FNOL II.

INPUT

All constants and variables needed for the program are contained in subroutine KONSTK and built-in values are supplied there for everything except the state vector and the epoch times. The state vector, option keys and epoch times are input through subroutine OVRLAY, which also provides for overlaying any of the built-in constants or variables. A complete description of the input necessary to run TRIP is given below.

The input format is 4 (I3, D12.8). The first 3 digits are fixed-point input (I3) and represent the C-array location of the variable in subroutine KONSTK. The C-array location is followed by the value desired.

C-array	Name (if any)	Variable
750		X (km) or a (km)
751		Y (km) or e
752		Z (km) or θ (true anomaly-deg.)
753		$\dot{X}$ (km/sec) or Ω (deg)
754		$\dot{Y}$ (km/sec) or i (deg)
755		$\dot{Z}$ (km/sec) or ω (deg)
756		Epoch time (year, month, day in form of yymm.dd)
757		Epoch time (hour, minutes, seconds in form of hhmm.sec)

758 Type

Reference coordinate system of input
1. Earth mean equator and equinox of 1950, 0^h, Jan. 1,
2. True ecliptic and equinox of date,
3. Selenographic-true moon equator — rotating,
4. Mars mean equator of date,
5. True Earth equator and equinox of date.

759 Stop time (year, month, day as above)

760 Stop time (hours, minutes, seconds as above)

761 TINC (days)

TINC = total days from start to stop time if only 1st and last point, or printout at periapsis or apoapsis is wanted, or printout at approximate steps of Δt is wanted (nearest time step to Δt).

TINC = Δt if printout at exact intervals of Δt is wanted.

Built-in value is 180. (days)

762 TOTAL ($\geq 1.$) =

1. If printout is wanted at the 1st and last points only, or if printout at periapsis or apoapsis is wanted, or if printout is wanted at approximate steps of Δt.

$\frac{\text{total days}}{\Delta t}$ If printout is wanted at exact steps of Δt.

Built-in value is 1.
For printout at exact steps, an additional print occurs if TOTAL * $\Delta t \neq$ stop time.

763 XM (reference 3)

100 000. If printout at 1st and last points is wanted, or if printout is wanted at periapsis, apoapsis or exact intervals of Δt.

0. If printout is wanted at approximate steps of Δt

Built-in value is 0.

764 Y(8) (reference 3) =

0. If printout is wanted at first and last points only; or if printout is wanted at periapsis, apoapsis or exact steps of Δt.

Δt (seconds) If printout is wanted at approximate steps of Δt.

Built-in value is 86400. (seconds)

765 SHADOW =

-1. Do not search for shadow times

≥ 0. Time in days from epoch to begin search for shadow times.

Built-in value is -1.

766 XNOR

Central body for initial input state vector
1. Earth
2. Moon
3. Sun
4. Venus
5. Mars
6. Jupiter

Built-in value is 1.

767 XNE

Error control for FNOL II. Controls the size of the automatic step calculated in FNOL II. Built-in value is 5. May be as high as 9. See reference 3 for details.

768 HARMONICS

Oblateness key in form of abc., where
a = Earth
b = Moon
c = Mars

0 Do not include oblateness
1 Include oblateness

Built-in value is 111. Only the central body oblateness is used.

769 SOLAR

Solar Pressure Key
0. Do not include solar pressure and ignore c(770) through c(774)
1. Include solar pressure

Built-in value is 0.

770	AREA	Cross sectional area of spacecraft in cm^2. Built-in value is 22225. Used only if c(769) = 1.
771	XMASS	Total mass of spacecraft in gms. Built-in value is 113000. Used only if c(769) = 1.
772	Reflectivity of spacecraft	Values from 0. to 1., inclusive. Used only if c(769) = 1. 1. Perfect reflector 0. Perfect absorber Built-in value is 0.2
773	SPEC. REFLECTION of spacecraft	Fraction of particles specularly reflected. 1. 100% 0. 0% Built-in value is 1. May be 0. to 1., inclusive. Used only if c(769) = 1.
774	CONSTANT	Solar pressure at 1 A.U. Built-in value is 4.7×10^{-5} dynes/cm^2. Used only if c(769) = 1.
775	INPUT TYPE	0. Cartesian. 1. Orbital elements. Built-in value is 0. Actual values are input through c(750) — c(756).
776	APPER	Apoapsis and periapsis key. 0. Do not print at apoapsis or periapsis. 1. Print only at apoapsis. -1. Print only at periapsis. Built-in value is 0.
777	OUTPUT =	Output options in form of abcdefgh. a: Central body mean Earth equator of 1950 b: Selenographic c: Mars mean equator of date d: Central body true ecliptic and equinox of date e: Earth-centered true ecliptic and equinox of date

f: Sun-centered true ecliptic and equinox of date
g: Central body true Earth equator and equinox of date
h: Earth-fixed latitude and longitude (only if Earth is central body)

0 Do not print this form.
1 Print this form.
Built-in value is 10000011.

Cases may be stacked. When this is desired, cards for the 1st case are followed by a blank card and then the cards for the second case. There is no limit to the number of cases that may be stacked. Again, since an overlay method is used on input, only those variables different from those for the preceding case need be input. A blank card at the end of the last case is necessary to end the program. A sample of the input is shown in Appendix B.

OUTPUT

The output options are listed above in the description of array c(777). TRIP has the capability of automatically switching body centers when the probe leaves the sphere of influence of one body and enters that of another body. This switching does not interfere with the printout options.

Printout for the central body consists of both the cartesian state vector and instantaneous osculating elements; for other bodies, only the state vector. A sample of the output with an explanation is shown in Appendix B.

CONSTANTS

All constants needed by TRIP are listed in subroutine KONSTK and are either described there by a comment card or are described above in the input section. The constants in c(31) through c(38) are no longer used by the program but were not taken out.

Any or all of these constants may be changed for a particular run by including the proper array number and the new value in the input data.

KNOWN RESTRICTIONS AND ANOMALIES

There are two restrictions to be noted in using TRIP:
1.) Only one type of printout can be used in a run.

2. The printout interval must be greater than two minutes which is the initial time step in the integrator. If a request for a smaller interval is made, the program automatically sets the printout interval to be slightly greater than 2 minutes and prints out a message to this effect.

There are also two known anomalies in the program, which cause inconvenience but do not produce incorrect results:

1. When periapsis printout is requested, occasionally the program will intersperse a printout at apoapsis and then continue with periapsis printouts. Similarly, a printout at periapsis may occur when printout is requested at apoapsis.
2. When shadow times are requested, if the satellite is already in shadow at the time the shadow search is initiated, the printout of the shadow time is incorrect for that shadow interval only. All subsequent printout are correct. This bug occurs because the search procedure used requires a point before shadow occurs in order to iterate to the correct time. These incorrect shadow times will be obvious to the user (see case 6, Appendix B).

A final note of caution — when exact printout is asked for, the numerical integrator must restart after each printout time in order to continue. This procedure may result in a loss of accuracy due to numerical problems; that is if 2 cases are stacked using the same trajectory, one asking for exact printout and the other asking for printout only at the last point, the final state vectors at the stop time may disagree somewhat. To a certain extent, the numerical errors may be minimized by increasing the size of the error control in array c(767) or by decreasing the rectification limit in array c(720). However this is a problem inherent to a certain extent in any numerical integration routine and probably can not be completely eliminated.

REFERENCES

1. Philco-Ford, WDL Division, Programmer's Manual for Quick-Look Mission Analysis Program, Contract NAS 5-3342, WDL-TR 2217, 24 January, 1964.

2. Kaufman, Bernard, A Semi Analytic Method of Predicting the Variation in Periapsis of A Mars Orbiter, GSFC document X-551-69-41, February 1969.

3. Linnekin, J. S.; Belliveau, L. J., FNOL2, A Fortran (IBM 7090) Subroutine For the Solution of Ordinary Differential Equations with Automatic Adjustment of the Interval of Integration, NOLTR 63-171, Naval Ordnance Laboratory, White Oak, Maryland, 17 July 1963.

4. Hartwell, J. G., Lewis, T. R., Mathematical and Programming Documentation of a General Purpose Integrator Using Power Series Methods, NAS1-9389, DBA Systems, Inc., Melbourne, Florida, December, 1969.

5. Linnekin, J. S., DE-19* Direct Access Double Precision Ephemeris Package for the IBM 360/95, GSFC document X-551-69-375, September, 1969.

APPENDIX A

Listing of TRIP

```
C----- ENCKE   PROGRAM   MAIN  . . . . . .                                    100
       IMPLICIT REAL*8(A-H,O-Z,$) .                                           200
       DIMENSION X(3),V(3),R1(3,8),V1(3,8)                                    300
       DIMENSION DUM(3,3),DATEFC(3,3),DATECT(3,3),XX(3),XV(3)                 400
       COMMON C(1000),IC(50),Z(3),VV(3),NOR,INP                               500
       DIMENSION XNOT(3)                                                      600
       DIMENSION ELI(6)                                                       700
       COMMON/APPER/ FPROLD,OLD,XMAX                                          800
       COMMON/JTERM/MEARTH,MMOON,MMARS                                        900
       DATA BLK/6H      /,XNOT1/3HNOT/                                       1000
       EQUIVALENCE (C(401),R1(1,1)),(C(425),V1(1,1)),                        1100
      1  (C(750),X(1)),(C(753),V(1))                                         1200
       DIMENSION A(3,3),FN(3,3),EMN(3,3),DATE(3,3),SDATE(3,3),              1300
      1DATET(3,3),SDATET(3,3),ADATE(3,3),ADATET(3,3),AR(3,3)                1400
       COMMON/ROT/ DATE,SDATE,DATET,SDATET,ADATE,ADATET,DATEFC,DATECT,FN     1500
       COMMON/XLIB/ SG,TA,XMLIB                                             1600
       COMMON/TUP/TLU                                                       1700
       COMMON /SHAD/SHADK                                                   1800
       COMMON/PRINT/ IC50,ISEL,MARDAT,ICENEC,IEAREC,ISUNEC,ICDATE,IEARFX    1900
       CALL KONSTK                                                          2000
     1 CALL OVRLAY                                                          2100
       C(462)=1.D0                                                          2200
       C(122)=1.D0                                                          2300
       FPROLD=0.D0                                                          2400
       OLD = 0.D0                                                           2500
       IF(C(775).EQ.0.D0) GO TO 2                                           2600
       NTEMP=C(766)                                                         2700
       DO 5 I=1,6                                                           2800
5      ELI(I) = C(I+749)                                                    2900
       CALL ORB2X(X,V,ELI,C(NTEMP))                                         3000
     2 CONTINUE                                                             3100
       IF(FNORM(X).EQ.0.D0) GO TO 20                                        3200
       SHADK=0.0D0                                                          3300
       TS=C(756)                                                            3400
       DF=C(757)                                                            3500
       INP=C(758)                                                           3600
       ST=C(759)                                                            3700
       STF=C(760)                                                           3800
       TINC=C(761)                                                          3900
       TOTAL=C(762)                                                         4000
       C(1000)=C(765)                                                       4100
       XNOR=C(766)                                                          4200
       NE=C(767)                                                            4300
       MEARTH=C(768)/100.D0                                                 4400
       TEMP=C(768)-MEARTH*100                                               4500
       MMOON=TEMP/10.D0                                                     4600
       TEMP=TEMP-MMOON*10                                                   4700
       MMARS=TEMP                                                           4800
       IC50=C(777)/10000000.D0                                              4900
       TEMP=C(777)-IC50*10000000                                            5000
       ISEL=TEMP/1000000.D0                                                 5100
       TEMP=TEMP-ISEL*1000000                                               5200
       MARDAT=TEMP/100000.D0                                                5300
       TEMP=TEMP-MARDAT*100000                                              5400
       ICENEC=TEMP/10000.D0                                                 5500
       TEMP=TEMP-ICENEC*10000                                               5600
       IEAREC=TEMP/1000.D0                                                  5700
       TEMP=TEMP-IEAREC*1000                                                5800
       ISUNEC=TEMP/100.D0                                                   5900
       TEMP=TEMP-ISUNEC*100                                                 6000
       ICDATE=TEMP/10.D0                                                    6100
       TEMP=TEMP-ICDATE*10                                                  6200
       IEARFX=TEMP                                                          6300
       NTOTAL=TOTAL                                                         6400
       NOR=XNOR                                                             6500
       CALL TIMEC(TS,DF,TW,TF)                                              6600
       CALL TIMEC(ST,STF,ST1,STF1)                                          6700
```

```
      IF(C(1000)) 60,50,50                                              6800
   60 WRITE(6,30)                                                       6900
      GO TO 70                                                          7000
   50 WRITE(6,40)                                                       7100
   40 FORMAT(1H1,19HSHADOW IS REQUESTED)                                7200
   30 FORMAT(1H1,23HSHADOW IS NOT REQUESTED)                            7300
   70 CONTINUE                                                          7400
      XNOT(1)=BLK                                                       7500
      XNOT(2)=BLK                                                       7600
      XNOT(3)=BLK                                                       7700
      IF(MEARTH.LT.1) XNOT(1)=XNUT1                                     7800
      IF(MMOON.LT.1) XNOT(2)=XNUT1                                      7900
      IF(MMARS.LT.1) XNOT(3)=XNUT1                                      8000
      WRITE(6,100) C(61),XNOT(1)                                        8100
      WRITE(6,100) C(62),XNOT(2)                                        8200
      WRITE(6,100) C(65),XNOT(3)                                        8300
  100 FORMAT(1HO,13HHARMONICS OF ,A6,4H IS ,A4,8HINCLUDED)              8400
      XNOT(1)=BLK                                                       8500
      IF(C(769).EQ.0.0D0) XNOT(1)=XNUT1                                 8600
      WRITE(6,102) XNOT(1)                                              8700
  102 FORMAT('0 SOLAR RADIATION PRESSURE IS ',A4,'INCLUDED')            8800
      TIME=TW+TF                                                        8900
      TLU=TIME                                                          9000
      CALL ROTEQ(TIME,A)                                                9100
      CALL NUTAIT(TIME,OM,CR,DT,EN,EPSIL)                               9200
      CALL MNA(TIME,OM,CR,DT,EPSIL,RO,G,GP,WW,EMN)                      9300
      XMLIB=180.0D0*.0174532925200 + CR-OM+TA-SG                        9400
      CALL MULT(EN,A,DATE)                                              9500
      DUM(1,1)=1.0D0                                                    9600
      DUM(1,2)=0.D0                                                     9700
      DUM(1,3)=0.D0                                                     9800
      DUM(2,1)=0.D0                                                     9900
      DUM(2,2)=DCOS(EPSIL)                                             10000
      DUM(2,3)=DSIN(EPSIL)                                             10100
      DUM(3,1)=0.D0                                                    10200
      DUM(3,2)=-DSIN(EPSIL)                                            10300
      DUM(3,3)=DCOS(EPSIL)                                             10400
      CALL MULT(DUM,DATE,DATEEC)                                       10500
      CALL MULT(EMN,DATE,SDATE)                                        10600
      CALL ARES(TS,DF,AR)                                              10700
      CALL MULT(AR,A,ADATE)                                            10800
      DO 101 I=1,3                                                     10900
      DO 101 J=1,3                                                     11000
      DATECT(J,I)=DATEEC(I,J)                                          11100
      DATET(J,I)=DATE(I,J)                                             11200
      SDATET(J,I)=SDATE(I,J)                                           11300
  101 ADATET(J,I)=ADATE(I,J)                                           11400
      WRITE(6,6)                                                       11500
    6 FORMAT(1HO,31HINPUT IN MEAN EQ AND EQ OF 1950)                   11600
      CALL DATOUT(TW,TF,DAYM,FDATE,0)                                  11700
      DO 600 I=1,3                                                     11800
      XX(I)=X(I)                                                       11900
  600 XV(I)=V(I)                                                       12000
      GO TO(200,300,400,500,700),INP                                   12100
  300 CALL M1(X,DATECT,XX)                                             12200
      CALL M1(V,DATECT,XV)                                             12300
      GO TO 200                                                        12400
  400 CALL M1(X,SDATET,XX)                                             12500
      CALL M1(V,SDATET,XV)                                             12600
      GO TO 200                                                        12700
  500 CALL M1(X,ADATET,XX)                                             12800
      CALL M1(V,ADATET,XV)                                             12900
      GO TO 200                                                        13000
  700 CALL M1(X,DATET,XX)                                              13100
      CALL M1(V,DATET,XV)                                              13200
  200 CONTINUE                                                         13300
```

```
      DO 11 I=1,3                                                       13400
      C(I+499)=XX(I)                                                    13500
   11 C(I+502)=XV(I)                                                    13600
      CALL OUTX(XX,XV,NOUT)                                             13700
      C(592)=TW                                                         13800
      C(593)=TF                                                         13900
      TFF=TF                                                            14000
      KK=1                                                              14100
   13 TFF=TFF+TINC                                                      14200
      CALL TFRAC(TW,TFF,TWF,TFF)                                        14300
   16 XMAX=0.D0                                                         14400
      CALL TRAJ(TWF,TFF,XX,XV,NE)                                       14500
      IF(C(462).EQ.0.D0)GO TO 1                                         14600
      TW=TWF                                                            14700
      DO 10 JJ=1,3                                                      14800
      C(JJ+499)=XX(JJ)                                                  14900
   10 C(JJ+502)=XV(JJ)                                                  15000
      STDT=(ST1-C(592)+STF1-C(593))*86400.D0                            15100
      IF(STDT-120.D0.LE.0.D0) GO TO 1                                   15200
      XMAX=0.D0                                                         15300
      IF(C(1000).GT.0.D0) C(1000)=0.D0                                  15400
   14 IF(C(462).EQ.0.D0) GO TO 1                                        15500
      IF(FPROLD.EQ.0.D0) GO TO 12                                       15600
      FPROLD=0.D0                                                       15700
      OLD = 0.D0                                                        15800
      STDTPR=(TWF-C(592)+TFF-C(593))*86400.D0                           15900
      IF(STDTPR.LE.120.D0) GO TO 12                                     16000
      IF (KK .LE. NTOTAL) GO TO 16                                      16100
      GO TO 15                                                          16200
   12 KK=KK+1                                                           16300
   15 IF(KK.LE.NTOTAL) GO TO 13                                         16400
      CALL TRAJ(ST1,STF1,XX,XV,NE)                                      16500
      IF(FPROLD.NE.0.D0)  GO TO 14                                      16600
      GO TO 1                                                           16700
   20 CONTINUE                                                          16800
      STOP                                                              16900
      END                                                               17000
```

```
      REAL FUNCTION ADOT*8(X,Y)                                          17100
      IMPLICIT REAL*8(A-H,O-Z,$)                                         17200
      DIMENSION  X(3),  Y(3)                                             17300
C     FUNCTION RETURNS ANGLE IN DEGREES BETWEEN TWO INPUT VECTORS        17400
C     RANGE IS RESTRICTED TO (0,180)                                     17500
      A=FNORM(X)                                                         17600
      B=FNORM(Y)                                                         17700
      ANG=DOT(X,Y)/A/B                                                   17800
      ADOT=ARKTNS(180,ANG,DSQRT(1.0D0-ANG*ANG))*57.29577900              17900
      RETURN                                                             18000
      END                                                                18100
```

```
      SUBROUTINE ARES(T1,T2,AR)                                          18200
      IMPLICIT REAL*8(A-H,O-Z,$)                                         18300
      DIMENSION AR(3,3),EE(3),O(3),EXO(3),EQ(3)                          18400
      DIMENSION TEM(3)                                                   18500
      DUM=0.DO                                                           18600
      DTR=0.017453292520                                                 18700
      IYR=T1/100.DO                                                      18800
      YR=IYR                                                             18900
      DT=YR-50.DO                                                        19000
      AOP= 317.793416667DO+0.6520833D-2*DT                               19100
      DOP=54.6575DO+0.35D-2*DT                                           19200
      BYR=YR*100.DO+1.01DO                                               19300
      CALL TIMEC(BYR,DUM,TW,TF)                                          19400
      CALL TIMEC(T1,T2,TW1,TF1)                                          19500
      TAU= ((TW1-TW)+(TF1-TF))/365.25DO                                  19600
      AO= AOP-0.0010130O*TAU                                             19700
      DO= DOP-0.000631DO*TAU                                             19800
      TE= (TW1+TF1+18262.5DO)/36525.DO                                   19900
      OM= 48.78644167DO+0.77099167DO*TE-0.13888889D-5*TE*TE              20000
      XI= 1.85033333DO-0.675D-3*TE+0.126111110-4*TE*TE                   20100
      E= 23.452294440-0.130125D-1*TE-0.16388889D-5*TE*TE                 20200
     1   +0.502777780-6*TE*TE*TE                                         20300
      AOR=AO*DTR                                                         20400
      DOR= DO*DTR                                                        20500
      OMR= OM*DTR                                                        20600
      XIR= XI*DTR                                                        20700
      ER=E*DTR                                                           20800
      SAO=DSIN(AOR)                                                      20900
      CAO=DCOS(AOR)                                                      21000
      SDO=DSIN(DOR)                                                      21100
      CDO=DCOS(DOR)                                                      21200
      SOM=DSIN(OMR)                                                      21300
      COM=DCOS(OMR)                                                      21400
      SI=DSIN(XIR)                                                       21500
      CI=DCOS(XIR)                                                       21600
      SE=DSIN(ER)                                                        21700
      CE=DCOS(ER)                                                        21800
C *******  THE FOLLOWING IS KAUFMAN'S METHOD  ******                     21900
      EE(1)=CAO*CDO                                                      22000
      EE(2)=SAO*CDO                                                      22100
      EE(3)=SDO                                                          22200
      O(1)=SI*SOM                                                        22300
      O(2)= -SI*COM*CE-CI*SE                                             22400
      O(3)=-SI*COM*SE+CI*CE                                              22500
      CALL CROSS(O,EE,EXO)                                               22600
      EQ(1)=-SAO                                                         22700
      EQ(2)=CAO                                                          22800
      EQ(3)=0.DO                                                         22900
      CALL CROSS(EQ,EXO,TEM)                                             23000
      SOMEG=DSQRT(TEM(1)**2+TEM(2)**2+TEM(3)**2)                         23100
      COMEG= DOT(EQ,EXO)                                                 23200
      OMG=ARKTNS(180,COMEG,SOMEG)                                        23300
      SOMEG=DSIN(OMG)                                                    23400
      COMEG=DCOS(OMG)                                                    23500
      AOM = AOR+1.57079632DO                                             23600
      XAI=1.570796327DO-DOR                                              23700
      SAOM=DSIN(AOM)                                                     23800
      CAOM=DCOS(AOM)                                                     23900
      SAI=DSIN(XAI)                                                      24000
      CAI=DCOS(XAI)                                                      24100
      AR(1,1)=COMEG*CAOM-SOMEG*SAOM*CAI                                  24200
      AR(1,2)=COMEG*SAOM+SOMEG*CAOM*CAI                                  24300
      AR(1,3)=SOMEG*SAI                                                  24400
      AR(2,1)=-SOMEG*CAOM-COMEG*SAOM*CAI                                 24500
      AR(2,2)=-SOMEG*SAOM+COMEG*CAOM*CAI                                 24600
      AR(2,3)=COMEG*SAI                                                  24700
      AR(3,1)=SAOM*SAI                                                   24800
```

```
AR(3,2)=-CAOM*SAI                                                    24900
AR(3,3)=CAI                                                          25000
RETURN                                                               25100
END                                                                  25200
```

```
      REAL FUNCTION ARKTNS*8(N,X,Y)                                    25300
      IMPLICIT REAL*8(A-H,O-Z,$)                                       25400
C     COMPUTES 4-QUADRANT ARCTANGENT OF Y/X IN RADIANS                 25500
C     N=360  ANGLE LIES IN RANGE (0,360) DEG                           25600
C     N=180  ANGLE LIES IN RANGE (-180,180) DEG                        25700
      TPI = 6.283185300000                                             25800
      XA = DABS(X)                                                     25900
      YA = DABS(Y)                                                     26000
      IF(XA-YA)1,1,2                                                   26100
    1 Z=X/YA                                                           26200
      GO TO 3                                                          26300
    2 Z=Y/XA                                                           26400
      YA=XA                                                            26500
    3 D=DSQRT(1.0D0+Z*Z)                                               26600
      YA=YA*D+X                                                        26700
      IF(YA)4,4,5                                                      26800
    4 ARKTNS=TPI/2.0D0                                                 26900
      GO TO 6                                                          27000
    5 ARKTNS=2.0D0*DATAN(Y/YA)                                         27100
    6 IF(N-180)7,9,7                                                   27200
    7 IF(ARKTNS)8,9,9                                                  27300
    8 ARKTNS=ARKTNS+TPI                                                27400
    9 RETURN                                                           27500
      END                                                              27600
```

```
      SUBROUTINE CROSS(A,B,C)                                          27700
      IMPLICIT REAL*8(A-H,O-Z,$)                                       27800
      DIMENSION A(3),B(3),C(3)                                         27900
C     DIMENSION A(3),B(3),C(3)                                         28000
      C(1)=A(2)*B(3)-A(3)*B(2)                                         28100
      C(2)=A(3)*B(1)-A(1)*B(3)                                         28200
      C(3)=A(1)*B(2)-A(2)*B(1)                                         28300
      RETURN                                                           28400
      END                                                              28500
```

```
      SUBROUTINE DATOUT(T1,T2,DATE,FDATE,KDATE)                          28600
      IMPLICIT REAL*8(A-H,O-Z,$)                                         28700
C     DATE RETURNED IN FORMAT(YEARS FROM 1900)(MONTH).(DAYS)             28800
C     FDATE RETURNED IN FORMAT (HOURS)(MIN).(SECONDS)                    28900
C     K SET 0 FOR PRINTOUT, SET - OR + FOR NO OUTPUT                     29000
C     GIVES CALENDER DATE FROM T1(WHOLE DAYS FROM 1950)                  29100
C     ANDT2(FRACT OF DAY)                                                29200
      DIMENSION C(12)                                                    29300
C     DIMENSION C(12)                                                    29400
      DATA Q000HL/6H  JAN./                                              29500
      C(1 )=Q000HL                                                       29600
      DATA Q001HL/6H  FEB./                                              29700
      C(2 )=Q001HL                                                       29800
      DATA Q002HL/6H MARCH/                                              29900
      C(3 )=Q002HL                                                       30000
      DATA Q003HL/6H APRIL/                                              30100
      C(4 )=Q003HL                                                       30200
      DATA Q004HL/6H   MAY/                                              30300
      C(5 )=Q004HL                                                       30400
      DATA Q005HL/6H  JUNE/                                              30500
      C(6 )=Q005HL                                                       30600
      DATA Q006HL/6H  JULY/                                              30700
      C(7 )=Q006HL                                                       30800
      DATA Q007HL/6H  AUG./                                              30900
      C(8)=Q007HL                                                        31000
      DATA Q008HL/6H SEPT./                                              31100
      C( 9)=Q008HL                                                       31200
      DATA Q009HL/6H  OCT./                                              31300
      C(10)=Q009HL                                                       31400
      DATA Q010HL/6H  NOV./                                              31500
      C(11)=Q010HL                                                       31600
      DATA Q011HL/6H  DEC./                                              31700
      C(12)=Q011HL                                                       31800
      MD=0                                                               31900
      K=T1+365.0D0                                                       32000
      IF(T1)6,6,7                                                        32100
 6    WRITE (   6,100)                                                   32200
 8    RETURN                                                             32300
 100  FORMAT(23H DATE IS 1950 OR BEFORE)                                 32400
 7    K1=K/1461                                                          32500
      K2=K-K1*1461                                                       32600
      KWN=K2/365                                                         32700
      KK=K1*4+1949+KWN                                                   32800
      N=1                                                                32900
      IF(KWN-3)112,111,111                                               33000
  111 N=0                                                                33100
  112 KWN=K2-KWN*365                                                     33200
      IF(KWN)11,11,13                                                    33300
 11   MONTH=1                                                            33400
      MD=1                                                               33500
      GO TO 25                                                           33600
   13 CONTINUE                                                           33700
      KNW=0                                                              33800
      JJ=0                                                               33900
 135  JJ=JJ+1                                                            34000
      IF(12-JJ)23,23,137                                                 34100
C     J,F,M,A,M,J,J,A,S,O,N,MONTHS FOR GO TO                             34200
 137  GO TO (14,15,14,16,14,16,14,14,16,14,16,14),JJ                     34300
 14   CONTINUE                                                           34400
      KNW=KNW+31                                                         34500
      GO TO 17                                                           34600
 15   CONTINUE                                                           34700
      IF(N)18,18,19                                                      34800
 18   KNW=KNW+1                                                          34900
 19   KNW=KNW+28                                                         35000
      GO TO 17                                                           35100
 16   KNW=KNW+30                                                         35200
```

```
17    CONTINUE                                                          35300
      IF(KWN-KNW)20,21,22                                               35400
22    CONTINUE                                                          35500
      MD=KNW                                                            35600
      GO TO 135                                                         35700
  20  CONTINUE                                                          35800
      MONTH=JJ                                                          35900
      MD=KWN-MD+1                                                       36000
      GO TO 25                                                          36100
  21  CONTINUE                                                          36200
       MONTH=JJ+1                                                       36300
      MD=1                                                              36400
      GO TO 25                                                          36500
 23   MONTH =12                                                         36600
      MD=KWN-MD+1                                                       36700
  25  CONTINUE                                                          36800
      TH=T2*24.0D0                                                      36900
       THP=IDINT(TH)                                                    37000
      FDATE=THP*100.0D0                                                 37100
      NHOUR=THP                                                         37200
       THP=(TH-THP)*60.0D0                                              37300
      TH=IDINT(THP)                                                     37400
      FDATE=FDATE+TH                                                    37500
       NMIN=TH                                                          37600
      THP=(THP-TH)*60.0D0                                               37700
      NSEC=THP                                                          37800
      FDATE=FDATE+THP/100.0D0                                           37900
      TSEC=NSEC                                                         38000
      DATE=(KK-1900)*100+MONTH                                          38100
      SP=MD                                                             38200
      DATE=DATE+SP/100.0D0                                              38300
      IF(KDATE) 8,50,8                                                  38400
  50  CONTINUE                                                          38500
      THP=(THP-TSEC)*1000.0D0                                           38600
      NFSEC=THP                                                         38700
      TT=IDINT(T2+.5D0)                                                 38800
      TP2=T2+.5D0-TT                                                    38900
      TP1=T1+TT+2433282.0D0                                             39000
      WRITE (   6,101)C(MONTH),MD,KK,NHOUR,NMIN,NSEC      ,NFSEC,TP1,TP2   39100
 101  FORMAT( 1H ,A6,I3,1H,,1X,I4,1H ,1X,I2,4HHRS,,I3,4HMIN,,I3,1H.,I3,    39200
     13HSEC,50X,12HJULIAN DATE ,F8.0,T111,F9.8)                         39300
      GO TO 8                                                           39400
      END                                                               39500
```

```
      SUBROUTINE DERIV(X,Y,D)                                                39600
      IMPLICIT REAL*8(A-H,O-Z,$)                                             39700
      DIMENSION Y(20),R1(3,8),V1(3,8),D(20),CB(20),NP(5), RM(5),RM1(5),      39800
     1DACC(3),Z1(3),VV1(3),RE(3),CACC(3) ,R2(3,8)                            39900
      DIMENSION DACC(3)                                                      40000
      DIMENSION SACC(3)                                                      40100
      COMMON C(1000),IC(50),Z(3),VV(3),NOR                                   40200
      COMMON/JTERM/MEARTH,MMOON,MMARS                                        40300
      COMMON/DISTRB/DACC,CACC,OACC                                           40400
      COMMON /SHAD/SHADK                                                     40500
      EQUIVALENCE (C(401),R1(1,1)),(C(425),V1(1,1))                          40600
C   MUST CALCULATE POSITION OF PROBE FROM INCREMENTS                         40700
      DT=X                                                                   40800
      U=C(NOR)                                                               40900
      IF(X.NE.0.D0) GO TO 321                                                41000
      DO 322 I=1,3                                                           41100
      Z(I)=C(I+499)                                                          41200
  322 VV(I)=C(I+502)                                                         41300
      GO TO 323                                                              41400
  321 CONTINUE                                                               41500
      MN=1                                                                   41600
      CALL STEPD(MN,DT,TA,C(500),C(503),U,Z,VV,1,CB)                         41700
  323 CONTINUE                                                               41800
      DO 10 I=1,3                                                            41900
      Z1(I)=Z(I)+Y(I)                                                        42000
   10 VV1(I)=VV(I)+Y(I+3)                                                    42100
      TW=C(592)                                                              42200
      TF=C(593)+(C(719)+C(506)+X)/86400.D0                                   42300
      CALL TFRAC(TW,TF,TW,TF)                                                42400
      CALL SHIFTP(NOR,Z1,VV1,TW,TF,R1,V1)                                    42500
      NP(1)=2                                                                42600
      NP(2)=3                                                                42700
      NP(3)=4                                                                42800
      NP(4)=5                                                                42900
      NP(5)=6                                                                43000
      GO TO(1,2,3,90,80,100),NOR                                             43100
    2 NP(1)=1                                                                43200
      GO TO 1                                                                43300
    3 NP(2)=1                                                                43400
      GO TO 1                                                                43500
   90 NP(3)=1                                                                43600
      GO TO 1                                                                43700
   80 NP(4)=1                                                                43800
      GO TO 1                                                                43900
  100 NP(5)=1                                                                44000
      GO TO 1                                                                44100
    1 CONTINUE                                                               44200
      DO 4 I=1,5                                                             44300
      NP1=NP(I)                                                              44400
      RM(I)=FNORM(R1(1,NP1))**3                                              44500
      DO 5 J=1,3                                                             44600
    5 R2(J,I+3)=R1(J,NOR)-R1(J,NP1)                                          44700
    4 RM1(I)=FNORM(R2(1,I+3))**3                                             44800
      NP1=NP(1)                                                              44900
      NP2=NP(2)                                                              45000
      NP3=NP(3)                                                              45100
      NP4=NP(4)                                                              45200
      NP5=NP(5)                                                              45300
      DO 6 I=1,3                                                             45400
    6 DACC(I)=-C(NP1)*(R1(I,NP1)/RM(1)+R2(I,4)/RM1(1))-C(NP2)*(R1(I,NP2)     45500
     1/RM(2)+R2(I,5)/RM1(2))                                                 45600
     2-C(NP3)*(R1(I,NP3)/RM(3)+R2(I,6)/RM1(3))-C(NP4)*(R1(I,NP4)             45700
     3/RM(4) +R2(I,7) /RM1(4))-C(NP5)*(R1(I,NP5)/RM(5)+R2(I,8)/RM1(5))       45800
      DO 7 I=1,3                                                             45900
    7 RE(I)=Z(I)+.5D0*Y(I)                                                   46000
      Q= DOT(RE,Y)/(FNORM(Z)**2)                                             46100
      SUM =1.D0                                                              46200
```

```
      TERM=1.D0                                                          46300
      DO 8 K=2,50                                                        46400
      XK=K                                                               46500
      TERM=TERM*((.5D0-XK)*2.D0*Q/(XK-1.D0))                             46600
      SUM=SUM+TERM                                                       46700
      IF(DABS(TERM).LT.0.00001D0*SUM) GO TO 9                            46800
    8 CONTINUE                                                           46900
      WRITE(6,20)                                                        47000
   20 FORMAT(1H1,34HQ SERIES IN ENCKE DID NOT CONVERGE)                  47100
      STOP                                                               47200
    9 FQ=1.D0-SUM                                                        47300
      H=C(NOR)/(FNORM(Z)**3)                                             47400
      DO 11 I=1,3                                                        47500
   11 CACC(I)=-H*Y(I)+H*FQ*R1(I,NOR)                                     47600
      DO 30 I=1,3                                                        47700
   30 OACC(I)=0.D0                                                       47800
      GO TO (40,50,21,21,60,21),NOR                                      47900
   40 IF(MEARTH.NE.1) GO TO 21                                           48000
      GO TO 70                                                           48100
   50 IF(MMOON.NE.1) GO TO 21                                            48200
      GO TO 70                                                           48300
   60 IF(MMARS.NE.1) GO TO 21                                            48400
   70 CONTINUE                                                           48500
      TWTE=C(592)                                                        48600
      TFTE=C(593)+(C(506)+X)/86400.D0                                    48700
      CALL TFRAC(TWTE,TFTE,TWTE,TFTE)                                    48800
      TIMUP=TWTE+TFTE                                                    48900
      CALL HARMON(R1,V1,OACC,TIMUP)                                      49000
   21 CONTINUE                                                           49100
      DO 13 I=1,3                                                        49200
   13 DACC(I)=          DACC(I)+OACC(I)                                  49300
      RAT = FNORM(Y(1)) / FNORM(Z(1))                                    49400
      IF(RAT.GE.C(720).OR.0.GE.C(720)) C(122)=0.0D0                      49500
      DO 17 I=1,3                                                        49600
   17 OACC(I)=DACC(I)+CACC(I)                                            49700
      IF(C(769).EQ.0.0D0.OR.SMADK.EQ.1.0D0) GO TO 551                    49800
C* * * * *   CALCULATE SOLAR PRESSURE * * * * * *                       49900
      CALL SOLAR(R1(1,3),SACC)                                           50000
      DO 1000 I=1,3                                                      50100
 1000 DACC(I)=DACC(I) + SACC(I)                                          50200
  551 C O N T I N U E                                                    50300
      DO 16 I=1,3                                                        50400
      D(I)=Y(I+3)                                                        50500
   16 D(I+3)=DACC(I)                                                     50600
      RETURN                                                             50700
      END                                                                50800
```

```
      REAL FUNCTION DOT*8(X,Y)                                          50900
      IMPLICIT REAL*8(A-H,O-Z,$)                                        51000
      DIMENSION X(3),Y(3)                                               51100
C     DIMENSION X(3),Y(3)                                               51200
      DOT = X(1)*Y(1) + X(2)*Y(2) + X(3)*Y(3)                           51300
      RETURN                                                            51400
      END                                                               51500
```

```
      SUBROUTINE FNOL2(J,N,G,L,M,NE,X,Y,D,DD,TT,OO)                    51600
      IMPLICIT REAL*8(A-H,O-Z,$)                                       51700
      COMMON BERNIE(1000)                                              51800
C                                                                      51900
C                                                                      52000
      DOUBLE PRECISION XD,YD,YA,YC,YP,YI                               52100
C     DIMENSION Y(50),D(50),YB(30,6),GI2(30),GI3(30),GI4(30),EF(30),   52200
      DIMENSION Y(8000)                                                52300
      DIMENSION ZZ(5),D(50),YB(30,6),GI2(30),GI3(30),GI4(30),EF(30),   52400
     1EF1(30),EF2(30),EF3(30),YI(30),ERROR(30),HA(30),YA(50),DA(50),   52500
     2YC(30),YP(30),YD(50)                                             52600
      EC=Y(N+3)                                                        52700
 9876 FORMAT(1HO,I7)                                                   52800
    1 H=G                                                              52900
    2 HZ=H                                                             53000
    3 LN=N+MAXO(L,3)                                                   53100
C     SUBROUTINE FNOL2(J,N,G,L,M,NE,X,Y,D,DERIV,TERM,OUT)              53200
 6876 FORMAT(1HO,I7)                                                   53300
    4 NA=0                                                             53400
    5 NB=1                                                             53500
    6 NF=0                                                             53600
    7 NG=0                                                             53700
    8 F=0.DO                                                           53800
    9 FA=0.DO                                                          53900
   10 FB=0.DO                                                          54000
   11 FC=0.DO                                                          54100
   12 CONTINUE                                                         54200
   13 ENE=NE                                                           54300
C     DO 200 I=1,LN                                                    54400
C 200 YD(I)=DBLE(Y(I))                                                 54500
C     XD=DBLE(X)                                                       54600
      DO 200 I=1,LN                                                    54700
  200 YD(I)=Y(I)                                                       54800
      XD=X                                                             54900
   14 IF(J-3)15,21,15                                                  55000
   15 IF(NE)18,16,18                                                   55100
   16 JA=4                                                             55200
   17 GO TO 22                                                         55300
   18 RE1=10.DO**(-ENE)                                                55400
   19 RE2=10.DO**(-ENE-3.0DO)                                          55500
   20 REM=10.DO**(-ENE-1.5DO)                                          55600
   21 JA=1                                                             55700
   22 DO 25 I=1,N                                                      55800
   23 DO 24 IC=1,5                                                     55900
   24 YB(I,IC)=0.DO                                                    56000
   25 ERROR(I)=0.DO                                                    56100
   26 CALL DERIV(X,Y,D)                                                56200
      CALL TERM(X,Y,D,F)                                               56300
      IF(DABS(F)-1.OD-9) 731,731,5209                                  56400
 5209 CONTINUE                                                         56500
      DO 300 I=1,N                                                     56600
      GI2(I)=D(I)                                                      56700
      GI3(I)=D(I)                                                      56800
      GI4(I)=D(I)                                                      56900
  300 EF(I)=D(I)                                                       57000
C  27 CALL OUTPUT(X,Y,D,ERROR,N,L,H)                                   57100
 27   CALL OUT(X,Y,D,ERROR,N,L,H)                                      57200
      IF(BERNIE(506).NE.0.DO) GO TO 29                                 57300
   28 FD=Y(N+1)                                                        57400
   29 IF(J-2) 30,129,30                                                57500
   30 GO TO(31,37,35,37),JA                                            57600
   31 DO 33 I=1,LN                                                     57700
   32 YA(I)=YD(I)                                                      57800
   33 DA(I)=D(I)                                                       57900
   34 GO TO 37                                                         58000
   35 HB=H                                                             58100
   36 H=2.DO*H                                                         58200
```

```
   37 HD2 = .5D0*H                                                    58300
      DO 39 I=1,N                                                     58400
   38 YB(I,NB)=D(I)                                                   58500
      XL = D(I) * HD2                                                 58600
C  39 Y(I)=SNGL(YD(I)+XL)                                            58700
   39 Y(I)=YD(I)+XL                                                   58800
C     X=SNGL(XD+HD2)                                                  58900
      X=XD+HD2                                                        59000
   40 CALL DERIV (X,Y,GI2)                                            59100
   41 DO 42 I=1,N                                                     59200
      XL = GI2(I)*HD2                                                 59300
C  42 Y(I)=SNGL(YD(I)+XL)                                            59400
   42 Y(I)=YD(I)+XL                                                   59500
   43 CALL DERIV (X,Y,GI3)                                            59600
   44 DO 45 I=1,N                                                     59700
      XL=GI3(I)*H                                                     59800
C  45 Y(I)=SNGL(YD(I)+XL)                                            59900
   45 Y(I)=YD(I)+XL                                                   60000
C     X=SNGL(XD+H)                                                    60100
      X=XD+H                                                          60200
   46 CALL DERIV(X,Y,GI4)                                             60300
   47 HD6 =H/6.D0                                                     60400
      GO TO(48,55,60,66),JA                                           60500
   48 DO 52 I=1,N                                                     60600
      XL=(D(I) + 2.D0*(GI2(I) + GI3(I)) +GI4(I))*HD6                  60700
   49 YC(I)=YD(I)+XL                                                  60800
   51 YD(I)=YA(I)                                                     60900
   52 ERROR(I)=0.D0                                                   61000
   53 JA=3                                                            61100
   54 GO TO 35                                                        61200
   55 DO 57 I=1,N                                                     61300
      XL=(D(I) + 2.D0*(GI2(I) + GI3(I)) +GI4(I))*HD6                  61400
   56 YD(I)=YD(I)+XL                                                  61500
C  57 ERROR(I)=SNGL(YD(I)-YP(I))/15.                                  61600
   57 ERROR(I)=(YD(I)-YP(I))/15.D0                                    61700
   58 JA=1                                                            61800
   59 GO TO 681                                                       61900
   60 DO 62 I=1,N                                                     62000
   61 YD(I)=YC(I)                                                     62100
      XL=(D(I) + 2.D0*(GI2(I) + GI3(I)) +GI4(I))*HD6                  62200
   62 YP(I)=YA(I)+XL                                                  62300
   63 H=HB                                                            62400
   64 JA=2                                                            62500
   65 GO TO 681                                                       62600
   66 DO 68 I=1,N                                                     62700
      XL=(D(I) + 2.D0*(GI2(I) + GI3(I)) +GI4(I))*HD6                  62800
   67 YD(I)=YD(I)+XL                                                  62900
   68 ERROR(I)=0.D0                                                   63000
  681 DO 69 I=1,N                                                     63100
C  69 Y(I)=SNGL(YD(I))                                                63200
   69 Y(I)=YD(I)                                                      63300
      XD=XD+H                                                         63400
C     X=SNGL(XD)                                                      63500
      X=XD                                                            63600
   70 CALL DERIV(X,Y,D)                                               63700
   71 FC=F                                                            63800
   72 CALL TERM(X,Y,D,F)                                              63900
   73 IF(DABS(F)-1.0D-9 )731,731,733                                  64000
  731 NF=5                                                            64100
  732 GO TO 124                                                       64200
  733 IF(F)74,124,76                                                  64300
   74 FA=1.D0                                                         64400
   75 GO TO 77                                                        64500
   76 FB=1.D0                                                         64600
   77 IF(FA-FB)83,78,83                                               64700
   78 NF=NF+1                                                         64800
```

```
   79 JA=4                                                                64900
   80 NB=1                                                                65000
   81 H=H*F/(FC-F)                                                        65100
   82 IF(NF-4)37,37,124                                                   65200
   83 IF(NE)84,117,84                                                     65300
   84 IF(JA-1)117,85,117                                                  65400
   85 IF(J-3)86,117,86                                                    65500
   86 DO 95 I=1,N                                                         65600
      IF(Y(I))886,885,886                                                 65700
  885 HA(I)=1000.D0                                                       65800
      GO TO 95                                                            65900
  886 IF(EC)880,890,87                                                    66000
   87 IF(DABS(Y(I))-EC) 880,880,890                                       66100
  880 IF(DABS(ERROR(I))-RE2) 882,94,881                                   66200
  881 IF(DABS(ERROR(I))-RE1)94,94,882                                     66300
  882 HA(I)=H*(REM/(DABS(ERROR(I))+.0000000001D0))**(.2D0)                66400
  883 GO TO 95                                                            66500
  890 IF(DABS(ERROR(I)/Y(I))-RE2)892,94,891                               66600
  891 IF(DABS(ERROR(I)/Y(I))-RE1)94,94,892                                66700
  892 HA(I)=H*(REM/(DABS(ERROR(I)/Y(I))+.0000000001D0))**(.2D0)           66800
  893 GO TO 95                                                            66900
   94 HA(I)=H                                                             67000
   95 CONTINUE                                                            67100
96    HB=DABS(HA(N))                                                      67200
97    DO 98 I=1,N                                                         67300
C 98  HB=AMIN1(ABS(HA(I)),HB)                                             67400
98    HB=DMIN1(DABS(HA(I)),HB)                                            67500
99    IF(DABS(H)-HB)100,117,101                                           67600
100   IF(DABS(HZ)-DABS(H))101,101,116                                     67700
101   DO 103 I=1,LN                                                       67800
102   YD(I)=YA(I)                                                         67900
C     Y(I)=SNGL(YD(I))                                                    68000
      Y(I)=YD(I)                                                          68100
103   D(I)=DA(I)                                                          68200
104   IF(NB-6) 107,105,105                                                68300
105   XD=XD-H                                                             68400
106   GO TO 109                                                           68500
107   XD=XD-2.D0*H                                                        68600
108   HZ=H                                                                68700
109   H=DSIGN(HB,H)                                                       68800
      X=XD                                                                68900
C     X=SNGL(XD)                                                          69000
      CALL DERIV(X,Y,D)                                                   69100
      CALL TERM(X,Y,D,F)                                                  69200
  110 NB=1                                                                69300
  111 XABS=DABS(.000001D0*X)                                              69400
  112 IF(DABS(H)-XABS)113,113,117                                         69500
  113 NG=NG+1                                                             69600
114   H=DSIGN(XABS,H)                                                     69700
 115  IF(NG - 10)124,150,150                                              69800
 150  WRITE(6,1261) H                                                     69900
1261  FORMAT (1H1,107HEXECUTION TERMINATED BECAUSE INTERVAL OF INTEGRATI  70000
     1ON LESS THAN 1.0E -6 TIMES INDEPENDENT VARIABLE (X).  X =,1PD15.7)  70100
      STOP                                                                70200
  116 HZ=H                                                                70300
  117 IF(N)118,118,121                                                    70400
  118 IF(DABS(Y(N+1)-FD)-Y(N+2))29,119,119                                70500
  119 FD=FD+Y(N+2)                                                        70600
  120 GO TO 124                                                           70700
  121 NA=NA+1                                                             70800
  122 IF(N-NA)123,123,29                                                  70900
  123 NA=0                                                                71000
C124  CALL OUTPUT(X,Y,D,ERROR,N,L,H)                                      71100
 124  CALL OUT(X,Y,D,ERROR,N,L,H)                                         71200
  125 IF(NF-4)29,29,126                                                   71300
  126 CONTINUE                                                            71400
```

```
  128 RETURN                                                                    71500
  129 NB=NB+1                                                                   71600
  130 IF(NB-6)30,131,136                                                        71700
  131 DO 134 I=1,N                                                              71800
  132 EF3(I)=YB(I,3)                                                            71900
  133 EF2(I)=YB(I,4)                                                            72000
  134 EF1(I)=YB(I,5)                                                            72100
  135 GO TO 137                                                                 72200
  136 NB=10                                                                     72300
  137 HD24 =H/24.D0                                                             72400
      DO 138 I=1,N                                                              72500
      XL =(55.D0*D(I) -59.D0*EF1(I) +37.D0*EF2(I) -9.D0*EF3(I))*HD24            72600
      YP(I)=YD(I)+XL                                                            72700
C 138 Y(I)=SNGL(YP(I))                                                          72800
C     X=SNGL(XD+H)                                                              72900
 138  Y(I)=YP(I)                                                                73000
      X=XD+H                                                                    73100
  139 CALL DERIV(X,Y,EF)                                                        73200
  140 DO 142 I=1,LN                                                             73300
  141 YA(I)=YD(I)                                                               73400
  142 DA(I)=D(I)                                                                73500
  143 DO 148 I=1,N                                                              73600
      XL = (9.D0*EF(I) +19.D0*D(I) -5.D0*EF1(I) +EF2(I))*HD24                   73700
  144 YD(I)=YD(I)+XL                                                            73800
C 145 ERROR(I)=-SNGL(YD(I)-YP(I))/14.                                           73900
 145  ERROR(I)=-(YD(I)-YP(I))/14.D0                                             74000
  146 EF3(I)=EF2(I)                                                             74100
  147 EF2(I)=EF1(I)                                                             74200
  148 EF1(I)=D(I)                                                               74300
999   CONTINUE                                                                  74400
  149 GO TO 681                                                                 74500
       END                                                                      74600
```

```
      REAL FUNCTION FNORM*8(X)                                          74700
      IMPLICIT REAL*8(A-H,O-Z,$)                                        74800
      DIMENSION X(3)                                                    74900
C     DIMENSION X(3)                                                    75000
    1 FNORM=DSQRT(X(1)**2+X(2)**2+X(3)**2)                              75100
    3 RETURN                                                            75200
      END                                                               75300
```

```
      SUBROUTINE GETACC (LCT,ICT,CNM,SNM,ECN,PVA,CTT,CTB,UMT,VMT,NTE)      75400
      IMPLICIT REAL*8(A-H,O-Z,$)                                           75500
      DIMENSION LCT(1),ICT(1),CNM(1),SNM(1),ECN(1)                         75600
      DIMENSION PVA(1),CTT(1),CTB(1),UMT(1),VMT(1)                         75700
      EQUIVALENCE (XP,PX),(YP,PY),(ZP,PZ)                                  75800
      ERD=ECN(1)                                                           75900
      XMU=ECN(2)                                                           76000
      ALF=ECN(3)                                                           76100
      PX= PVA(1)                                                           76200
      PY= PVA(2)                                                           76300
      PZ= PVA(3)                                                           76400
      CGB=DCOS(ALF)                                                        76500
      SGB=DSIN(ALF)                                                        76600
      RMT=1.0D0/(PX*PX+PY*PY+PZ*PZ)                                        76700
      TMA=RMT*ERD                                                          76800
      CLT=TMA*(XP*CGB+YP*SGB)                                              76900
      SLT=TMA*(YP*CGB-XP*SGB)                                              77000
      RZR=TMA*ZP                                                           77100
      RMR=TMA*ERD                                                          77200
      TWR=0.5D0/ERD                                                        77300
      RMO=DSQRT(RMT)                                                       77400
      LMX=0                                                                77500
      LNC=1                                                                77600
      LA=LCT(2)                                                            77700
      IF (NTE-1)15,15,20                                                   77800
   15 LA=0                                                                 77900
   20 LB=LCT(1)                                                            78000
      LC=LA                                                                78100
      NB=NTE+1                                                             78200
      DO 75 I=1,NB                                                         78300
      KA=LA-1                                                              78400
      KB=LB                                                                78500
      KC=LC+1                                                              78600
      IF (KB-KA)30,35,35                                                   78700
   30 KB=KA                                                                78800
   35 IF (LC) 50,50,40                                                     78900
   40 IF (KB-KC)45,50,50                                                   79000
   45 KB=KC                                                                79100
   50 LNC=LNC+KB+1                                                         79200
      ICT(I)=LNC                                                           79300
      LA=LB                                                                79400
      LB=LC                                                                79500
      LC=LCT(I+2)                                                          79600
      IF (LMX-LA)60,65,65                                                  79700
   60 LMX=LA                                                               79800
   65 IF (I-NTE+1)75,70,70                                                 79900
   70 LC=0                                                                 80000
   75 CONTINUE                                                             80100
      TMA=2.0D0                                                            80200
      TMB=2.0D0                                                            80300
      DO 90 I=1,LMX                                                        80400
      CTT(I)=-TMA                                                          80500
      CTB(I)= TMB                                                          80600
      TMA=TMA+2.0D0                                                        80700
      TMB=TMB+TMA                                                          80800
   90 CONTINUE                                                             80900
      UMT(1)=XMU*RMO                                                       81000
      VMT(1)=0.0D0                                                         81100
      LA=1                                                                 81200
      LB=1                                                                 81300
      NA=2                                                                 81400
      KB=2                                                                 81500
      DO 160 I=1,NB                                                        81600
      KC=ICT(I)-1                                                          81700
      KA=I-1                                                               81800
      TMB=KA+KA                                                            81900
```

```
      TMA=TMB+1.0D0                                                    82000
      TMC=1.0D0                                                        82100
      IF (KC-KB)140,100,100                                            82200
  100 DO 130 LC=KB,KC                                                  82300
      TMD=RZR*UMT(LB)*TMA                                              82400
      TME=RZR*VMT(LB)*TMA                                              82500
      IF (KB-LC)110,120,120                                            82600
  110 TMD=TMD-RMR*UMT(LB-1)*TMB                                        82700
      TME=TME-RMR*VMT(LB-1)*TMB                                        82800
  120 UMT(NA)=TMD/TMC                                                  82900
      VMT(NA)=TME/TMC                                                  83000
      TMA=TMA+2.0D0                                                    83100
      TMB=TMB+1.0D0                                                    83200
      TMC=TMC+1.0D0                                                    83300
      NA=NA+1                                                          83400
  130 LB=LB+1                                                          83500
  140 IF (I-NB)150,160,160                                             83600
  150 TMC=KA+KA+1                                                      83700
      UMT(NA)=TMC*(CLT*UMT(LA)-SLT*VMT(LA))                            83800
      VMT(NA)=TMC*(CLT*VMT(LA)+SLT*UMT(LA))                            83900
      NA=NA+1                                                          84000
      KB=KC+2                                                          84100
      LB=LB+1                                                          84200
      LA=LB                                                            84300
  160 CONTINUE                                                         84400
      TMA=0.0D0                                                        84500
      TMB=0.0D0                                                        84600
      TMC=0.0D0                                                        84700
      TMD=0.5D0                                                        84800
      KB=1                                                             84900
      LA=ICT(1)                                                        85000
      LB=2                                                             85100
      LC=LA                                                            85200
      DO 260 I=1,NTE                                                   85300
      KC=ICT(I)                                                        85400
      IF (KC)260,260,210                                               85500
  210 IF (I-2)230,215,220                                              85600
  215 LA=3                                                             85700
      GO TO 225                                                        85800
  220 LA=ICT(I-2)+2                                                    85900
  225 LB=ICT(I-1)+1                                                    86000
      LC=ICT(I)                                                        86100
  230 DO 250 NA=1,KC                                                   86200
      TME=CTB(NA)                                                      86300
      TMF=TME                                                          86400
      IF (I-1)235,235,240                                              86500
  235 TMF=TMD*TME                                                      86600
      TME=NA                                                           86700
      TMD=TMD*TME                                                      86800
      TME=NA+2                                                         86900
      TMD=TMD/TME                                                      87000
      TME=-TMF                                                         87100
  240 RMR=TME*UMT(LA)                                                  87200
      RZR=TMF*VMT(LA)                                                  87300
      CLT=UMT(LC)                                                      87400
      SLT=VMT(LC)                                                      87500
      TME=RMR-CLT                                                      87600
      TMF=RZR+SLT                                                      87700
      RMR=RMR+CLT                                                      87800
      RZR=RZR-SLT                                                      87900
      CLT=CNM(KB)                                                      88000
      SLT=SNM(KB)                                                      88100
      TMA=TMA+CLT*TME+SLT*RZR                                          88200
      TMB=TMB-CLT*TMF+SLT*RMR                                          88300
      TMC=TMC+CTT(NA)*(CLT*UMT(LB)+SLT*VMT(LB))                        88400
      LA=LA+1                                                          88500
```

```
      LB=LB+1                                                          88600
      LC=LC+1                                                          88700
  250 KB=KB+1                                                          88800
  260 CONTINUE                                                         88900
      TMA=TMA*TWR                                                      89000
      TMB=TMB*TWR                                                      89100
      PVA(7)=(CGB*TMA-SGB*TMB)                                         89200
      PVA(8)=(SGB*TMA+CGB*TMB)                                         89300
      PVA(9)=TMC*TWR                                                   89400
      RETURN                                                           89500
      END                                                              89600
```

```
      SUBROUTINE GETTAP                                                 89700
      DEFINE FILE 10(958,6636,L,IV)                                     89800
      DOUBLE PRECISION TAB3,JDI,JDF,JD1,TDAY,JDIF,JDP                   89900
      REAL NUTAT                                                        90000
      REAL*8 TAB31                                                      90100
      COMMON/CETBL2/ICW,ICENT,IREQ(13)                                  90200
      COMMON/CETBL3/TAB3(829),NUTAT(204),CKSUM                          90300
      COMMON/CETBL9/JD1,TDAY,JDIF,IERR1                                 90400
      DATA IV/0/                                                        90500
      DATA IWPRV/0/                                                     90600
      JDP=JD1+TDAY                                                      90700
      IF(JDP.LT.2438760.5D0.OR.JDP.GT.2446424.5D0)GO TO 100             90800
      IERR1=0                                                           90900
      IF(ICW.NE.1) GO TO 205                                            91000
      DO 333 I=1,204                                                    91100
333   NUTAT(I)=0.                                                       91200
      ICW=2                                                             91300
      IW=1                                                              91400
      READ(10'IW)TAB3                                                   91500
      TAB31=TAB3(1)                                                     91600
205   IW=IDINT((JDP-TAB31)/8.D0)+1.D0                                   91700
      IF(IW.EQ.IWPRV)GO TO 220                                          91800
      IWPRV=IW                                                          91900
200   READ(10'IW)TAB3                                                   92000
      IF(JDP-TAB3(1))210,220,230                                        92100
210   IW=IW-2                                                           92200
      GO TO 200                                                         92300
230   IW=IW+1                                                           92400
      IF(JDP-(TAB3(1)+8.D0))220,200,200                                 92500
220   JDIF=JDP-TAB3(1)                                                  92600
      RETURN                                                            92700
101   FORMAT(' EPHEMERIS ERROR--JULIAN DATE ',D25.7,'IS BEFORE JAN 1965 92800
     1OR AFTER DEC 1985')                                               92900
100   WRITE(6,101)JDP                                                   93000
      STOP                                                              93100
      END                                                               93200
```

```
      SUBROUTINE GHA(TSEC,D,GHAN,DA,OMEGA)                              93300
      IMPLICIT REAL*8(A-H,O-Z)                                          93400
      OMEGA=.0041780742DO/(1.DO+5.21D-13*D)                             93500
      DD=0.DO                                                           93600
      DD=D                                                              93700
      DD=DD*(.98564735DO/360.DO)                                        93800
      DX=IDINT(DD)                                                      93900
      DD=DD-DX                                                          94000
      DF=DD                                                             94100
      TEM1=100.07554DO+360.DO*DF+2.90150-13*D*D                         94200
     1+OMEGA*TSEC                                                       94300
    1 IF(TEM1)2,3,3                                                     94400
    2 TEM1=TEM1+360.DO                                                  94500
      GO TO 1                                                           94600
    3 IF(TEM1-360.DO)5,4,4                                              94700
    4 TEM1=TEM1-360.DO                                                  94800
      GO TO 3                                                           94900
    5 GHAN=TEM1+DA*57.2957795DO                                         95000
      RETURN                                                            95100
      END                                                               95200
```

```
      SUBROUTINE GOTOR(K,VM,C,F,E1)                                     95300
      IMPLICIT REAL*8(A-H,O-Z,$)                                        95400
      DIMENSION C(2),F(4)                                               95500
C     DIMENSION C(2),F(4)                                               95600
C                                                                       95700
C                                                                       95800
C                                                                       95900
C                                                                       96000
      NMAX=20                                                           96100
      N=0                                                               96200
      GO TO (1,2),K                                                     96300
    1 CONTINUE                                                          96400
C     FIRST GUESS IS OBTAINED FOR ELLIPTICAL CASE                       96500
    8 CONTINUE                                                          96600
      IF(E1-1.0D0)30,31,31                                              96700
   30 CONTINUE                                                          96800
      D2=E1*E1                                                          96900
      F(1)=E1*D2*(.16666667D+00-D2*(.833333333D-02-D2*(.198412698D-03-D2 97000
     1*(.275573192D-05-D2*.250521083D-07))))                            97100
      F(2)=D2*(.5D0-D2*(.41666667D-01-D2*(.13888889D-02-D2*(.24801587D-0 97200
     14-D2*.27557319D-06))))                                            97300
      F(3)=E1-F(1)                                                      97400
      F(4)=1.0D0-F(2)                                                   97500
      GO TO 3                                                           97600
   31 CONTINUE                                                          97700
      F(3)=DSIN(E1)                                                     97800
      F(4)=DCOS(E1)                                                     97900
      F(1)=E1-F(3)                                                      98000
      F(2)=1.0D0-F(4)                                                   98100
      GO TO 3                                                           98200
    2 CONTINUE                                                          98300
C     FIRST GUESS IS OBTAINED FORHYPERBOLIC CASE                        98400
    9 CONTINUE                                                          98500
      IF(E1-1.0D0)32,33,33                                              98600
   32 CONTINUE                                                          98700
      D2=E1*E1                                                          98800
      F(1) =E1*D2*(.16666667D+00+D2*(.83333333D-02+D2*(.198412698D-03+D2 98900
     1*(.275573192D-05+D2*.250521083D-07))))                            99000
      F(2)=D2*(0.5D0+D2*(.41666667D-01+D2*(.13888889D-02+D2*(.24801587D- 99100
     104+D2*.27557319D-06))))                                           99200
      F(3)=E1+F(1)                                                      99300
      F(4)=1.0D0+F(2)                                                   99400
      GO TO 3                                                           99500
   33 CONTINUE                                                          99600
      EX=.5D0*DEXP(E1)                                                  99700
      OX=.25D0/EX                                                       99800
      F(3)=EX-OX                                                        99900
      F(4)=EX+OX                                                       100000
      F(1)=F(3)-E1                                                     100100
      F(2)=F(4)-1.0D0                                                  100200
    3 CONTINUE                                                         100300
      CM=F(1)+C(1)*F(3)+C(2)*F(2)                                      100400
      DM=F(2)+C(1)*F(4)+C(2)*F(3)                                      100500
      DE=(VM-CM)/DM                                                    100600
      ERROR=DE                                                         100700
      AB=DABS(DE)                                                      100800
      IF(AB-1.000)10,10,11                                             100900
   11 DE=DE/AB                                                         101000
   10 E2=E1+DE                                                         101100
      IF ((E2+E1).EQ. 0.D0)   GO TO 4                                  101200
      IF(DABS((E2-E1)/(E2+E1))-3.D-8)4,4,5                             101300
    5 CONTINUE                                                         101400
      IF(N-NMAX)6,7,7                                                  101500
    7 CONTINUE                                                         101600
      GO TO 4                                                          101700
```

```
    6 CONTINUE                                                          101800
      N=N+1                                                             101900
      E1=E2                                                             102000
      GO TO (8,9),K                                                     102100
    4 CONTINUE                                                          102200
      RETURN                                                            102300
      END                                                               102400
```

```
      SUBROUTINE HARMON(R1,V1,ACC,TIME)                                 102500
      IMPLICIT REAL*8 (A-H,O-Z,$)                                       102600
      DIMENSION DATEEC(3,3),DATECT(3,3)                                 102700
      DIMENSION R1(3,8),V1(3,8),RR(3),ACC(3),TEMP(3),DATE(3,3),         102800
     1  SDATE(3,3),DATET(3,3),SDATET(3,3),ADATE(3,3),ADATET(3,3)        102900
      DIMENSION A(3,3),EN(3,3),EMN(3,3),AR(3,3),LCT(8),ICT(9),          103000
     1  CNM(36),SNM(36),ECN(3),PVA(9),CTT(8),CTB(8),UMT(45),VMT(45),    103100
     2  LCTM(5),ICTM(6),CNMM(15),SNMM(15),CTTM(5),CTBM(5),UMTM(21),     103200
     3  VMTM(21)                                                        103300
      COMMON/ROT/ DATE,SDATE,DATET,SDATET,ADATE,ADATET,DATEEC,DATECT,EN  103400
      COMMON/XLIB/ SG,TA,XMLIB                                          103500
      COMMON C(1000),IC(50),Z(3),VV(3),NOR                              103600
      COMMON/TUP/ TLU                                                   103700
      DATA LCT/8,7,6,5,4,3,2,1/, LCTM/5,4,3,2,1/                        103800
      EQUIVALENCE  (C(200),CNM(1)), (C(236),SNM(1)),(C(272),CNMM(1))    103900
      EQUIVALENCE (C(287),SNMM(1))                                      104000
      KEY=1                                                             104100
      IF( DABS(TLU-TIME) .LT. C(901) )  GO TO 100                       104200
      TLU=TIME                                                          104300
      KEY=2                                                             104400
      CALL ROTEQ(TIME,A)                                                104500
      CALL NUTAIT(TIME,OM,CR,DT,EN,EPSIL)                               104600
      CALL MULT(EN,A,DATE)                                              104700
      DO 101 I=1,3                                                      104800
      DO 101  J=1,3                                                     104900
  101 DATET(J,I) = DATE(I,J)                                            105000
  100 CONTINUE                                                          105100
      GO TO (20,4,80,80,5),  NOR                                        105200
   20 CONTINUE                                                          105300
      NTE=8                                                             105400
      ECN(1) = C(21)                                                    105500
      ECN(2) = C(1)                                                     105600
      ITIME = TIME                                                      105700
      T2 = (TIME-ITIME)*86400.0D0                                       105800
      T1 = ITIME                                                        105900
      DA = EN(2,1)                                                      106000
      CALL GHA(T2,T1,GHAN,DA,OMEGA)                                     106100
      ECN(3) = GHAN*.01745329252D0                                      106200
      CALL M1(R1(1,1),DATE,RR)                                          106300
      DO 1 I=1,3                                                        106400
    1 PVA(I) = RR(I)                                                    106500
      CALL GETACC(LCT,ICT,CNM,SNM,ECN,PVA,CTT,CTB,UMT,VMT,NTE)          106600
      CALL M1 (PVA(7),DATET,ACC)                                        106700
      RETURN                                                            106800
    4 CONTINUE                                                          106900
      GO TO (200,202),  KEY                                             107000
  202 CALL MNA(TIME,OM,CR,DT,EPSIL,RU,G,GP,WW,EMN)                      107100
      CALL MULT(EMN,DATE,SDATE)                                         107200
      DO 201 I=1,3                                                      107300
      DO 201 J=1,3                                                      107400
  201 SDATET(J,I) = SDATE(I,J)                                          107500
  200 CONTINUE                                                          107600
      DP=TIME                                                           107700
      TP=DP/36525.D0                                                    107800
      T2P=TP*TP                                                         107900
      T3P=T2P*TP                                                        108000
      OM=12.11279D0-.05295392200*DP +.0020795D0*TP                      108100
     1   +.002081D0*T2P+.2D-5*T3P                                       108200
      CR=64.375452D0 +13.176397D0*DP -.00113157500*TP                   108300
     1   -.001130150D0*T2P+ .19D-5*T3P                                  108400
      EPSIL=23.4457587D0-.01309404D0*TP -.88D-6*T2P +.5D-6*T3P           108500
      OM=OM*C(75)                                                       108600
      CR=CR*C(75)                                                       108700
      EPSIL=EPSIL*C(75)                                                 108800
      XMLIB = 180.D0*.0174532925200 + CR-OM+TA-SG                       108900
      NTE=5                                                             109000
```

```
      ECN(1) = C(22)                                                          109100
      ECN(2) = C(2)                                                           109200
      ECN(3) = 0.D0                                                           109300
      CALL M1(R1(1,2),SDATE,RR)                                               109400
      DO 2 I=1,3                                                              109500
    2 PVA(I) = RR(I)                                                          109600
      CALL GETACC(LCTM,ICTM,CNMM,SNMM,ECN,PVA,CTTM,CTBM,UMTM,VMTM,NTE)        109700
      CALL M1(PVA(7),SDATET,ACC)                                              109800
      RETURN                                                                  109900
    5 CONTINUE                                                                110000
      XJ2 = C(725)                                                            110100
      XJ3 = C(726)                                                            110200
      RE = C(25)                                                              110300
      U = C(5)                                                                110400
      R = FNORM(R1(1,5))                                                      110500
      GO TO (300,302),  KEY                                                   110600
  302 ITIME = TIME                                                            110700
      T2 = TIME-ITIME                                                         110800
      T1 = ITIME                                                              110900
      CALL DATOUT (T1,T2,DATE,FDATE,0)                                        111000
      CALL ARES(DATE,FDATE,AR)                                                111100
      CALL MULT(AR,A,ADATE)                                                   111200
      DO 301 I=1,3                                                            111300
      DO 301 J=1,3                                                            111400
  301 ADATET(J,I) = ADATE(I,J)                                                111500
  300 CONTINUE                                                                111600
      CALL M1(R1(1,5),ADATE,RR)                                               111700
      R2 = R**2                                                               111800
      R5 = R**5                                                               111900
      R7 = R5*R2                                                              112000
      RE2 = RE*RE                                                             112100
      RE3 = RE2*RE                                                            112200
      Z2 = RR(3)*RR(3)                                                        112300
      Z3 = Z2*RR(3)                                                           112400
      COEF = -1.5D0*U*XJ2*RE2/R5                                              112500
      DO 10 I=1,3                                                             112600
   10 PVA(I+6) = COEF*(-5.D0*Z2*RR(I)/R2 + RR(I))                             112700
      PVA(9) = PVA(9) + COEF*2.D0*RR(3)                                       112800
      IF(XJ3.EQ.0.D0)  GO TO 13                                               112900
      COEF = -.5D0*U*XJ3*RE3/R7                                               113000
      DO 14 I=1,3                                                             113100
   14 TEMP(I) = COEF*(-35.D0*Z3*RR(1)/R2 + 15.D0*RR(I)*RR(3))                 113200
      TEMP(3) = TEMP(3) + COEF*(15.D0*Z2-3.D0*R2)                             113300
      DO 15 I=1,3                                                             113400
   15 PVA(I+6) = PVA(I+6) + TEMP(I)                                           113500
   13 CALL M1(PVA(7),ADATET,ACC)                                              113600
C     CONTINUE                                                                113700
   80 RETURN                                                                  113800
      END                                                                     113900
```

```
      SUBROUTINE INTR1(TW,TF,NB,POS,IDUM,VEL,DUM2)                          114000
      IMPLICIT REAL*8 (A-H,O-Z)                                             114100
C*****************************************************************       114200
C       THIS VERSION OF THE 360 JPL DOUBLE PRECISION EPHEMERIS              114300
C     WAS MODIFIED BY JERRY S. LINNEKIN OF CODE 551 GSFC,GREENBELT MD.      114400
C     IT HAS BEEN MODIFIED TO HANDLE  SEVEN BODIES INSTEAD OF THE           114500
C     NORMAL ELEVEN. THE BODIES AND ORDER ARE EARTH,MOON,SUN,VENUS,MARS,    114600
C     SATURN AND JUPITER. SATURN AND JUPITER HAVE BEEN INTERCHANGED         114700
C     TO CORRESPOND TO THE QUICK LOOK MISSION ANALYSIS PROGRAM.             114800
C     THE READ ROUTINE-GETTAP HAS BEEN MODIFIED TO USE THE DIRECT ACCESS    114900
C     READ FEATURE OF 360 FORTRANH.IN ADDITION,THE NUTATION VARIABLES       115000
C     HAVE BEEN ELIMINATED FROM THIS VERSION SO THAT AN EPHEMERIS           115100
C     RECORD WILL FIT ON ONE TRACK OF A 2316 DISK PACK.                     115200
C     THE DECK AS IT APPEARS HERE IS SET UP AS A DIRECT REPLACEMENT         115300
C     FOR THE SINGLE PRECISION  INTR1 IN THE QUICK LOOK MISSION             115400
C     ANALYSIS PROGRAM.                                                     115500
C*****************************************************************       115600
C     IN ADDITION TO THE ABOVE CHANGES,THE FOLLOWING COMMENT CARDS          115700
C     DESCRIBE THE CHANGES NECESSARY TO USE THIS PACKAGE WITH THE           115800
C     MARK2 PROGRAM ,THE MARK2 COVERAGE PROGRAM AND THE QUICK LOOK          115900
C     COVERAGE PROGRAM                                                      116000
C       ******         MARK2 PROGRAM    *********                         116100
C     SUBROUTINE ANTR (TW,TF,NB,POS,VEL) MK2 PROGRAM                        116200
C     DATA NCENT/3,11,10,2,4,5,6/        MARK2                              116300
C     NCENTR=NCENT(NB)                   FOR MARK II                        116400
C       ******   MARK2 COVERAGE PROGRAM*********                           116500
C     SUBROUTINE ANTR1(TW,TF,NB,POS,KK,VEL,DIS)   MK2 COVERAGE PROGRAM      116600
C     DATA NCENT/3,11,10,2,4,5,6/        MARK2                              116700
C     NCENTR=NCENT(NB)                                                      116800
C       ******  COVER -QUICK LOOK COVERAGE PROG  ****                       116900
C      NO CHANGE NECESSARY DUE TO CAREFUL PLANNING BY PROGRAMMER            117000
C*****************************************************************       117100
C       TO EXTEND THE EPHEMERIS FOR ALL BODIES,CHANGE THE  FOLLOWING        117200
C     POS(21) TO POS(33),VEL(21) TO VEL(33) AND NCENT(7) TO NCENT(11)       117300
C     REPLACE  THE NCENT DATA CARD WITH                                     117400
C     DATA NCENT/3,11,10,2,4,5,6,1,7,8,9/                                   117500
C     THIS WILL RESULT IN THE FOLLOWING BODIES IN THE ORDER                 117600
C     THAT THEY ARE LISTED EARTH,MOON,SUN,VENUS,MARS,JUPITER,SATURN,        117700
C     MERCURY,URANUS,NEPTUNE AND PLUTO.                                     117800
C*****************************************************************       117900
C     ARGUMENT DESCRIPTION                                                  118000
C     TW    INPUT, WHOLE DAYS FROM 1950, REAL*8                             118100
C     TF    INPUT, FRACTIONAL DAYS FROM 1950, REAL*8                        118200
C     NB      INPUT, CENTRAL BODY NUMBER (1-EARTH, 2-MOON, 3-SUN,           118300
C     4-VENUS, 5-MARS, 6-SATURN, 7-JUPITER), INTEGER*4                      118400
C     POS   OUTPUT, POSITION ARRAY, POS(1)-POS(3), EARTH X,Y,Z              118500
C     VEL   OUTPUT, VELOCITY ARRAY, REAL*8                                  118600
C     NCENTR   CENTRAL BODY NUMBER (3-EARTH,11-MOON, 10-SUN, 2-VENUS,       118700
C     AU   ASTRONOMICAL UNIT                                                118800
C     REM   EQUATORIAL RADIUS OF EARTH                                      118900
C     4-MARS, 6-SATURN, 5-JUPITER)                                          119000
C     EMRAT   EARTH MOON MASS RATIO                                         119100
      REAL*8 JED,NUT                                                        119200
      REAL*8 JEDPRV                                                         119300
      REAL*8 JDN                                                            119400
      REAL*8 JEZ                                                            119500
      REAL*8 JD1                                                            119600
      DIMENSION POS(21),VEL(21),NCENT(7),IREQ(13),TABOUT(6,12),NUT(4)       119700
      COMMON /CETBL1/ AU,REM,TPD,EMRAT                                      119800
      COMMON /CETBL2/ ICW,NCENTR,IREQ                                       119900
      COMMON /CETBL4/ TABOUT,NUT                                            120000
      DATA NCENT/3,11,10,2,4,6,5/                                           120100
      DATA JEDPRV/0.D0/,IERR/0/                                             120200
      DATA IFIRST/0/                                                        120300
      DATA NCENTP/0/                                                        120400
      IF(IFIRST.NE.0)GO TO 20                                               120500
      ICW=1                                                                 120600
```

```
      IFIRST=1                                                          120700
      AU=149597900.D0                                                   120800
      REM=6378.14200                                                    120900
      TPD=86400.D0                                                      121000
      EMRAT=81.301D0                                                    121100
 20   DO 10 I=1,13                                                      121200
   10 IREQ(I)=2                                                         121300
      IF(TF-.5D0)38,39,39                                               121400
   38 SEC1=TF*86400.D0                                                  121500
      GO TO 40                                                          121600
   39 DT=TW+.5D0                                                        121700
      SEC1=(TF-.5D0)*86400.D0                                           121800
      GO TO 41                                                          121900
   40 DT=TW                                                             122000
 41   JD1=DT+2433282.5D0                                                122100
C*********************************************************************** 122200
C*********************************************************************** 122300
      TSEC=SEC1                                                         122400
      JED=JD1                                                           122500
      JEZ=JED+TSEC                                                      122600
      NCENTR=NCENT(NB+1)                                                122700
      IF(JEZ.EQ.JEDPRV.AND.NCENTR.EQ.NCENTP) GO TO 1                    122800
      JEDPRV=JEZ                                                        122900
      NCENTP=NCENTR                                                     123000
      CALL READE(JED,TSEC,IERR)                                         123100
      IF(IERR.EQ.0) GO TO 1                                             123200
      WRITE(6,100) IERR,NCENTR,ICW,JD3                                  123300
  100 FORMAT(23HOEPHEMERIS ERROR, IERR=,I3,2I5,D14.2)                   123400
    1 CONTINUE                                                          123500
      DO 2 J=1,7                                                        123600
      DO 2 I=1,3                                                        123700
      II=(J-1)*3+I                                                      123800
      JJ=NCENT(J)                                                       123900
      POS(II)=TABOUT(I,JJ)                                              124000
 2    VEL(II)=TABOUT(I+3,JJ)                                            124100
      RETURN                                                            124200
      END                                                               124300
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```
      SUBROUTINE ITER(IB,R1,V1,F,K,KK,DT,R,V)                          124400
      IMPLICIT REAL*8(A-H,O-Z,$)                                       124500
      COMMON C(1000),IC(50),Z(3),VV(3),NOR                             124600
      COMMON/STEPS/ STEP,XOLD                                          124700
      DIMENSION X1(3),R1(3,8),R(3,8),V1(3,8),V(3,8),RR(3),VVV(3),CB(20) 124800
      COUNT=0.D0                                                       124900
      ZRS=6.965D5                                                      125000
      XK=1                                                             125100
      F=0.D0                                                           125200
      DT=0.D0                                                          125300
      T=0.D0                                                           125400
      LK=1                                                             125500
      TOLD=0.D0                                                        125600
      FOLD=0.D0                                                        125700
      NN=1                                                             125800
      IF(KK.EQ.2) XK=-1                                                125900
C   K=1 MEANS EARTH SHADOW, K=2 MEANS MOON SHADOW                      126000
C    K=3 MEANS OTHER PLANET SHADOW                                     126100
C   KK=1 MEANS PENUMBRA, KK=2 MEANS UMBRA                              126200
      DO 2000 I=1,8                                                    126300
      DO 2000 J=1,3                                                    126400
      R(J,I)=R1(J,I)                                                   126500
 2000 V(J,I)=V1(J,I)                                                   126600
      GO TO (1,2,10),K                                                 126700
    1 DO 3 I=1,3                                                       126800
    3 X1(I)=R(I,1)-R(I,3)                                              126900
      SEVA= ADOT(X1,R(1,1))                                            127000
      RFS=FNORM(R(1,3))                                                127100
      RFE= FNORM(R(1,1))                                               127200
      DELS= DARSIN(6500.D0/RFE)*57.295779500                           127300
      ZRE=6500.D0                                                      127400
      GO TO 4                                                          127500
    2 DO 5 I=1,3                                                       127600
    5 X1(I)=R(I,2)-R(I,3)                                              127700
      SEVA= ADOT(X1,R(1,2))                                            127800
      RFS= FNORM(R(1,3))                                               127900
      RFE= FNORM(R(1,2))                                               128000
      DELS=DARSIN(1738.D0/RFE)*57.295779500                            128100
      ZRE=1738.D0                                                      128200
      GO TO 4                                                          128300
   10 DO 20 I = 1, 3                                                   128400
   20 X1(I) = R(I, NOR) - R(I,3)                                       128500
      SEVA= ADOT(X1,R(1,NOR))                                          128600
      RFS=FNORM(R(1,3))                                                128700
      RFE= FNORM(R(1,NOR))                                             128800
      DELS=DARSIN(C(NOR+20)/RFE)*57.2957795D0                          128900
      ZRE=C(NOR+20)                                                    129000
    4 CONTINUE                                                         129100
      ZRE=DSIGN(ZRE,XK)                                                129200
      SIG=DARSIN((ZRS+ZRE)/RFS)*57.295779500                           129300
      F=SEVA+DELS+XK*SIG-180.D0                                        129400
      IF(DABS(F).LE.0.000001D0) RETURN                                 129500
      IF(COUNT.GT.100.D0) GO TO 11                                     129600
      GO TO (6,7),LK                                                   129700
    6 LK=2                                                             129800
      DT=-STEP                                                         129900
      GO TO 8                                                          130000
    7 DT=(TOLD*F-T*FOLD)/(F-FOLD)                                      130100
    8 FOLD=F                                                           130200
      TOLD=T                                                           130300
      T=DT                                                             130400
      CALL STEPD(NN,DT,TA,R1(1,IB),V1(1,IB),C(IB),RR,VVV,1,CB)         130500
      TIM= C(593)+(XOLD+C(506)+T)/86400.D0                             130600
      CALL TFRAC(C(592),TIM,TT,TTF)                                    130700
      CALL SHIFTP(IB,RR,VVV,TT,TTF,R,V)                                130800
      COUNT=COUNT+1.D0                                                 130900
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      GO TO (1,2,10),K                                                  131000
   11 WRITE(6,12)                                                       131100
   12 FORMAT(1HO,22HMAX ITERATIONS IN ITER)                             131200
      STOP                                                              131300
      END                                                               131400
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      SUBROUTINE KONSTK                                                 131500
      IMPLICIT REAL*8(A-H,O-Z,$)                                        131600
      DIMENSION C(1000),IC(50)                                          131700
      DIMENSION S(40,1),SSS(40,6)                                       131800
      DIMENSION DNAME(2,6)                                              131900
      DIMENSION D(7,3)                                                  132000
C THE FOLLOWING STATEMENT(S) HAVE BEEN MANUFACTURED BY THE TRANSLATOR TO 132100
C   COMPENSATE FOR THE FACT THAT EQUIVALENCE DOES NOT REORDER COMMON---  132200
      COMMON  C                                                         132300
      COMMON  IC      , SSS                                             132400
C     DIMENSION C(1000),IC(50)                                          132500
C     DIMENSION S(40,1),SSS(40,6)                                       132600
C     DIMENSION DNAME(2,6)                                              132700
C     DIMENSION D(7,3)                                                  132800
C     COMMON C,IC,SSS                                                   132900
      EQUIVALENCE (C(201),S(1,1)),(C(341),D(1,1)),(C(448),DNAME(1,1))   133000
C     DEFINES CONSTANTS NEEDED BY PROGRAM                               133100
C                                                                       133200
      DO 1 I=1,1000                                                     133300
    1 C(I)=0.0D0                                                        133400
C     PLANETARY GRAVITATIONAL CONSTANTS (KM3/SEC2)                      133500
      C(1) = 398603.2D0                                                 133600
      C(2) = 4902.778D0                                                 133700
      C(3) = .13271545D12                                               133800
      C(4) = 324769.5D0                                                 133900
      C(5)=42915.515D0                                                  134000
      C(6)=.126710(9D9                                                  134100
      C(7)=10000.0L 0                                                   134200
      C(8)=10000.0L0                                                    134300
C     RADIUS OF SPHERE OF INFLUENCE (KM)                                134400
      C(11)=925000.0D0                                                  134500
      C(12)=6o000.0D0                                                   134600
      C(13)=1.D10                                                       134700
      C(14)=616000.0D0                                                  134800
      C(15)=565000.0D0                                                  134900
      C(16)=.48D8                                                       135000
      C(17)=100000.0D0                                                  135100
      C(18)=100000.0D0                                                  135200
C     IMPACT RADIUS  (KM)                                               135300
      C(21)=6378.165D0                                                  135400
      C(22)=1738.0D0                                                    135500
      C(23)=694000.0D0                                                  135600
      C(24)=6050.0D0                                                    135700
      C(25) = 3417.0D0                                                  135800
      C(26)=71000.0D0                                                   135900
      C(27)=10000.0D0                                                   136000
      C(28)=10000.0D0                                                   136100
C     MINIMUM TIME STEP FOR OUTPUT (SEC)                                136200
      C(31)=43200.0D0                                                   136300
      C(32)=21600.0D0                                                   136400
      C(33)=1728000.0D0                                                 136500
      C(34)=43200.0D0                                                   136600
      C(35)=43200.0D0                                                   136700
      C(36)=86400.0D0                                                   136800
      C(37)=43200.0D0                                                   136900
      C(38)=43200.0D0                                                   137000
C     SIDEREAL ROTATION RATES  (RAD/SEC)                                137100
      C(41)=.72921152D-4                                                137200
C     INTERPOLATION INTERVALS FOR EPHEMERIS  (DAYS)                     137300
      C(51)=40.0D0                                                      137400
      C(54)=40.0D0                                                      137500
      C(55)=40.0D0                                                      137600
      C(56)=100.0D0                                                     137700
C     NAMES OF EPHEMERIS BODIES                                         137800
      DATA 0000HL/6H EARTH/                                             137900
      C(61)=0000HL                                                      138000
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      DATA Q001HL/6H  MOON/                                                 138100
      C(62)=Q001HL                                                          138200
      DATA Q002HL/6H   SUN/                                                 138300
      C(63)=Q002HL                                                          138400
      DATA Q003HL/6H VENUS/                                                 138500
      C(64)=Q003HL                                                          138600
      DATA Q004HL/6H  MARS/                                                 138700
      C(65)=Q004HL                                                          138800
      DATA Q005HL/6HJUPTER/                                                 138900
      C(66)=Q005HL                                                          139000
      DATA Q006HL/6HBODY 7/                                                 139100
      C(67)=Q006HL                                                          139200
      DATA Q007HL/6HBODY 8/                                                 139300
      C(68)=Q007HL                                                          139400
C     ASTRONOMICAL UNIT IN KM                                               139500
      C(70)=.1495D9                                                         139600
C     SECONDS PER MEAN SOLAR DAY AND RECIPROCAL                             139700
      C(71)=86400.0D0                                                       139800
      C(72)=1.1574074D-5                                                    139900
C     SEMI-MAJOR AND SEMI-MINOR AXES OF THE EARTH (KM)                      140000
      C(73)=6378.2064D0                                                     140100
      C(74)=6356.5838D0                                                     140200
C     DEGREE-RADIAN CONVERSIONS                                             140300
      C(75)=.0174533293D0                                                   140400
      C(76) = 57.2957795D0                                                  140500
      C(77) = 1.5707963200                                                  140600
      C(78) = 3.1415926500                                                  140700
      C(79) = 6.2831853000                                                  140800
      DATA Q008HL/6H     K/                                                 140900
      C(85)=Q008HL                                                          141000
      DATA Q009HL/6HM-KM/S/                                                 141100
      C(86 )=Q009HL                                                         141200
      DATA Q010HL/6HEC-DEG/                                                 141300
      C(87)=Q010HL                                                          141400
      DATA Q011HL/6H     U/                                                 141500
      C(88 )=Q011HL                                                         141600
      DATA Q012HL/6HNITS A/                                                 141700
      C(89 )=Q012HL                                                         141800
      DATA Q013HL/6HU--DEG/                                                 141900
      C(90 )=Q013HL                                                         142000
      DATA Q014HL/6H   FQU/                                                 142100
      C(91)=Q014HL                                                          142200
      DATA Q015HL/6HATOR D/                                                 142300
      C(92)=Q015HL                                                          142400
      DATA Q016HL/6HF DATE/                                                 142500
      C(93)=Q016HL                                                          142600
      DATA Q017HL/6H  ECLI/                                                 142700
      C(94)=Q017HL                                                          142800
      DATA Q018HL/6HPTIC O/                                                 142900
      C(95)=Q018HL                                                          143000
      C(96)=Q016HL                                                          143100
      DATA Q019HL/6H     S/                                                 143200
      C(97)=Q019HL                                                          143300
      DATA Q020HL/6HELENOG/                                                 143400
      C(98)=Q020HL                                                          143500
      DATA Q021HL/6HRAPHIC/                                                 143600
      C(99)=Q021HL                                                          143700
      C(122)=1.0D0                                                          143800
C **** THE FOLLOWING ARE EARTH POTENTIAL COEFFICIENTS ****                  143900
C       C(200) THRU C(207) IS C(0,0) THRU C(7,0)                            144000
C       C(208) THRU C(214) IS C(1,1) THRU C(7,1)                            144100
C       C(215) THRU C(220) IS C(2,2) THRU C(7,2)                            144200
C       C(221) THRU C(225) IS C(3,3) THRU C(7,3)                            144300
C       C(226) THRU C(229) IS C(4,4) THRU C(7,4)                            144400
C       C(230) THRU C(232) IS C(5,5) THRU C(7,5)                            144500
C       C(233) THRU C(234) IS C(6,6) THRU C(7,6)                            144600
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C       C(235) IS C(7,7)                                                    144700
C       C(236) THRU C(243) IS S(0,0) THRU S(7,0)                            144800
C       C(244) THRU C(250) IS S(1,1) THRU S(7,1)                            144900
C       C(251) THRU C(256) IS S(2,2) THRU S(7,2)                            145000
C       C(257) THRU C(261) IS S(3,3) THRU S(7,3)                            145100
C       C(262) THRU C(265) IS S(4,4) THRU S(7,4)                            145200
C       C(266) THRU C(268) IS S(5,5) THRU S(7,5)                            145300
C       C(269) THRU C(270) IS S(6,6) THRU S(7,6)                            145400
C       C(271)          IS S(7,7)                                           145500
      C(200)=0.0D0                                                          145600
      C(201)=0.0D0                                                          145700
      C(202)=-.108264500002D-2                                              145800
      C(203)=0.25459999990D-5                                               145900
      C(204) = .164 D-5                                                     146000
      C(205) = .210 D-6                                                     146100
      C(206) = -.6459999999930D-6                                           146200
      C(207) = .3329999999980D-6                                            146300
      C(208) = 0.D0                                                         146400
      C(209) = 0.D0                                                         146500
      C(210) = .209111899862 D-5                                            146600
      C(211) = -.542646846485 D-6                                           146700
      C(212) = -.676515582477D-7                                            146800
      C(213) = -.36979402246 D-7                                            146900
      C(214) = .14418923578 D-6                                             147000
      C(215) = .153563789676D-5                                             147100
      C(216) = .2507087287360-6                                             147200
      C(217) = .737902432577D-7                                             147300
      C(218) = .1021177075260-6                                             147400
      C(219) = .8583830313850-8                                             147500
      C(220) = .362552678174 D-7                                            147600
      C(221) = .7822771248130-7                                             147700
      C(222) = .5085697732730-7                                             147800
      C(223) = -.171778742888D-7                                            147900
      C(224) = -.119630040940-8                                             148000
      C(225) = -.352147606138 D-8                                           148100
      C(226) = -.11198293875 D-8                                            148200
      C(227) = -.2063363282040-8                                            148300
      C(228) = -.1665608129460-9                                            148400
      C(229) = -.3227765545750-9                                            148500
      C(230) = .384108946188D-9                                             148600
      C(231) = -.252611520257 D-9                                           148700
      C(232) = .2689804621530-10                                            148800
      C(233) = -.9319190365590-11                                           148900
      C(234) = -.1450663738260-10                                           149000
      C(235) = .1020279453390-11                                            149100
      C(236) = 0.D0                                                         149200
      C(237) = 0.D0                                                         149300
      C(238) = 0.D0                                                         149400
      C(239) = 0.D0                                                         149500
      C(240) = 0.D0                                                         149600
      C(241) = 0.D0                                                         149700
      C(242) = 0.D0                                                         149800
      C(243) = 0.D0                                                         149900
      C(244) = 0.D0                                                         150000
      C(245) = 0.D0                                                         150100
      C(246) = .2873128376320-6                                             150200
      C(247) = -.4449324667790-6                                            150300
      C(248) = -.882039307460-7                                             150400
      C(249) = -.212434863970-7                                             150500
      C(250) = .114180308536 D-6                                            150600
      C(251) = -.8720466750118 D-6                                          150700
      C(252) = -.183761983737 D-6                                           150800
      C(253) = .1478040933150-6                                             150900
      C(254) = -.3754565474840-7                                            151000
      C(255) = -.455316216648 D-7                                           151100
      C(256) = .162351886106 D-7                                            151200
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      C(257) = .225898207164 D-6                                          151300
      C(258) = -.113546717887D-7                                          151400
      C(259) = .231240615425 D-9                                          151500
      C(260) = .642750579065D-9                                           151600
      C(261) = .253546276422D-9                                           151700
      C(262) = .485963696475D-8                                           151800
      C(263) = .498321698304 D-9                                          151900
      C(264) = -.196087502512D-8                                          152000
      C(265) = -.216600056362D-9                                          152100
      C(266) = -.145764420605D-8                                          152200
      C(267) = -.369636026451D-9                                          152300
      C(268) = .191117696793D-10                                          152400
      C(269) = -.361118626660D-10                                         152500
      C(270) = .437281413924D-11                                          152600
      C(271) = .178085140954D-11                                          152700
C **** THE FOLLOWING ARE MOON POTENTIAL COEFFICIENTS ****                 152800
C       C(272) THRU C(276) IS C(0,0) THRU C(4,0)                          152900
C       C(277) THRU C(280) IS C(1,1) THRU C(4,1)                          153000
C       C(281) THRU C(283) IS C(2,2) THRU C(4,2)                          153100
C       C(284) THRU C(285) IS C(3,3) THRU C(4,3)                          153200
C       C(286)       IS C(4,4)                                            153300
C       C(287) THRU C(291) IS S(0,0) THRU S(4,0)                          153400
C       C(292) THRU C(295) IS S(1,1) THRU S(4,1)                          153500
C       C(296) THRU C(298) IS S(2,2) THRU S(4,2)                          153600
C       C(299) THRU C(300) IS S(3,3) THRU S(4,3)                          153700
C       C(301)             IS S(4,4)                                      153800
      C(272)=0.0D0                                                        153900
      C(273)=0.0D0                                                        154000
      C(274)=-.207108D-3                                                  154100
      C(275)=0.21D-4                                                      154200
      C(279)=0.34D-4                                                      154300
      C(281)=0.20716D-4                                                   154400
      C(284)=0.02583D-4                                                   154500
C     C(462)= FLAG FOR IMPACT                                             154600
      C(462)=1.D0                                                         154700
      C(506)=0.D0                                                         154800
C     C(719)= REDUCTION FROM UNIVERSIAL TO EPHM TIME 1966                 154900
      C(719)=40.0D0                                                       155000
C       C(720)= RETIFICATION LIMIT IN ROUTINE DERIV                       155100
      C(720)=0.025D0                                                      155200
C       C(725)= J2 OF MARS                                                155300
      C(725)=0.1946667D-2                                                 155400
C     C(726)= J3 /F MARS                                                  155500
      C(726)=0.D0                                                         155600
C       C(758) STANDS FOR TYPE OF INPUT                                   155700
C              =1   EARTH MEAN EQUATOR AND EQUINOX OF 1950                155800
C              =2   TRUE EQUINOX AND ECLIPTIC OF DATE                     155900
C              =3   SELENOGRAPHIC TRUE MOON EQUATOR OF DATE               156000
C              =4   MARS MEAN EQUATOR OF DATE                             156100
C              =5   TRUE EARTH EQUATOR AND EQUINOX OF DATE                156200
      C(758)=1.D0                                                         156300
C       C(761) IS DAYS FOR INTEGRATION                                    156400
      C(761)=180.0D0                                                      156500
      C(762)=1.0D0                                                        156600
      C(763)=0.0D0                                                        156700
      C(764)=86400.D0                                                     156800
      C(765)=-1.0D0                                                       156900
      C(766)=1.0D0                                                        157000
      C(767)=5.0D0                                                        157100
      C(768)=111.D0                                                       157200
C---- C(769) SOLAR PRESS KEY      0.0=DO NOT INCLUDE  1.0= INCLUDE        157300
      C(769)=0.0D0                                                        157400
C---- C(770) AREA FOR SOLAR PRESSURES (CM.**2)                            157500
      C(770)=22225.D0                                                     157600
C---- C(771) MASS FOR SOLAR PRESS (GM.)                                   157700
      C(771)=113000.D0                                                    157800
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C---- C(772) REFLECTIVITY                                                    157900
      C(772)=0.2D0                                                           158000
C---- C(773) FRACTION OF PARTICLES REFLECTED                                 158100
      C(773)=1.0D0                                                           158200
C---- C(774) SOLAR PRESS AT ONE A.U.                                         158300
      C(774)=4.7D-5                                                          158400
C---- C(775) IS KEY FOR INPUT.=0. INPUT IS CARTESIAN.=1. INPUT IS            158500
C      ORBITAL ELEMENTS                                                      158600
      C(775)=0.D0                                                            158700
C ---- C(776) IS KEY FOR STOPPING AT APOGEE OR PERIGEE.                       158800
C ---- =0. DO NOT STOP,  =1. STOP AT APOGEE, =-1. STOP AT PERIGEE            158900
      C(776)=0.D0                                                            159000
C----C(777) IS THE KEY FOR EXTRA OUTOUT AND IS IN THE FORM ABCDEFGH.         159100
C----0 MEANS DO NOT PRINT AND 1 MEANS PRINT.                                 159200
C---- A= CENTRAL BODY MEAN EARTH EQUATOR OF 1950                             159300
C---- B= MOON FIXED                                                          159400
C---- C= MARS MEAN EQUATOR OF DATE                                           159500
C---- G= CENTRAL BODY TRUE EARTH EQUATOR OF DATE                             159900
C---- H=EARTH FIXED LATITUDE AND LONGITUDE                                   160000
      C(777)=10000011.                                                       160100
C       C(901) IS DELTA T FOR UPDATING TRANSFORMATIONS IN HARMON              160200
      C(901)=15.D0                                                           160300
C     THESE CONSTANTS WERE DEFINED IN MAIN                                   160400
       IC(1)=0                                                               160500
       IC(2)=0                                                               160600
       RETURN                                                                160700
       END                                                                   160800
```

```
      SUBROUTINE M1 (X,A,Y)                                          160900
      IMPLICIT REAL*8(A-H,O-Z,$)                                     161000
C     SUBROUTINE GIVES Y=AX                                          161100
      DIMENSION  X(3),Y(3),A(3,3)                                    161200
C     DIMENSION  X(3),Y(3),A(3,3)                                    161300
      DO 1 I=1,3                                                     161400
      Y(I)=0.DO                                                      161500
      DO 1 J=1,3                                                     161600
    1 Y(I)=Y(I)+A(I,J)*X(J)                                          161700
      RETURN                                                         161800
      END                                                            161900
```

```
      SUBROUTINE MNA(TIME,OM,CR,DT,EPSIL,RO,G,GP,WW,FM)                 162000
      IMPLICIT REAL*8(A-H,O-Z,$)                                        162100
      DIMENSION EM(3,3),DF(3)                                           162200
      COMMON/XLIB/ SG,TA                                                162300
C                                                                       162400
C                                                                       162500
C                                                                       162600
      D = TIME                                                          162700
      T = D/36525.D0                                                    162800
      T2 = T*T                                                          162900
      T3 = T2*T                                                         163000
      A=13.064992D0                                                     163100
      DO 6 I=1,3                                                        163200
      DD=0.D0                                                           163300
      DD=D                                                              163400
      DD=DD*(A/360.D0)                                                  163500
      DD=DD-IDINT(DD)                                                   163600
      DF(I)=DD                                                          163700
      GO TO (4,5,6),I                                                   163800
    4 A=.985600500                                                      163900
      GO TO 6                                                           164000
    5 A=.164358600                                                      164100
    6 CONTINUE                                                          164200
      G=215.54013D0+360.D0*DF(1)                                        164300
      GP=358.00906700+360.D0*DF(2)                                      164400
      WW=196.745632D0+360.D0*DF(3)                                      164500
      G = G*.01745329600                                                164600
      GP = GP*.01745329600                                              164700
      WW = WW*.01745329600                                              164800
      YN = 1.535D0*.01745329600                                         164900
      RO = -.0297222D0*DCOS(G)+.0102777D0*DCOS(G+2.D0*WW)               165000
     1     -.00305555D0*DCOS (2.D0*G+2.D0*WW)                           165100
      TA = -.003333D0*DSIN(G)+.0163888D0*DSIN(GP)                       165200
     1   +.005D0*DSIN(2.D0*WW)                                          165300
      SG = -.0302777D0*DSIN(G) + .0102777D0*DSIN(G+2.D0*WW)             165400
     1     -.00305555D0*DSIN (2.D0*G+2.D0*WW)                           165500
      SG = (SG*.01745329600)/DSIN (YN)                                  165600
      RO = RO*.01745329600                                              165700
      TA = TA*.01745329600                                              165800
      YN = YN + RO                                                      165900
      RO = OM + SG + DT                                                 166000
      CI = DCOS (RO)*DSIN (EPSIL)*DSIN (YN)                             166100
     1    +DCOS (EPSIL)*DCOS (YN)                                       166200
      SI = 1.D0 - CI**2                                                 166300
      SI = DSQRT (SI)                                                   166400
      SO = -DSIN (RO)*DSIN (YN)/SI                                      166500
      CO = 1.D0 - SO**2                                                 166600
      CO = DSQRT (CO)                                                   166700
      SD = -DSIN (RO)*DSIN (EPSIL)/SI                                   166800
      CD = -DSIN (RO)*SO*DCOS (EPSIL) - DCOS (RO)*CO                    166900
      DL=ARKTNS(0,CD,SD)                                                167000
    8 CONTINUE                                                          167100
      CA = DL + (CR + TA) - (OM + SG)                                   167200
      SA = DSIN (CA)                                                    167300
      CA = DCOS (CA)                                                    167400
      RO = DCOS (RO)*DSIN (EPSIL)/(SI*CO)                               167500
      EM(1,1) = CA*CO - SA*SO*CI                                        167600
      EM(1,2) = CA*SO + SA*CO*CI                                        167700
      EM(1,3) = SA*SI                                                   167800
      EM(2,1) = -SA*CO - CA*SO*CI                                       167900
      EM(2,2) = -SA*SO + CA*CO*CI                                       168000
      EM(2,3) = CA*SI                                                   168100
      EM(3,1) = SO*SI                                                   168200
      EM(3,2) = -CO*SI                                                  168300
      EM(3,3) = CI                                                      168400
      RETURN                                                            168500
      END                                                               168600
```

```
      SUBROUTINE MULT(A,B,C)                                          168700
      IMPLICIT REAL*8(A-H,O-Z,$)                                      168800
      DIMENSION A(3,3),B(3,3),C(3,3)                                  168900
C     DIMENSION A(3,3),B(3,3),C(3,3)                                  169000
      DO 1 I=1,3                                                      169100
      DO 1 J=1,3                                                      169200
      C(I,J) = 0.DO                                                   169300
      DO 1 K=1,3                                                      169400
    1 C(I,J) = C(I,J) + A(I,K)*B(K,J)                                 169500
      RETURN                                                          169600
      END                                                             169700
```

```
      SUBROUTINE NUTAIT (TIME,DM,CR,DT,EN,EPSIL)                        169800
      IMPLICIT REAL*8(A-H,O-Z,$)                                        169900
      DIMENSION EN(3,3)                                                 170000
C     DIMENSION EN(3,3)                                                 170100
      DD7=0.DO                                                          170200
      D = TIME                                                          170300
      T = D/36525.0DO                                                   170400
      T2 = T*T                                                          170500
      T3 = T2*T                                                         170600
      DM= 12.11279DO0-.052953922D0*D+.0020795D0*T+.002081000*T2+.000002 170700
     200D0*T3                                                           170800
      CR = 64.375452D0+13.176397D0*D-.001131575D0*T-.00113015D0*T2+.0000 170900
     2013D0*T3                                                          171000
      GP = 208.84399D0+.11140408D0*D-.01033400D0*T-.01034300D0*T2-.00001 171100
     2200D0*T3                                                          171200
      VL = 280.08121D0+.98564734D0*D+.00030300D0*(T+T2)                 171300
      G = 282.08053D0+.470684D-04*D+.00045525D0*T+.00045750D0*T2+.000003 171400
     200D0*T3                                                           171500
      DM = DM*.017453296D0                                              171600
      CR = CR*.017453296D0                                              171700
      GP = GP*.017453296D0                                              171800
      VL = VL*.017453296D0                                              171900
      G = G*.017453296D0                                                172000
      DE1 = 25.584400D0 * DCOS(DM)                                      172100
      DE2 = -.2511D0 * DCOS(2.D0*DM)                                    172200
      DE3 = 1.533600*DCOS(2.D0*VL)                                      172300
      DE4 = .0666D0* DCOS( 3.D0* VL -G )                                172400
      DE5 = -.0258D0 * DCOS( VL+G )                                     172500
      DE6 = - .0183D0 * DCOS( 2.D0*VL-DM)                               172600
      DE7 = -.0067D0 * DCOS( 2.D0*GP - DM )                             172700
      DE = DE1 + DE2 + DE3 + DE4 + DE5 + DE6 + DE7                      172800
      DD1 = .2456D0 * DCOS(2.D0*CR)                                     172900
      DD2 = .0508D0 * DCOS( 2.D0* CR - DM)                              173000
      DD3 = .0369D0 * DCOS(3.D0* CR - GP )                              173100
      DD4 = -.0139D0 * DCOS( CR+GP)                                     173200
      DD5 = -.0086D0 * DCOS( CR-GP+DM )                                 173300
      DD6 = .0083D0 * DCOS( CR-GP-DM )                                  173400
      DD8 = .0061D0 * DCOS( 3.D0 * CR+GP - 2.D0*VL )                    173500
      DD9 = .0064D0 * DCOS( 3.D0*CR -GP -DM)                            173600
      DD = DD1 + DD2 + DD3 + DD4 + DD5 + DD6 + DD7 + DD8 + DD9          173700
      DT1 = -( 47.892700D0 + .0482D0*T) * DSIN(DM)                      173800
      DT2 = .58D0 * DSIN( 2.D0*DM )                                     173900
      DT3 = -3.536100D0 * DSIN( 2.DO * VL )                             174000
      DT4 = -.1378D0 * DSIN( 3.D0*VL -G )                               174100
      DT5 = .0594D0 * DSIN( VL+G )                                      174200
      DT6 = .0344D0 * DSIN( 2.D0*VL - DM)                               174300
      DT7 = .0125D0 * DSIN( 2.D0*GP - DM )                              174400
      DT8 = .35D0 * DSIN( VL-G )                                        174500
      DT9 = .0125D0 * DSIN( 2.D0*VL - 2.D0*GP )                         174600
      DT = DT1 + DT2 + DT3 + DT4 + DT5 + DT6 + DT7 + DT8 + DT9          174700
      DS1 = -.5658D0 * DSIN( 2.D0*CR )                                  174800
      DS2 = -.095D0 * DSIN( 2.D0*CR - DM )                              174900
      DS3 = -.072500 * DSIN( 3.D0*CR - GP )                             175000
      DS4 = .0317D0 * DSIN( CR+GP )                                     175100
      DS5 = .0161D0 * DSIN( CR -GP +DM )                                175200
      DS6 = .0158D0 * DSIN( CR -GP -DM )                                175300
      DS7 = -.0144D0 * DSIN( 3.D0*CR + GP - 2.D0*VL )                   175400
      DS8 = -.0122D0 * DSIN( 3.D0*CR - GP - DM )                        175500
      DS9 = .1875D0 * DSIN( CR - GP )                                   175600
      DS10 = .0078D0 * DSIN( 2.D0*CR - 2.D0*GP )                        175700
      DS11 = .0414D0 * DSIN( CR + GP - 2.D0*VL )                        175800
      DS12 = .0167D0 * DSIN( 2.D0*CR - 2.D0*VL )                        175900
      DS13 = -.0089D0 * DSIN( 4.D0*CR - 2.D0*VL )                       176000
      DS = DS1+DS2+DS3+DS4+DS5+DS6+DS7+DS8+DS9+DS10+DS11+DS12+DS13      176100
      DE = .17453296D-5*(DE+DD)                                         176[illegible]
      DT = .17453296D-5*(DT+DS)                                         [illegible].0300
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```
EB = 23.445758700-.013094040D0*T-.000000880D0*T2+.000000500*T3          176400
EB = EB*.017453296D0                                                    176500
EPSIL = EB+DE                                                           176600
EN(1,1) = 1.0DC                                                         176700
EN(1,2)=-DT*DCOS(EB)                                                    176800
EN(1,3)=-DT*DSIN(EB)                                                    176900
EN(2,1) = -EN(1,2)                                                      177000
EN(2,2) = 1.0D0                                                         177100
EN(2,3) = -DE                                                           177200
EN(3,1) = -EN(1,3)                                                      177300
EN(3,2) = DE                                                            177400
EN(3,3) = 1.0D0                                                         177500
RETURN                                                                  177600
END                                                                     177700
```

```
      SUBROUTINE ORB(X,DX,U,NOUT)                                       177800
      IMPLICIT REAL*8(A-H,O-Z,$)                                        177900
      DIMENSION C(1000)                                                 178000
      DIMENSION X(3),DX(3),B(3)                                         178100
C THE FOLLOWING STATEMENT(S) HAVE BEEN MANUFACTURED BY THE TRANSLATOR TO 178200
C   COMPENSATE FOR THE FACT THAT EQUIVALENCE DOES NOT REORDER COMMON---  178300
      COMMON  C                                                         178400
C     COMMON C                                                          178500
C     DIMENSION C(1000)                                                 178600
C     DIMENSION X(3),DX(3),B(3)                                         178700
      EQUIVALENCE (C(700),SMA),(C(701),ECC),(C(702),OINC),(C(703),OMG)  178800
     1,(C(704),BEP),(C(705),RCA),(C(706),C3),(C(707),THET),(C(708),PERV) 178900
     2,(C(709),P),(C(710),BB  ),(C(711),TPER)                           179000
      CALL CROSS(X,DX,B)                                                179100
      R2 = DOT(X,X)                                                     179200
      R=DSQRT(R2)                                                       179300
      V2 = DOT(DX,DX)                                                   179400
      B2 = DOT(B,B)                                                     179500
      BB=DSQRT(B2)                                                      179600
      A=DOT(X,DX)/U                                                     179700
      P  = B2/U                                                         179800
      C3 = V2-2.0D0*U/R                                                 179900
      SMA=-U/C3                                                         180000
      ECC=DSQRT(DABS(1.0D0+C3*P/U))                                     180100
      OINC=ARKTNS(180,B(3),DSQRT(B(1)**2+B(2)**2))                      180200
      OMG= ARKTNS(360,-B(2),B(1))                                       180300
      RCA=P/(1.0D0+ECC)                                                 180400
      THT=ARKTNS(360,(P-R),BB*A)                                        180500
      BET= ARKTNS(360,X(2)*B(1)-X(1)*B(2),X(3)*BB)                      180600
      BEP= BET-THT                                                      180700
      IF(BEP) 2,3,3                                                     180800
    2 BEP=BEP+6.2831853D0                                               180900
    3 CONTINUE                                                          181000
      RTD=57.2957951D0                                                  181100
      OINC=OINC*RTD                                                     181200
      OMG=OMG*RTD                                                       181300
      BEP=BEP*RTD                                                       181400
      PERV=DSQRT(DABS(C3+2.0D0*U/RCA))                                  181500
      VIMP=PERV-DSQRT(U/RCA)                                            181600
      CTAS=(P/R-1.0D0)/ECC                                              181700
      IF(DABS(CTAS).LT.1.D0) GO TO 200                                  181800
      STAS=0.D0                                                         181900
      CTAS=DSIGN(1.0D0,CTAS)                                            182000
      GO TO 201                                                         182100
  200 STAS=DSQRT(1.0D0-CTAS*CTAS)                                       182200
      STAS = DSIGN( STAS,A )                                            182300
  201 CONTINUE                                                          182400
      THE=ARKTNS(180,CTAS,STAS)                                         182500
      THET=THE*RTD                                                      182600
      CALL TCONIC(U,ECC,SMA,P,THE,TPER,FAC)                             182700
      TPER=TPER/86400.0D0                                               182800
      IF(SMA)10,10,11                                                   182900
   10 WRITE (    6,7)SMA,ECC,OINC,OMG,BEP,RCA,C3,THET,PERV,    P,VIMP,TPER  183000
    7 FORMAT(5H  SMAD15.8,5H  ECCD15.8,5H  INCD15.8,5H  LAND15.8,       183100
     15H  APFD15.8,5H  RCAD15.8/5H   C3D15.8,5H THETD15.8,5H PERVD15.8,  183200
     25H  SLRD15.8,5H IMPVD15.8,5H TPERD15.8)                           183300
      GO TO 12                                                          183400
   11 F1=A*U/DSQRT(U*SMA)                                               183500
      F2=1.0D0-R/SMA                                                    183600
      SINE=F1/ECC                                                       183700
      COSE=F2/ECC                                                       183800
      E=ARKTNS(360,COSE,SINE)                                           183900
      XMAN=(E-ECC*SINE)*RTD                                             184000
      PERH = FAC * C(79) / 3600.D0                                      184100
      APBK=SMA*(1.D0+ECC)                                               184200
      WRITE (    6,5)SMA,ECC,OINC,OMG,BEP,RCA,C3,THET,APBK,    XMAN,PERH,T  184300
```

```
     1PER                                                                    184400
    5 FORMAT(5H  SMAD15.8,5H  ECCD15.8,5H  INCD15.8,5H  LAND15.8,           184500
     15H  APFD15.8,5H  RCAD15.8/5H   C3D15.8,5H THETD15.8,5H APOGD15.8,     184600
     25H  MAND15.8,5H PERHD15.8,5H TPERD15.8)                               184700
   12 CONTINUE                                                              184800
      RETURN                                                                184900
      END                                                                   185000
```

```
      SUBROUTINE ORB2X(X,VX,E, U)                                          185100
      IMPLICIT REAL*8(A-H,O-Z )                                            185200
      DIMENSION X(3),VX(3),EL(6),A(3,2)                                    185300
C     EL CONSISTS OF INPUT ORBITAL ELEMENTS                                185400
C     (1) SEMI-MAJOR AXIS (+ IF ELLIPTIC, -FOR HYPERBOLIC)                 185500
C     (2) ECCENTRICITY    (LESS THAN 1. ELLIPTIC, GREATER HYPERBOLTC)      185600
C     (3) TRUE ANOMALY    (DEGREES)                                        185700
C     ***IF C379 CHANGED TO 1.; MEAN ANOMALY IS USED FOR INPUT             185800
      C379 = 0.D0                                                          185900
C     (4) LONGITUDE OF THE ASCENDING NODE (DEGREES)                        186000
C     (5) INCLINATION   (DEGREES)                                          186100
C     (6) ARGUMENT OF PERIAPSIS (DEGREES)                                  186200
      DATA DR/.01745329D0/                                                 186300
      COM=DCOS(DR*EL(4))                                                   186400
      SOM=DSIN(DR*EL(4))                                                   186500
      CIN=DCOS(DR*EL(5))                                                   186600
      SNI=DSIN(DR*EL(5))                                                   186700
      IF(C379  )10,10,20                                                   186800
 20   XM=EL(3)*DR                                                          186900
      ECC=EL(2)                                                            187000
      E=XM+ECC*DSIN (XM)+(ECC**2/2.D0)*DSIN (2.D0*XM)+(ECC**3/24.D0)*(9.   187100
     1D0*DSIN (3.D0*XM)-3.D0*DSIN (XM))+(ECC**4/192.D0)*(64.D0*DSIN (4.D   187200
     *0*XM)-32.D0*DSIN (2.D0*XM))                                          187300
      CTA=(DCOS (E)-ECC)/(1.D0-ECC*DCOS (E))                               187400
      STA=DSQRT (1.D0-ECC**2)*DSIN (E)/(1.D0-ECC*DCOS (E))                 187500
      TAA=ARKTNS(180,CTA,STA)                                              187600
      GO TO 21                                                             187700
 10   CTA=DCOS (DR*EL(3))                                                  187800
      STA=DSIN(DR*EL(3))                                                   187900
      TAA=EL(3)*DR                                                         188000
   21 TBB=TAA+EL(6)*DR                                                     188100
      CBA=DCOS(TBB)                                                        188200
      SBA=DSIN(TBB)                                                        188300
      A(1,1)=COM*CBA-(SOM*CIN)*SBA                                         188400
      A(2,1)=SOM*CBA+(COM*CIN)*SBA                                         188500
      A(3,1)=SNI*SBA                                                       188600
      A(1,2)=-COM*SBA-(SOM*CIN)*CBA                                        188700
      A(2,2)=-SOM*SBA+(COM*CIN)*CBA                                        188800
      A(3,2)=SNI*CBA                                                       188900
      P=EL(1)*(1.0D0-EL(2)**2)                                             189000
      R=P/(1.0D0+EL(2)*CTA)                                                189100
C     R IS THE RADIUS VECTOR MAGNITUDE                                     189200
      VR=EL(2)*STA*DSQRT(U/P)                                              189300
C     VR IS THE RADIAL COMPONENT OF VELOCITY                               189400
      VT=DSQRT(U*(2.0D0/R-1.0D0/EL(1))-VR*VR)                              189500
C     VT IS THE TANGENTIAL COMPONENT OF VELOCITY                           189600
      DO 1 I=1,3                                                           189700
      X(I)=R*A(I,1)                                                        189800
      VX(I)=VR*A(I,1)+VT*A(I,2)                                            189900
    1 CONTINUE                                                             190000
      RETURN                                                               190100
      END                                                                  190200
```

```
      SUBROUTINE OUT(X,Y,D,ERROR,N,L,H)                                  190300
      IMPLICIT REAL*8(A-H,O-Z,$)                                         190400
      DIMENSION A(3,3),EN(3,3),EMN(3,3),AR(3,3)                          190500
      DIMENSION DATE(3,3),SDATE(3,3),DATET(3,3),SDATET(3,3),ADATE(3,3),  190600
     1ADATET(3,3),DATEEC(3,3),DATECT(3,3),XX(3),XV(3)                    190700
      DIMENSION Y(20),D(20),ERROR(30)                                    190800
      DIMENSION RATE(3),PERT(3), PERTT(3)                                190900
      DIMENSION DACC(3),CACC(3),OACC(3)                                  191000
      DIMENSION R1(3,8),V1(3,8)                                          191100
      DIMENSION  XTEMP(3), VTEMP(3)                                      191200
      DIMENSION DUM(3,3)                                                 191300
      COMMON/DISTRB/DACC,CACC,OACC                                       191400
      COMMON /ROT/ DATE,SDATE,DATET,SDATET,ADATE,ADATET,DATEEC,DATECT    191500
      COMMON/TIME/TW,TF                                                  191600
      COMMON C(1000),IC(50),Z(3),VV(3),NOR,INP                           191700
      COMMON/TUP/TLU                                                     191800
      COMMON/PRINT/ IC50,ISEL,MARDAT,ICENEC,IEAREC,ISUNEC,ICDATE,IEARFX  191900
      DATA ST/-1./,ST1/-1./                                              192000
      EQUIVALENCE (C(401),R1(1,1)),(C(425),V1(1,1))                      192100
    3 TIM    =C(593)+(X+C(506))/86400.DO                                 192200
      CALL TFRAC(C(592),TIM    ,TW,TF)                                   192300
      IF (C(122) .NE. 0.DO ) GO TO 3000                                  192400
      ST1 = TW                                                           192500
      ST = TF                                                            192600
      IF(C(594)-(C(506)+X).GT.0.DO) GO TO 50                             192700
 3000 IF(TW.EQ.ST1.AND.DABS(TF-ST).LE..0000200) GO TO 50                 192800
      DO 1002 JJ=1,3                                                     192900
 1002 PERT(JJ)=DACC(JJ)-CACC(JJ)                                         193000
      ST1=TW                                                             193100
      ST=TF                                                              193200
      WRITE(6,9)                                                         193300
    9 FORMAT(1HO)                                                        193400
      CALL DATOUT(TW,TF,DAYM,FDATE,0)                                    193500
      TP=TW+TF                                                           193600
      TLU=TP                                                             193700
      CALL ROTEQ(TP,A)                                                   193800
      CALL NUTAIT(TP,OM,CR,DT,EN,EPSIL)                                  193900
      CALL MULT(EN,A,DATE)                                               194000
      DUM(1,1)=1.DO                                                      194100
      DUM(1,2)=0.DO                                                      194200
      DUM(1,3)=0.DO                                                      194300
      DUM(2,1)=0.DO                                                      194400
      DUM(2,2)=DCOS(EPSIL)                                               194500
      DUM(2,3)=DSIN(EPSIL)                                               194600
      DUM(3,1)=0.DO                                                      194700
      DUM(3,2)=-DUM(2,3)                                                 194800
      DUM(3,3)= DUM(2,2)                                                 194900
      CALL MULT(DUM,DATE,DATEEC)                                         195000
      DO 800 I=1,3                                                       195100
      DO 800 J=1,3                                                       195200
  800.  DATET(J,I)=DATE(I,J)                                             195300
C                                                                        195400
  100 IF(ICDATE.EQ.0) GO TO 30                                           195500
      CALL MI(R1(1,NOR),DATE,XX)                                         195600
      CALL MI(V1(1,NOR),DATE,XV)                                         195700
      WRITE(6,48) C(NOR+60)                                              195800
   48 FORMAT(1HO,A6,1X,'CENTERED',3X,'TRUE EARTH EQUATOR AND EQUINOX OF  195900
     1DATE')                                                             196000
      CALL OUTX(XX,XV,NOUT)                                              196100
      CALL ORB(XX,XV,C(NOR),NOUT)                                        196200
   30 IF(IC50.EQ.0.AND.C(777).NE.0.DO) GO TO 31                          196300
      WRITE(6,10) C(NOR+60)                                              196400
   10 FORMAT(1HO,A6,1X,8HCENTERED,3X,51HCENTRAL BODY MEAN EARTH EQUATOR  196500
     1AND EQUINOX OF 1950)                                              196600
      CALL OUTX(R1(1,NOR),V1(1,NOR),NOUT)                                196700
      CALL ORB(R1(1,NOR),V1(1,NOR),C(NOR),NOUT)                          196800
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   31 IF(IEARFX.EQ.0.OR.NOR.NE.1) GO TO 200                          196900
      ITIME=TP                                                       197000
      T2=(TP-ITIME)*86400.D0                                         197100
      T1=ITIME                                                       197200
      DA=EN(2,1)                                                     197300
      CALL GHA(T2,T1,GHAN,DA,OMEGA)                                  197400
      GHAN=GHAN*C(75)                                                197500
      CALL M1(R1(1,NOR),DATE,XTEMP)                                  197600
      SINT=DSIN(GHAN)                                                197700
      COST=DCOS(GHAN)                                                197800
      XX(1)= XTEMP(1)*COST+XTEMP(2)*SINT                             197900
      XX(2)=-XTEMP(1)*SINT+XTEMP(2)*COST                             198000
      XX(3)=XTEMP(3)                                                 198100
      XLONGI=ARKTNS(180,XX(1),XX(2))*C(76)                           198300
C                                                                    198400
  200 CONTINUE                                                       198500
      IF(ISEL.EQ.0.OR.NOR.NE.2) GO TO 300                            198600
      CALL MNA(TP,OM,CR,DT,EPSIL,RO,G,GP,WW,EMN)                     198700
      CALL MULT(EMN,DATE,SDATE)                                      198800
      DO 801 I=1,3                                                   198900
      DO 801 J=1,3                                                   199000
  801 SDATET(J,I)=SDATE(I,J)                                         199100
      CALL M1(R1(1,NOR),SDATE,XX)                                    199200
      CALL M1(V1(1,NOR),SDATE,XV)                                    199300
      CALL M1(PERT,SDATE,PERTT)                                      199400
      WRITE(6,500) C(NOR+60)                                         199500
  500 FORMAT(1HO,A6,1X,'FIXED TRUE MOON EQUATOR OF DATE')            199600
      CALL OUTX(XX,XV,NOUT)                                          199700
      CALL ORB(XX,XV,C(NOR),NOUT)                                    199800
  300 CONTINUE                                                       199900
      IF(MARDAT.EQ.0.OR.NOR.NE.5) GO TO 1001                         200000
      CALL ARES(DAYM,FDATE,AR)                                       200100
      CALL MULT(AR,A,ADATE)                                          200200
      DO 802 I=1,3                                                   200300
      DO 802 J=1,3                                                   200400
  802 ADATET(J,I)=ADATE(I,J)                                         200500
      CALL M1(R1(1,NOR),ADATE,XX)                                    200600
      CALL M1(V1(1,NOR),ADATE,XV)                                    200700
      CALL M1(PERT,ADATE,PERTT)                                      200800
      WRITE(6,700) C(NOR+60)                                         200900
  700 FORMAT(1HO,A6,1X,35HCENTERED MARS MEAN EQUATOR OF DATE )       201000
  600 CALL OUTX(XX,XV,NOUT)                                          201100
      CALL ORB(XX,XV,C(NOR),NOUT)                                    201200
C                                                                    201300
C                                                                    201400
 1001 IOR=NOR                                                        201500
  400 CONTINUE                                                       201600
      IF(IOR.EQ.3.AND.ISUNEC.EQ.0) GO TO 32                          201900
      CALL M1(V1(1,IOR),DATEEC,XV)                                   202100
C                                                                    202200
      WRITE(6,900) C(IOR+60)                                         202300
  900 FORMAT(1HO,A6,1X,'CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE')  202400
      CALL OUTX(XX,XV,NOUT)                                          202500
C                                                                    202600
      IF(IOR.EQ.NOR) CALL ORB(XX,XV,C(NOR),NOUT)                     202700
   32 CONTINUE                                                       202800
      IF(IOR.EQ.3.AND.NOR.NE.3) GO TO 14                             202900
      IF(IOR.EQ.1) GO TO 1000                                        203000
      IOR=1                                                          203100
      GO TO 400                                                      203200
 1000 IF(IOR.EQ.3) GO TO 14                                          203300
      IF(NOR.EQ.3) GO TO 14                                          203400
      IOR=3                                                          203500
      GO TO 400                                                      203600
   14 CONTINUE                                                       203700
      IF(NOR.NE.1.OR.IEARFX.EQ.0) GO TO 33                           203800
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      WRITE(6,3001) XLATI,XLONGI                                        203900
   33 CONTINUE                                                          204100
      WRITE(6,21)C(461)                                                 204200
   21 FORMAT(20HONUMBER OF STEPS IS D20.8)                              204300
C                                                                       204400
C                                                                       204500
C                                                                       204600
   50 RETURN                                                            204700
      END                                                               204800
```

```
      SUBROUTINE OUTX(X,VX,NOUT)                                        204900
      IMPLICIT REAL*8(A-H,O-Z,$)                                        205000
      DIMENSION X(3),VX(3),C(6)                                         205100
C     DIMENSION X(3),VX(3),C(6)                                         205200
      CALL RVOUT(X,VX,C)                                                205300
      WRITE (   6,5)X,VX,C                                              205400
    5 FORMAT(5H     XD15.8,5H     YD15.8,5H     ZD15.8,5H    DXD15.8,   205500
     1 5H    DYD15.8,5H    DZD15.8/5H     RD15.8,5H  DECD15.8,5H   RAD15.8,  205600
     2 5H     VD15.8,5H  PTHD15.8,5H    AZD15.8)                       205700
      RETURN                                                            205800
      END                                                               205900
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      SUBROUTINE OVRLAY                                                 206000
      IMPLICIT REAL*8(A-H,O-Z,$)                                        206100
      COMMON S(1000),IC(5)                                              206200
      DIMENSION BUFP(4),IND(4)                                          206300
   16 FORMAT(4(I3,D12.8))                                               206400
  994 FORMAT(1HO)                                                       206500
  995 FORMAT(4(5X,I3,D17.8))                                            206600
  996 FORMAT('1',40X,13HOVERLAY INPUT)                                  206700
      K=-1                                                              206800
   15 CONTINUE                                                          206900
      READ(5,16,END=20) (IND(I),BUFP(I),I=1,4)                          207000
      DO 10 N=1,4                                                       207100
      N=N                                                               207200
      GO TO (11,12,12,12),N                                             207300
   11 CONTINUE                                                          207400
      IF(IND(N))13,13,17                                                207500
   17 IF(K)18,19,19                                                     207600
   18 WRITE(6,996)                                                      207700
      K=0                                                               207800
   19 CONTINUE                                                          207900
      WRITE(6,995) (IND(J),BUFP(J),J=1,4)                               208000
      GO TO 14                                                          208100
   12 IF(IND(N)) 15,15,14                                               208200
   14 CONTINUE                                                          208300
      J=IND(N)                                                          208400
      S(J)=BUFP(N)                                                      208500
   10 CONTINUE                                                          208600
      GO TO 15                                                          208700
   13 CONTINUE                                                          208800
      WRITE(6,994)                                                      208900
       RETURN                                                           209000
   20 STOP                                                              209100
      END                                                               209200
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      SUBROUTINE READE(JED,TSEC,IERR)                                   209300
       IMPLICIT REAL*8(A-H,O-Z)                                         209400
C      READE.                    READ,INTERPOLATE,TRANSLATE JPL EPHEMERIS 209500
C     J.E. EKELUND, MESA SCIENTIFIC CORP., 1965 SEPT 15                 209600
C     C.L. LAWSON, JPL, 1966 MAR 17                                     209700
C     READ JPL EPHEMERIS AT THE JULIAN EPHEMERIS DATE                   209800
C     GIVEN BY (JED+TSEC/86400.D0)                                      209900
C                                                                       210000
C**   ITEMS COMMUNICATED THROUGH THE CALLING SEQUENCE **                210100
C                                                                       210200
C     JED       REFERENCE JULIAN EPHEMERIS DATE.                        210300
C     TSEC      SECONDS OF EPHEMERIS TIME PAST JED.                     210400
C               ANY COMBINATION OF VALUES OF JED AND TSEC               210500
C               IS ACCEPTABLE AS LONG AS (JED+TSEC/86400.D0)            210600
C               IS WITHIN THE RANGE OF THE EPHEMERIS TAPE               210700
C               BEING USED. HOWEVER TO OBTAIN THE                       210800
C               FINEST POSSIBLE RESOLUTION IN INTERPOLATION             210900
C               THE NUMBER JED MUST BE AN EXACT MACHINE                 211000
C               NUMBER. FOR EXAMPLE JED COULD BE A DATE ENDING          211100
C               WITH .0 OR .5 .                                         211200
C     IERR      ERROR FLAG                                              211300
C               0=NO ERROR                                              211400
C               1=(JED+TSEC/86400.D0) LESS THAN FIRST DATE              211500
C                 ON TAPE                                               211600
C               2=(JED+TSEC/86400.D0) GREATER THAN LAST DATE            211700
C                 ON TAPE                                               211800
C               3=SOME IREQ(I) IS NOT 0,1, OR 2                         211900
C               4=ICENT   IS NOT IN THE RANGE 1 THRU 11                 212000
C               5=ICW IS NOT 1,2, OR 3                                  212100
C                                                                       212200
C** THE FOLLOWING ITEMS ARE INPUT THROUGH COMMON **                     212300
C *  COMMON BLOCK CETBL1 *                                              212400
C     AU            A.U. EXPRESSED IN DESIRED OUTPUT UNITS            212500
C     RE            EQUATORIAL RADIUS OF EARTH IN DESIRED OUTPUT UNITS 212600
C                   RE IS USED TO SCALE THE LUNAR EPHEMERIS           212700
C     TPD             DESIRED NUMBER OF TIME UNITS PER DAY            212800
      COMMON/CETBL2/ICW,ICENT  ,IREQ(13)                                212900
C                                                                       213000
C *  COMMON BLOCK CETBL2 *                                              213100
C     ICW       FLAG INDICATING STATUS OF COMMON BLOCKS REC2 AND CETBL3  213200
C               1 MEANS NEITHER BLOCKS CONTAIN VALID DATA                213300
C               2 MEANS BOTH BLOCKS CONTAIN VALID DATA                   213400
C               3 MEANS REC2 IS VALID, CETBL3 IS NOT                     213500
C               USER MUST SET ICW=1 BEFORE INITIAL CALL                  213600
C     ICENTR    SPECIFIES CENTRAL BODY FOR COORDINATE                    213700
C               TRANSLATION AS FOLLOWS..                                 213800
C                1 MERC      5 JUP       9 PLUTO                         213900
C                2 VENUS     6 SAT      10 SUN                           214000
C                3 EARTH     7 URANUS   11 MOON                          214100
C                4 MARS      8 NEP                                       214200
C     IREQ()    IREQ(J) SPECIFIES OUTPUT DESIRED FOR                     214300
C               BODY NO. J.                                              214400
C               IREQ(J)=0 NO OUTPUT                                      214500
C                       1 POSITION                                       214600
C                       2 POSITION AND VELOCITY                          214700
C               J RUNS FROM 1 TO 11 AS FOLLOWS..                         214800
C                1 MERC      5 JUP       9 PLUTO                         214900
C                2 VENUS     6 SAT      10 SUN                           215000
C                3 EARTH     7 URANUS   11 MOON                          215100
C                4 MARS      8 NEP      12 ERTH-MN-BARYCENTER            215200
C                                      13 NUTATION                       215300
C *  COMMON BLOCK CETBL3 *                                               215400
C   TAB3 829 DOUBLE PREC. WORD BUFFER TO ACCOMODATE  J.D. AND EPHEMERIS. 215500
C   NUTAT 204 SINGLE PREC. WORD BUFFER TO ACCOMODATE NUTATION DATA.      215600
C   CKSUM 1 S.P. WORD FOR CHECKSUM.                                      215700
C** THE FOLLOWING ITEMS ARE OUTPUT THROUGH COMMON **                     215800
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C *  COMMON BLOCK CETBL4 *                                                  215900
C      TABOUT( , )  PLANETARY AND LUNAR OUTPUT, SCALED AND                216000
C        TRANSLATED WITH RESPECT TO CENTER.                               216100
C                   TABOUT (I,J) CONTAINS OUTPUT FOR                      216200
C                   BODY NO. J. (1 .LE. J .LE. 12)                        216300
C                   THE INDEX I IDENTIFIES COMPONENTS AS FOLLOWS..        216400
C                   1=X         2=Y       3=Z                             216500
C                   4=XDOT      5=YDOT    6=ZDOT                          216600
C      NUT( )       NUTATION OUTPUT                                       216700
C                   NUT(1)=DELTA LONGITUDE                                216800
C                   NUT(2)=DELTA OBLIQUITY                                216900
C                   NUT(3)=TIME DERIVATIVE OF NUT(1)                      217000
C                   NUT(4)=TIME DERIVATIVE OF NUT(2)                      217100
C                                                                         217200
      COMMON /CETBL5/ BIVECT( 6,13)                                       217300
C                                                                         217400
C *  COMMON BLOCK CETBL5 *                                                217500
C      BIVECT( , )  WORKING ARRAY. CONTENTS ARE INTERPOLATED              217600
C                   AND SCALED BUT NOT TRANSLATED. 1ST INDEX RUNS         217700
C                   OVER X,Y,Z,XDOT,YDOT,ZDOT AS IN TABOUT                217800
C                   BUT 2ND INDEX IS DIFFERENT AS FOLLOWS..               217900
C              BODIES 1 THRU 9 ARE HELIOCENTRIC.                          218000
C                   1 MERC      5 JUP       9 PLUTO                       218100
C                   2 VENUS     6 SAT      10 MOON REL TO EARTH           218200
C                   3 ERTHMN    7 URANUS   11 ERTHMN REL TO EARTH         218300
C                   4 MARS      8 NEP      12 ERTHMN REL TO MOON          218400
C                                          13 SEE 4092+                   218500
C                                                                         218600
C      THE COMMON BLOCK 'CETBL9' IS FOR COMMUNICATION                     218700
C      BETWEEN RDEP2 AND GETR2.                                           218800
      COMMON /CETBL1/           AU,RE,TPD,EMRAT                         218900
      COMMON /CETBL3/ TAB3(829),NUTAT(204),CKSUM                        219000
      COMMON/CETBL4/TABOUT(6,12),NUT(4)                                 219100
      COMMON/CETBL9/JD1,TDAY,JDIF,IERR1                                 219200
      LOGICAL WFLAG                                                     219300
      INTEGER KREQ(12),MCENT(11),M1(20),JREQ(11), IPOS(11),IVEL(11)     219400
      REAL NUTAT ,STP(11)                                               219500
      DOUBLE PRECISION      AU,RE,EMRAT,  TPD,TAB3,BIVECT,TABOUT,NUT    219600
      DOUBLE PRECISION JD1,TDAY,JDIF ,JED                               219700
      DOUBLE PRECISION TSEC,RAT, FAC,U(2,3),C,TEMP                      219800
C                                        FAC=1/86400                    219900
      DATA FAC/1.1574074074074074D-5/                                   220000
C                                                                       220100
      DATA STP/' 2.,8*4.,2*.5/                                          220200
      DATA KREQ/5,5,2,6*5,4,3,1/                                        220300
      DATA MCENT/15,15,0,6*15,10,5/                                     220400
      DATA M1/11,0,10,11,0,12,10,0,12,0,3,3,3,0,0,3,13,13,0,0/          220500
      DATA                                                              220600
     * IPOS  /02,092,146,200,254,308,362,416,470,524,1/                 220700
     *,IVEL  /47,119,173,227,281,335,389,443,497,677,103/               220800
      DATA U/6*0.D0/                                                    220900
C                                                                       221000
  499 CONTINUE                                                          221100
      JD1=JED                                                           221200
      TDAY=TSEC*FAC                                                     221300
C                                                                       221400
C     IERR1=IERR                                                        221500
      CALL GETTAP                                                       221600
C                                                                       221700
      IF(IERR1 .NE. 0) GO TO 5000                                       221800
      IF(ICENT .GE. 1 .AND. ICENT .LE. 11) GO TO 10                     221900
      IERR1=4                                                           222000
      GO TO 5000                                                        222100
   10 CONTINUE                                                          222200
C                                                                       222300
C                          SET JREQ(I)TO CONTROL INTERPOLATION          222400
```

```
      DO 20 I=1,10                                                    222500
      IF(IREQ(I) .GE. 0 .AND. IREQ(I) .LE. 2) GO TO 20                222600
      IERR1=3                                                         222700
      GO TO 5000                                                      222800
   20 JREQ(I)=IREQ(I)                                                 222900
C                              BARYCENTER FLAG                       223000
      JREQ(3)=IREQ(12)                                                223100
      MAXPL=JREQ(1)                                                   223200
      DO 24 I=2,10                                                    223300
   24 MAXPL=MAXO(MAXPL,JREQ(I))                                       223400
      MAXEM=MAXO(IREQ(3),IREQ(11))                                    223500
      MAXALL=MAXO(MAXPL,MAXEM)                                        223600
      IF(ICENT.EQ.3.OR.ICENT.EQ.11) GO TO 28                          223700
C                              CENTER IS NOT EARTH OR MOON           223800
C                              10=MOON,3=ERTHMN                      223900
      JREQ(10)=MAXEM                                                  224000
      JREQ(3)=MAXO(JREQ(3),MAXEM)                                     224100
      JREQ(ICENT)=MAXALL                                              224200
      GO TO 32                                                        224300
C                                                                     224400
C                              CENTER IS EARTH OR MOON                224500
C                              10=MOON, 3=ERTHMN                      224600
   28 JREQ(10)=MAXALL                                                 224700
      JREQ(3)=MAXPL                                                   224800
   32 JREQ(11)=IREQ(13)                                               224900
      LUNAR=JREQ(10)                                                  225000
      IBARY=JREQ(3)*3                                                 225100
C                                                                     225200
C                              JREQ( )IS NOW SET                      225300
C                                                                     225400
      SAVE=0.                                                         225500
 6001 CONTINUE                                                        225600
      DO 240 IBODY=1,11                                               225700
      IF(JREQ(IBODY)) 240,240,40                                      225800
   40 IF(STP(IBODY).EQ.SAVE) GO TO 165                                225900
      SAVE=STP(IBODY)                                                 226000
  160 TEMP=JDIF/SAVE                                                  226100
      KK=TEMP                                                         226200
      U(1,1)=TEMP-FLOAT(KK)                                           226300
      IF(U(1,1))161,165,161                                           226400
  161 CONTINUE                                                        226500
      U(2,1)=1.D0-U(1,1)                                              226600
      DO 163 IU=1,2                                                   226700
      U(IU,3)=U(IU,1)*U(IU,1)                                         226800
      U(IU,2)=(U(IU,3)-1.D0)/6.D0                                     226900
  163 U(IU,3)=(U(IU,3)-4.D0)/20.D0                                    227000
  165 IF(IBODY-10) 169,167,220                                        227100
  167 C=RE                                                            227200
      GO TO 172                                                       227300
  169 C=AU                                                            227400
C                              INTERPOLATE IBODY=1,2,...,10           227500
  172 IGET1=IPOS(IBODY)+KK*9                                          227600
      IC1=1                                                           227700
  200 CONTINUE                                                        227800
      IF(U(1,1))203,201,203                                           227900
  203 IGET2=IGET1+6                                                   228000
      DO 204 IGET=IGET1,IGET2,3                                       228100
      BIVECT(IC1,IBODY)=                                              228200
     *            C*(U(2,1)*(TAB3(IGET   )+                        228300
     *               U(2,2)*(TAB3(IGET+ 1)+                        228400
     *               U(2,3)* TAB3(IGET+ 2)))+                      228500
     *               U(1,1)*(TAB3(IGET+ 9)+                        228600
     *               U(1,2)*(TAB3(IGET+10)+                        228700
     *               U(1,3)* TAB3(IGET+11))) )                     228800
  204 IC1=IC1+1                                                       228900
      GO TO 205                                                       229000
```

```
  201 IC2=IC1+2                                                          229100
      DO 202 I=IC1,IC2                                                   229200
      BIVECT(I,IBODY)=C*TAB3(IGET1)                                      229300
  202 IGET1=IGET1+3                                                      229400
  205 CONTINUE                                                           229500
      JREQ(IBODY)=JREQ(IBODY)-1                                          229600
      IF(JREQ(IBODY)) 240,240,207                                        229700
  207 IGET1=IVEL(IBODY)+KK*9                                             229800
      IC1=4                                                              229900
      C=C/TPD                                                            230000
      GO TO 200                                                          230100
C                                                                        230200
C                              INTERPOLATE    IBODY=11    NUTATION      230300
C                                                                        230400
  220 C=1.DO                                                             230500
      IGET1=IPOS(IBODY)+KK*6                                             230600
      IC1=1                                                              230700
  222 IGET2=IGET1+3                                                      230800
  225 IF(U(1,1))228,226,228                                              230900
  228 DO 230 IGET=IGET1,IGET2,3                                          231000
      NUT(IC1)=                                                          231100
     *   C*(U(2,1)*(NUTAT(IGET  )+                                       231200
     *      U(2,2)*(NUTAT(IGET+1)+                                       231300
     *      U(2,3)* NUTAT(IGET+2))+                                      231400
     *      U(1,1)*(NUTAT(IGET+6)+                                       231500
     *      U(1,2)*(NUTAT(IGET+7)+                                       231600
     *      U(1,3)* NUTAT(IGET+8))) )                                    231700
  230 IC1=IC1+1                                                          231800
      GO TO  232                                                         231900
  226 DO 227 IGET=IGET1,IGET2,3                                          232000
      NUT(IC1)=C*NUTAT(IGET)                                             232100
  227 IC1=IC1+1                                                          232200
  232 CONTINUE                                                           232300
      JREQ(IBODY)=JREQ(IBODY)-1                                          232400
      IF(JREQ(IBODY)) 240,240,236                                        232500
  236 C=C/TPD                                                            232600
      IGET1=IVEL(IBODY)+KK*6                                             232700
      IC1=3                                                              232800
      GO TO 222                                                          232900
  240 CONTINUE                                                           233000
C                                                                        233100
C                              INTERPOLATION IS FINISHED                 233200
C                              RESULTS ARE IN BIVECT( , )AND NUT( )      233300
C                              TEST MOON REQUEST                         233400
      IF(LUNAR    ) 4020,4020,4010                                       233500
C                              NOTE..EMRAT=EARTH MASS/MOON MASS          233600
C                              SET BIVECT( ,11)=ERTHMN CENTERED AT EARTH 233700
C                              SET BIVECT( ,12)=ERTHMN CENTERED AT MOON  233800
 4010 RAT=1.DO/(EMRAT+1.DO)                                              233900
      IMAX=LUNAR * 3                                                     234000
      DO 4016 I=1,IMAX                                                   234100
      BIVECT(I,11)=RAT*BIVECT(I,10)                                      234200
 4016 BIVECT(I,12)=-EMRAT*BIVECT(I,11)                                   234300
C                                                                        234400
 4020 WFLAG=.FALSE.                                                      234500
      KCENT=MCENT(ICENT)                                                 234600
C                                                                        234700
C                              BEGIN TRANSLATION LOOP                    234800
C                                                                        234900
      DO 4108  IBODY=1,12                                                235000
      IF(IREQ(IBODY)) 4108,4108,4024                                     235100
 4024 IMAX=IREQ(IBODY)*3                                                 235200
      KASE=KCENT+KREQ(IBODY)                                             235300
      K1=M1(KASE)                                                        235400
      GO TO (4032,4040,4032,4048,4052,                                   235500
     *       4032,4068,4040,4048,4056,                                   235600
```

```
     *        4032,4076,4076,4040,4028,                                  235700
     *        4084,4088,4088,4064,4080),KASE                             235800
C                                                                        235900
C                              KASE=15                                   236000
 4028 K1=IBODY                                                           236100
C                              KASE=1,3,6,11                             236200
 4032 DO 4036 I=1,IMAX                                                   236300
 4036 TABOUT(I,IBODY)=BIVECT(I,K1)                                       236400
      GO TO 4108                                                         236500
C                              KASE=2,8,14                               236600
 4040 DO 4044 I=1,IMAX                                                   236700
 4044 TABOUT(I,IBODY)=0.D0                                               236800
      GO TO 4108                                                         236900
C                              KASE=4,9                                  237000
 4048 K2=3                                                               237100
      GO TO 4100                                                         237200
C                              KASE=5                                    237300
 4052 L2=11                                                              237400
      GO TO 4060                                                         237500
C                              KASE=10                                   237600
 4056 L2=12                                                              237700
 4060 K1=IBODY                                                           237800
      K2=13                                                              237900
      GO TO 4092                                                         238000
C                              KASE=19                                   238100
 4064 K1=ICENT                                                           238200
C                              KASE=7                                    238300
 4068 DO 4072 I=1,IMAX                                                   238400
 4072 TABOUT(I,IBODY)=-BIVECT(I,K1)                                      238500
      GO TO 4108                                                         238600
C                              KASE=12,13                                238700
 4076 K2=KASE-1                                                          238800
      GO TO 4100                                                         238900
C                              KASE=20                                   239000
 4080 K1=IBODY                                                           239100
C                              KASE=16                                   239200
 4084 K2=ICENT                                                           239300
      GO TO 4100                                                         239400
C                              KASE=17,18                                239500
 4088 L2=ICENT                                                           239600
      K2=KASE-6                                                          239700
 4092 IF(WFLAG) GO TO 4100                                               239800
      WFLAG=.TRUE.                                                       239900
C                                                                        240000
C                              BIVECT( ,13)IS AN AUXILIARY VECTOR        240100
C                              NEEDED WHEN KASE=5,10,17,18.              240200
C              FOR KASE=05     BIVECT( ,13)=EARTH  CENTERED AT SUN       240300
C              FOR KASE=10     BIVECT( ,13)=MOON  CENTERED AT SUN        240400
C              FOR KASE=17,18     BIVECT( ,13)=ERTHMN  CENTERED AT ICENT 240500
C                                                                        240600
      DO 4096 I=1,IBARY                                                  240700
 4096 BIVECT(I,13)=BIVECT(I,3)-BIVECT(I,L2)                              240800
 4100 DO 4104 I=1,IMAX                                                   240900
 4104 TABOUT(I,IBODY)=BIVECT(I,K1)-BIVECT(I,K2)                          241000
 4108 CONTINUE                                                           241100
 5000 IERR=IERR1                                                         241200
      RETURN                                                             241300
      END                                                                241400
```

```
      SUBROUTINE ROTEQ(TIME,A)                                          241500
      IMPLICIT REAL*8(A-H,O-Z,$)                                        241600
      DIMENSION A(3,3)                                                  241700
      T = TIME/36525.D0                                                 241800
      T2 = T*T                                                          241900
      T3 = T2*T                                                         242000
      A(1,1) = 1.D0 - .00029697D0*T2 - .00000013D0*T3                   242100
      A(1,2) = -.02234988D0*T - .00000676D0*T2 + .00000221D0*T3         242200
      A(2,1) = -A(1,2)                                                  242300
      A(1,3) = -.00971711D0*T + .00000207D0*T2 + .00000096D0*T3         242400
      A(3,1) = -A(1,3)                                                  242500
      A(2,2) = 1.D0 - .00024976D0*T2 - .00000015D0*T3                   242600
      A(2,3) = -.00010859D0*T2 - .00000003D0*T3                         242700
      A(3,2) = A(2,3)                                                   242800
      A(3,3) = 1.D0 - .00004721D0*T2 + .00000002D0*T3                   242900
      RETURN                                                            243000
      END                                                               243100
```

```
      SUBROUTINE RVOUT(A,B,C)                                          243200
      IMPLICIT REAL*8(A-H,O-Z,$)                                       243300
      DIMENSION A(3),B(3),C(6)                                         243400
C     C IS RADIUS, LAT, LON, VELOCITY, GAMMA, AZIMUTH                  243500
      CALL SPER(A,C)                                                   243600
      C(4)=FNORM(B)                                                    243700
      C(5)=90.DO-ADOT(A,B)                                             243800
      VE=B(2)*A(1)-B(1)*A(2)                                           243900
      VN=C(1)*B(3)-A(3)*DOT(A,B)/C(1)                                  244000
      C(6)=57.2957795100*ARKTNS(180,VN,VE)                             244100
      RETURN                                                           244200
      END                                                              244300
```

```
      SUBROUTINE SHADOW(R1,V1,X,  STEP)                                 244400
      IMPLICIT REAL*8(A-H,O-Z,$).                                       244500
      COMMON C(1000),IC(50),Z(3),VV(3),NOR                              244600
      COMMON /SHAD/SHADK                                                244700
      DIMENSION R1(3,8),V1(3,8)                                         244800
      DIMENSION X1(3)                                                   244900
      DIMENSION R(3,8),V(3,8)                                           245000
      DATA IPFLAG/1/,IUFLAG/1/,IMFLAG/1/,IMUFLG/1/, FLAG/0./,FLAG1/0./, 245100
     1FLAG2/0./,FLAG3/0./                                               245200
      DATA IVFLAG/1/,IVUFLG/1/,PFLAG/0./,PUFLAG/0./                     245300
    6 FORMAT(1H0,15HBODY CENTER IS ,A6)                                 245400
      IF(STEP.EQ.0.DO)RETURN                                            245500
      GO TO (41,41,505 ,400,400,400),NOR                                245600
   41 CONTINUE                                                          245700
      DO 4 I=1,3                                                        245800
    4 X1(I)=R1(I,1)-R1(I,3)                                             245900
      SEVA=ADOT(X1,R1(1,1))                                             246000
      RFS=FNORM(R1(1,3))                                                246100
      RFE=FNORM(R1(1,1))                                                246200
      DELS=DARSIN(6500.DO/RFE)*57.295779500                             246300
      IF(SEVA-90.DO) 300,300,301                                        246400
  301 ZRS=6.965D5                                                       246500
      ZRE=6500.DO                                                       246600
      ZPSIG=DARSIN((ZRS+ZRE)/RFS)*57.295779500                          246700
      FS=SEVA+DELS+ZPSIG-180.DO                                         246800
      IF(FS) 300,302,302                                                246900
  302 FLAG=1.DO                                                         247000
      IF(IPFLAG.NE.1) GO TO 1000                                        247100
      K=1                                                               247200
      N=1                                                               247300
      IPFLAG=2                                                          247400
      KK=1                                                              247500
      WRITE(6,5)                                                        247600
    5 FORMAT(1H0,60HPROBE ENTERED EARTH PENUMBRA. TIME AND ORBIT ARE GIV 247700
     1EN BELOW)                                                         247800
      SHADK=1.0DO                                                       247900
      GO TO 20                                                          248000
 1000 CONTINUE                                                          248100
      ZSIGMA=DARSIN((ZRS-ZRE)/RFS)*57.295779500                         248200
      FS=DELS-ZSIGMA+SEVA-180.DO                                        248300
      IF(FS)303,304,304                                                 248400
  304 FLAG1=1.DO                                                        248500
      IF(IUFLAG.NE.1) GO TO 310                                         248600
      K=1                                                               248700
      IUFLAG=2                                                          248800
      N=2                                                               248900
      KK=2                                                              249000
      WRITE(6,7)                                                        249100
    7 FORMAT(1H0,57HPROBE ENTERED EARTH UMBRA. TIME AND ORBIT ARE GIVEN 249200
     1BELOW)                                                            249300
      SHADK=1.0DO                                                       249400
      GO TO 20                                                          249500
  300 FLAG=0.DO                                                         249600
  303 FLAG1=0.DO                                                        249700
  310 DO 30 I=1,3                                                       249800
   30 X1(I)=R1(I,2)-R1(I,3)                                             249900
      SEVA=ADOT(X1,R1(1,2))                                             250000
      IF(SEVA-90.DO) 2000,2000,901                                      250100
  901 ZRS=6.965D5                                                       250200
      ZRE=1738.DO                                                       250300
      ZPSIG=DARSIN((ZRS+ZRE)/RFS)*57.295779500                          250400
      DELM=DARSIN(C(22)/FNORM(R1(1,2)))*57.295779500                    250500
      FS=SEVA+DELM+ZPSIG-180.DO                                         250600
      IF(FS) 2000,902,902                                               250700
  902 FLAG2=1.DO                                                        250800
      IF(IMFLAG.NE.1) GO TO 3000                                        250900
```

```
      K=2                                                                  251000
      IMFLAG=2                                                             251100
      N=3                                                                  251200
      KK=1                                                                 251300
      WRITE(6,8)                                                           251400
    8 FORMAT(1HO,59HPROBE ENTERED MOON PENUMBRA. TIME AND ORBIT ARE GIVE   251500
     1N BELOW)                                                             251600
      SHADK=1.0D0                                                          251700
      GO TO 20                                                             251800
3000 CONTINUE                                                              251900
      ZSIGMA=DARSIN((ZRS-ZRE)/RFS)*57.295779500                            252000
      FS=DELM-ZSIGMA+SEVA-180.DO                                           252100
      IF(FS)2001,904,904                                                   252200
  904 FLAG3=1.DO                                                           252300
      IF(IMUFLG.NE.1) GO TO 2010                                           252400
      K=2                                                                  252500
      IMUFLG=2                                                             252600
      N=4                                                                  252700
      KK=2                                                                 252800
      WRITE(6,9)                                                           252900
    9 FORMAT(1HO,56HPROBE ENTERED MOON UMBRA. TIME AND ORBIT ARE GIVEN B   253000
     1ELOW)                                                                253100
      SHADK=1.0D0                                                          253200
      GO TO 20                                                             253300
2000 FLAG2=0.DO                                                            253400
2001 FLAG3=0.DO                                                            253500
2010 CONTINUE                                                              253600
      IF(IPFLAG.NE.2.OR.FLAG.NE.0.DO) GO TO 11                             253700
      WRITE(6,12)                                                          253800
   12 FORMAT(1HO,61HPROBE HAS LEFT EARTH PENUMBRA. TIME AND ORBIT ARE GI   253900
     1VEN BELOW)                                                           254000
      SHADK=0.0D0                                                          254100
      K=1                                                                  254200
      N=5                                                                  254300
      KK=1                                                                 254400
      IPFLAG=1                                                             254500
      GO TO 20                                                             254600
   11 IF(IUFLAG.NE.2.OR.FLAG1.NE.0.DO) GO TO 14                            254700
      WRITE(6,  )                                                          254800
   13 FORMAT(1H  ,58HPROBE HAS LEFT EARTH UMBRA. TIME AND ORBIT ARE GIVEN  254900
     1 BELOW)                                                              255000
      SHADK=0.0D0                                                          255100
      KK=2                                                                 255200
      N=6                                                                  255300
      K=1                                                                  255400
      IUFLAG=1                                                             255500
      GO TO 20                                                             255600
   14 IF(IMFLAG.NE.2.OR.FLAG2.NE.0.DO) GO TO 15                            255700
      WRITE(6,16)                                                          255800
   16 FORMAT(1HO,60HPROBE HAS LEFT MOON PENUMBRA. TIME AND ORBIT ARE GIV   255900
     1EN BELOW)                                                            256000
      SHADK=0.0D0                                                          256100
      KK=1                                                                 256200
      K=2                                                                  256300
      N=7                                                                  256400
      IMFLAG=1                                                             256500
      GO TO 20                                                             256600
   15 IF(IMUFLG.NE.2.OR.FLAG3.NE.0.DO) GO TO 505                           256700
      WRITE(6,18)                                                          256800
   18 FORMAT(1HO,57HPROBE HAS LEFT MOON UMBRA. TIME AND ORBIT ARE GIVEN    256900
     1BELOW)                                                               257000
      SHADK=0.0D0                                                          257100
      K=2                                                                  257200
      N=8                                                                  257300
      KK=2                                                                 257400
      IMUFLG=1                                                             257500
```

```
   20 CALL ITER(NOR,R1,V1,FS,K,KK,DT,R,V)                                257600
      TIM=C(593)+(X+C(506)+DT)/86400.D0                                  257700
      CALL TFRAC(C(592),TIM,TT,TTF)                                      257800
      CALL DATOUT(TT,TTF,DATE,FDATE,0)                                   257900
C                                                                        258000
C                                                                        258100
C                                                                        258200
      GO TO (1000,310,3000,2010,11,14,15,505 ,405,502,503,505),N         258300
  400 DO 401 I=1,3                                                       258400
  401 X1(I)=R1(I,NOR)-R1(I,3)                                            258500
      SEVA=ADOT(X1,R1(1,NOR))                                            258600
      RFS=FNORM(R1(1,3))                                                 258700
      RFE=FNORM(R1(1,NOR))                                               258800
      DELS=DARSIN(C(NOR+20)/RFE)*57.295779SD0                            258900
      IF(SEVA-90.D0)500,500,402                                          259000
  402 ZRS=6.965D5                                                        259100
      ZRE=C(NOR+20)                                                      259200
      ZPSIG=DARSIN((ZRS+ZRE)/RFS)*57.295779SD0                           259300
      FS=SEVA+DELS+ZPSIG-180.D0                                          259400
      IF(FS)500,403,403                                                  259500
  403 PFLAG=1.D0                                                         259600
      IF(IVFLAG.NE.1) GO TO 405                                          259700
      K=3                                                                259800
      N=9                                                                259900
      IVFLAG=2                                                           260000
      KK=1                                                               260100
      WRITE(6,404)C(NOR+60)                                              260200
  404 FORMAT(1HO,26HPROBE ENTERED PENUMBRA OF ,A6,30HTIME AND ORBIT ARE  260300
     1GIVEN BELOW)                                                       260400
      SHADK=1.0D0                                                        260500
      GO TO 20                                                           260600
  405 CONTINUE                                                           260700
      ZSIGMA=DARSIN((ZRS-ZRE)/RFS)*57.295779SD0                          260800
      FS=DELS-ZSIGMA+SEVA-180.D0                                         260900
      IF(FS)501,406,406                                                  261000
  406 PUFLAG=1.D0                                                        261100
      IF(IVUFLG.NE.1) GO TO 502                                          261200
      K=3                                                                261300
      IVUFLG=2                                                           261400
      N=10                                                               261500
      KK=2                                                               261600
      WRITE(6,407) C(NOR+60)                                             261700
  407 FORMAT(1HO,23HPROBE ENTERED UMBRA OF ,A6,30HTIME AND ORBIT ARE GIV 261800
     1EN BELOW)                                                          261900
      SHADK=1.0D0                                                        262000
      GO TO 20                                                           262100
  500 PFLAG=0.D0                                                         262200
  501 PUFLAG=0.D0                                                        262300
  502 IF(IVFLAG.NE.2.OR.PFLAG.NE.0.D0) GO TO 503                         262400
      WRITE(6,504) C(NOR+60)                                             262500
  504 FORMAT(1HO,27HPROBE HAS LEFT PENUMBRA OF ,A6,30HTIME AND ORBIT ARE 262600
     1 GIVEN BELOW)                                                      262700
      SHADK=0.0D0                                                        262800
      K=3                                                                262900
      N=11                                                               263000
      KK=1                                                               263100
      IVFLAG=1                                                           263200
      GO TO 20                                                           263300
  503 IF(IVUFLG.NE.2.OR.PUFLAG.NE.0.D0) GO TO 505                        263400
      WRITE(6,506) C(NOR+60)                                             263500
  506 FORMAT(1HO,24HPROBE HAS LEFT UMBRA OF ,A6,30HTIME AND ORBIT ARE GI 263600
     1VEN BELOW)                                                         263700
      SHADK=0.0D0                                                        263800
      KK=2                                                               263900
      N=12                                                               264000
      K=3                                                                264100
```

```
      IVUFLG=1                                                          264200
      GO TO 20                                                          264300
  505 CONTINUE                                                          264400
      RETURN                                                            264500
      END                                                               264600
```

```
      SUBROUTINE SHIFTP(NOR,R,V,TW,TF,RR,VV)                            264700
      IMPLICIT REAL*8(A-H,O-Z,$)                                        264800
      DIMENSION C(1000),IC(50),R(3),V(3),RR(3,8),VV(3,8),PO(22),VE(22),  264900
     1R1(3,2),V1(3,2),N(2),SPAR(20,2),T1(2,2)                           265000
      DIMENSION X(3),W(3)                                               265100
      COMMON  C       , IC                                              265200
      EQUIVALENCE (C(663),R1(1,1)),(C(681),V1(1,1)),(C(695),T1(1,1)),   265300
     1(IC(1),IB1), (IC(2),IB2),(IC(12),N(1)),(C(7),SPMSD),(C(3),US)     265400
     2,(C(801),PO(1)),(C(823),VE(1)),(C(561),SPAR(1,1))                 265500
     3,(C(699),SWNET)                                                   265600
      IC(2)=0.D0                                                        265700
      IF(SWNET)100,100,18                                               265800
  100 DIS=1.D10                                                         265900
      DO 1 I=1,3                                                        266000
      X(I)=R(I)                                                         266100
    1 W(I)=V(I)                                                         266200
      NM1=NOR-1                                                         266300
      IF(NOR-6)4,3,2                                                    266400
    2 KKK=-1                                                            266500
      NM1=2                                                             266600
      GO TO 7                                                           266700
3     NM1 = 6                                                           266800
    4 CONTINUE                                                          266900
      KKK=0                                                             267000
      IF(IB1-6)5,5,6                                                    267100
    5 IF(IB2-6)9,9,6                                                    267200
    6 KKK=1                                                             267300
    7 CONTINUE                                                          267400
      DO 8 I=1,2                                                        267500
      K=I+6                                                             267600
      TT=(IDINT(TW-T1(1,I))+TF-T1(2,I))*SPMSD                           267700
      CALL STEPD(N(I),TT,TA,R1(1,I),V1(1,I),US,RR(1,K),VV(1,K),1,       267800
     1SPAR(1,I))                                                        267900
    8 CONTINUE                                                          268000
    9 CONTINUE                                                          268100
      CALL INTR1(TW,TF,NM1,PO,1,VE,DIS)                                 268200
      IF(KKK)10,12,12                                                   268300
   10 NOR=NOR                                                           268400
      DO 11 I=1,3                                                       268500
      X(I)=X(I)+RR(I,NOR)                                               268600
   11 W(I)=W(I)+VV(I,NOR)                                               268700
   12 CONTINUE                                                          268800
      DO 13 J=1,5                                                       268900
      DO 13 I=1,3                                                       269000
      L=3*J-3+I                                                         269100
      RR(I,J)=X(I)-PO(L)                                                269200
   13 VV(I,J)=W(I)-VE(L)                                                269300
      DO 14 I=1,3                                                       269400
      RR(I,6)=X(I)-PO(I+18)                                             269500
   14 VV(I,6)=W(I)-VE(I+18)                                             269600
      IF(KKK)15,17,15                                                   269700
   15 DO 16 I=1,2                                                       269800
      K=I+6                                                             269900
      DO 16 J=1,3                                                       270000
      RR(J,K)=RR(J,3)-RR(J,K)                                           270100
   16 VV(J,K)=VV(J,3)-VV(J,K)                                           270200
   17 CONTINUE                                                          270300
      GO TO 35                                                          270400
   18 TT=((TW-T1(1,1))+TF-T1(2,1))*SPMSD                                270500
      M=2                                                               270600
      CALL STEPD(M,TT,TA,R1(1,1),V1(1,1),C(3),RR(1,1),VV(1,1),1,        270700
     1SPAR(1,1))                                                        270800
      TT=((TW-T1(1,2))+TF-T1(2,2))*SPMSD                                270900
      IF(IC(1)+IC(2)-3)19,19,25                                         271000
   19 M=2                                                               271100
      CALL STEPD(M,TT,TA,R1(1,2),V1(1,2),C(1),RR(1,2),VV(1,2),1,        271200
```

```
     1SPAR(1,2))                                                        271300
      DO 24 I=1,3                                                       271400
      IF(NOR-2)20,21,22                                                 271500
   20 RR(I,3)=-RR(I,1)                                                  271600
      VV(I,3)=-VV(I,1)                                                  271700
      RR(I,1)=0.D0                                                      271800
      VV(I,1)=0.D0                                                      271900
      GO TO 23                                                          272000
   21 RR(I,3)=-RR(I,1)-RR(I,2)                                          272100
      VV(I,3)=-VV(I,1)-VV(I,2)                                          272200
      RR(I,2)=0.D0                                                      272300
      VV(I,2)=0.D0                                                      272400
      GO TO 23                                                          272500
   22 RR(I,2)=RR(I,2)+RR(I,1)                                           272600
      VV(I,2)=VV(I,2)+VV(I,1)                                           272700
      RR(I,3)=0.D0                                                      272800
      VV(I,3)=0.D0                                                      272900
   23 DO 24 J=1,3                                                       273000
      RR(I,J)=R(I)-RR(I,J)                                              273100
      VV(I,J)=V(I)-VV(I,J)                                              273200
   24 CONTINUE                                                          273300
      GO TO 35                                                          273400
   25 M=2                                                               273500
      IF(IC(1)-3)27,27,26                                               273600
   26 K=IC(1)                                                           273700
      GO TO 28                                                          273800
   27 K=IC(2)                                                           273900
   28 CONTINUE                                                          274000
      CALL STEPD(M,TT,TA,R1(1,2),V1(1,2),C(3),RR(1,K),VV(1,K),1,        274100
     1SPAR(1,2))                                                        274200
      DO 34 I=1,3                                                       274300
      IF(NOR-3)29,31,32                                                 274400
   29 RR(I,3)=-RR(I,1)                                                  274500
      VV(I,3)=-VV(I,1)                                                  274600
      IF(K.EQ.3) GO TO 30                                               274700
      RR(I,K)=RR(I,K)-RR(I,1)                                           274800
      VV(I,K)=VV(I,K)-VV(I,1)                                           274900
   30 RR(I,1)=0.D0                                                      275000
      VV(I,1)=0.D0                                                      275100
      GO TO 33                                                          275200
   31 RR(I,3)=0.D0                                                      275300
      VV(I,3)=0.D0                                                      275400
      GO TO 33                                                          275500
   32 RR(I,1)=-RR(I,K)+RR(I,1)                                          275600
      VV(I,1)=-VV(I,K)+VV(I,1)                                          275700
      RR(I,3)=-RR(I,K)                                                  275800
      VV(I,3)=-VV(I,K)                                                  275900
      RR(I,K)=0.D0                                                      276000
      VV(I,K)=0.D0                                                      276100
   33 RR(I,1)=R(I)-RR(I,1)                                              276200
      VV(I,1)=V(I)-VV(I,1)                                              276300
      RR(I,3)=R(I)-RR(I,3)                                              276400
      VV(I,3)=V(I)-VV(I,3)                                              276500
      IF(K.EQ.1.OR.K.EQ.3) GO TO 34                                     276600
      RR(I,K)=R(I)-RR(I,K)                                              276700
      VV(I,K)=V(I)-VV(I,K)                                              276800
   34 CONTINUE                                                          276900
   35 CONTINUE                                                          277000
      RETURN                                                            277100
      END                                                               277200
```

```
      SUBROUTINE SOLAR (R,SACC)                                          277300
      IMPLICIT REAL * 8 (A-H,O-Z)                                        277400
      COMMON C(1000)                                                     277500
      DIMENSION R(3),SACC(3),RX(3)                                       277600
      P=C(774)                                                           277700
      A=C(770)                                                           277800
      EM=C(771)                                                          277900
      GAMMA=C(772)                                                       278000
      SIGMA=C(773)                                                       278100
      C1=P*A*(1.0 + 2.0/3.0*GAMMA + 1.0/3.0*GAMMA*SIGMA)/EM              278200
      DO 11 J=1,3                                                        278300
      RX(J)=R(J) / 1.495D8                                               278400
11    C O N T I N U E                                                    278500
      RAU=(RX(1)**2 + RX(2)** 2 +RX(3)**2)**0.5                          278600
      C2=C1/RAU**3                                                       278700
      DO 12 K=1,3                                                        278800
      SACC(K)=C2*RX(K)*1.0D-5                                            278900
12    C O N T I N U E                                                    279000
100   RETURN                                                             279100
      END                                                                279200
```

```
      SUBROUTINE SPER(X,Y)                                              279300
      IMPLICIT REAL*8(A-H,O-Z,$)                                        279400
C     CONVERTS CARTESIAN TO SPHERICAL. RETURNS IN DEG                   279500
      DIMENSION X(3),Y(3)                                               279600
C     DIMENSION X(3),Y(3)                                               279700
      RTD=.572957795D+02                                                279800
      A=X(1)*X(1)+X(2)*X(2)                                             279900
      Y(1)=DSQRT(A+X(3)*X(3))                                           280000
      Y(2)=DATAN(X(3)/DSQRT(A))*RTD                                     280100
      Y(3)=ARKTNS(180, X(1),X(2))*RTD                                   280200
      RETURN                                                            280300
      END                                                               280400
```

```
      SUBROUTINE STEPD(N,T,TA,R,V,U,RR,VV,M,SB)                          280500
      IMPLICIT REAL*8(A-H,O-Z,$).                                        280600
C     CB IS A STORAGE VECTOR WHOSE ELEMENTS ARE                          280700
C     (1) INITIAL TRUE ANOMALY          (11) ANGULAR MOMENTUM SQUARED H2 280800
C     (2) SEMI-LATUS RECTUM             (12) ANGULAR MOMENTUM MAGNITUDE H280900
C     (3) ECCENTRICITY                  (13) MU TIMES RADIUS MAGNITUDE UR281000
C     (4) RADIUS-SQUARED                (14) R DOT V                     281100
C     (5) RADIUS MAGNITUDE              (15) H2-UR                       281200
C     (6) SEMI-MAJOR AXIS (A)           (16) H*RDOTV                     281300
C     (7) ABSOLUTE VALUE OF (A)         (17) U/(R*H2)                    281400
C     (8) MEAN MOTION                   (18) RV/H                        281500
C     (9) TIME COEFFICIENT  R/ABA       (19) TIME FROM PERIAPSIS (+ DR -)281600
C     (10)TIME COEFFICIENT RV/SQRT(UA)  (20) SWITCH 1 ELLIP, 2 HYPER     281700
      DIMENSION R(3),V(3),HVEC(3),RR(3),VV(3),F(4),CB(20)                281800
      DIMENSION SB(20)                                                   281900
C     DIMENSION R(3),V(3),HVEC(3),RR(3),VV(3),F(4),CB(20)                282000
C     DIMENSION SB(20)                                                   282100
C                                                                        282200
C                                                                        282300
C                                                                        282400
C                                                                        282500
      N=N                                                                282600
      GO TO (1,7),N                                                      282700
    1 CONTINUE                                                           282800
      PI=.3141592650+01                                                  282900
      TPI=.6283185300+01                                                 283000
      CB(4)=DOT(R,R)                                                     283100
      CB(5)=DSQRT(CB(4))                                                 283200
      V2=DOT(V,V)                                                        283300
      CB(14)=DOT(R,V)                                                    283400
      VM=DSQRT(V2)                                                       283500
      CB(6)=CB(5)/(2.0D0-CB(5)*V2/U)                                     283600
      CB(7)=DABS(CB(6))                                                  283700
      CB(8)=DSQRT(U/CB(7))/CB(7)                                         283800
      CB(9)=CB(5)/CB(7)                                                  283900
      CB(10)=CB(14)/DSQRT(U*CB(7))                                       284000
      CALL CROSS(R,V,HVEC)                                               284100
      CB(11)=DOT(HVEC,HVEC)                                              284200
      CB(12)=DSQRT(CB(11))                                               284300
      CB(13)=U*CB(5)                                                     284400
      CB(2)=CB(11)/U                                                     284500
      EC2=1.0D0-CB(2)/CB(6)                                              284600
      IF(EC2.GE.(-1.D-6).AND.EC2.LE.0.D0) GO TO 200                      284700
      CB(3)=DSQRT(EC2)                                                   284800
      GO TO 201                                                          284900
  200 CB(3)=0.D0                                                         285000
  201 CONTINUE                                                           285100
      CB(15)=CB(11)-CB(13)                                               285200
      CB(16)=CB(12)*CB(14)                                               285300
      CB(17)=U/(CB(5)*CB(11))                                            285400
      CB(18)=CB(14)/CB(12)                                               285500
      CB(1)=ARKTNS(180,CB(15),CB(16))                                    285600
      TA2=CB(1)                                                          285700
      IF(CB(6))3,3,2                                                     285800
    2 CONTINUE                                                           285900
      CB(20)=1.0D0                                                       286000
      E1=CB(8)*T                                                         286100
      GO TO 4                                                            286200
    3 CONTINUE                                                           286300
      CB(20)=2.0D0                                                       286400
      E1=0.000                                                           286500
    4 CONTINUE                                                           286600
      CALL TCONIC(U,CB(3),CB(6),CB(2),TA2,TFP,FAC)                       286700
      N=N                                                                286800
      GO TO (6,5),N                                                      286900
    5 CONTINUE                                                           287000
```

```
      T=TFP-CB(19)+TAP*PD                                                287100
      GO TO 12                                                           287200
    6 CONTINUE                                                           287300
      CB(19)=TFP                                                         287400
      N=2                                                                287500
      DO 60 I=1,20                                                       287600
   60 SB(I)=CB(I)                                                        287700
      GO TO 700                                                          287800
    7 CONTINUE                                                           287900
      DO 70 I=1,20                                                       288000
   70 CB(I)=SB(I)                                                        288100
  700 CONTINUE                                                           288200
      PD=TPI/CB(8)                                                       288300
      IF(M)8,8,11                                                        288400
    8 CONTINUE                                                           288500
C     TA IS THE INCREMENTAL TRUE ANOMALY                                 288600
      CT=DCOS(TA)                                                        288700
      ST=DSIN(TA)                                                        288800
      EF=CT-ST*CB(18)                                                    288900
      GE=ST*CB(4)/CB(12)                                                 289000
      R2OR1=CB(11)/(CB(13)+CB(15)*CT-CB(16)*ST)                          289100
      EF=R2OR1*EF                                                        289200
      GE=R2OR1*GE                                                        289300
      EFD=CB(17)*(CB(14)-CB(14)*CT-CB(12)*ST)                            289400
      GED=(CB(15)+CB(13)*CT)/CB(11)                                      289500
      TA2=CB(1)+TA                                                       289600
      TAP=IDINT(TA2/TPI)                                                 289700
      TA2=TA2-TPI*TAP                                                    289800
      IF(IDINT(TA2/PI)) 9,4,10                                           289900
    9 TAP=TAP-1.0D0                                                      290000
      GO TO 4                                                            290100
   10 TAP=TAP+1.0D0                                                      290200
      GO TO 4                                                            290300
   11 CONTINUE                                                           290400
      K=CB(20)                                                           290500
      EMDT=CB(8)*T                                                       290600
      CALL GOTOR(K,EMDT,CB(9),F,E1)                                      290700
      EF=-F(2)/CB(9)+1.0D0                                               290800
      GE=-F(1)/CB(8)+T                                                   290900
      ROA=F(2)+CB(9)*F(4)+CB(10)*F(3)                                    291000
      EFD=-CB(7)*CB(8)*F(3)/(CB(5)*ROA)                                  291100
      GED=-F(2)/ROA+1.0D0                                                291200
      TA=ARKTNS(180,CB(4)*EF+CB(14)*GE,CB(12)*GE)                        291300
      IF(K-1)110,110,12                                                  291400
  110 CONTINUE                                                           291500
      TAP=IDINT(T/PD)                                                    291600
      IF(TA*T)111,112,112                                                291700
  111 TAP=TAP+DSIGN(1.0D0,T)                                             291800
  112 TA=TA+TAP*TPI                                                      291900
   12 CONTINUE                                                           292000
      DO 13 I=1,3                                                        292100
      RR(I)=EF*R(I)+GE*V(I)                                              292200
      VV(I)=EFD*R(I)+GED*V(I)                                            292300
   13 CONTINUE                                                           292400
      RETURN                                                             292500
      END                                                                292600
```

```
      SUBROUTINE TCONIC(U,EC,A,SLR,TA2,T,FAC)                           292700
      IMPLICIT REAL*8(A-H,O-Z,$)                                        292800
      TANG(QQQQFL)=DSIN(QQQQFL)/DCOS(QQQQFL)                            292900
      AB = DABS(A)                                                      293000
      FAC=AB*DSQRT(AB/U)                                                293100
      ECA=(1.0D0-EC)/(1.0D0+EC)                                         293200
      ABE = DSQRT( DABS(ECA) )                                          293300
      THE=TANG(.5D0*TA2)                                                293400
      IF(ABE-.0000500)11,11,12                                          293500
   12 CONTINUE                                                          293600
      ECA=2.0D0*DATAN(ABE*THE)                                          293700
      IF(A)14,11,13                                                     293800
   13 T=FAC*(ECA-EC*DSIN(ECA))                                          293900
      GO TO 16                                                          294000
   14 ANG=.785398163D0 + ECA/2.D0                                       294100
      T=FAC*(EC*TANG(ECA)-DLOG(TANG(ANG)))                              294200
      GO TO 16                                                          294300
   11 FAC=DSQRT(SLR**3/U)*2.0D0/((1.0D0+EC)**2)                         294400
      EC1=ECA*THE**2                                                    294500
      T=FAC*(THE+THE**3*((1.0D0-2.0D0*ECA)/3.0D0-(2.0D0-3.0D0*ECA)*EC1/5  294600
     1.0D0+(3.0D0-4.0D0*ECA)*EC1**2/7.0D0-(4.0D0-5.0D0*ECA)*EC1**3/9.0D0  294700
     2))                                                                294800
   16 CONTINUE                                                          294900
      RETURN                                                            295000
      END                                                               295100
```

```
      SUBROUTINE TERM(X,Y,D,F)                                          295200
      IMPLICIT REAL*8(A-H,O-Z,$)                                        295300
      COMMON  C(1000),IC(50),Z(3),VV(3),NOR                             295400
      COMMON/APPER/ FPROLD ,OLD,XMAX                                    295500
      DIMENSION R1(3,8),V1(3,8)                                         295600
      DIMENSION Y(20),D(20)                                             295700
      COMMON/STEPS/ STEP,XOLDD                                          295800
      EQUIVALENCE (C(401),R1(1,1)), (C(425),V1(1,1))                    295900
      DATA XOLD/0./                                                     296000
      STEP = X-XOLD                                                     296100
      XOLD=X                                                            296200
      XOLDD=XOLD                                                        296300
      Y(7)=X+C(506)                                                     296400
      C(461) = C(461)+1.D0                                              296500
      F=C(594)-(C(506)+X)                                               296600
      IF(C(776).EQ.0.D0) GO TO 5                                        296700
      FPR=C(776)*(90.D0-ADOT(R1(1,NOR),V1(1,NOR)))                      296800
      IF (FPR.GT. 0.D0 .AND. X .NE. 0.D0) OLD=FPR                       296900
      IF(FPROLD.EQ.0.D0.AND.FPR.GT.0.D0) GO TO 5                        297000
      IF (X .EQ. 0.D0 .OR. OLD .EQ. 0.D0) GO TO 5                       297100
      FPROLD=1.D0                                                       297200
      F=FPR                                                             297300
    5 CONTINUE                                                          297400
      IF(C(1000))4000,10,10                                             297500
   10 IF(DABS(X+C(506)).LE.XMAX) GO TO 4000                             297600
      XMAX=DABS(X+C(506))                                               297700
      IF(XMAX-C(1000)*86400.D0)4000,11,11                               297800
   11 CONTINUE                                                          297900
      CALL SHADOW(R1,V1,XOLD,STEP)                                      298000
 4000 CONTINUE                                                          298100
      IF(FNORM(R1(1,NOR)).GT.C(NOR+20)) GO TO 2                         298200
      WRITE(6,3) C(NOR+60)                                              298300
    3 FORMAT(1H0,19HPROBE HAS IMPACTED ,A6)                             298400
      F=0.D0                                                            298500
      C(122)=10.D0                                                      298600
      C(462)=0.D0                                                       298700
      RETURN                                                            298800
    2 CONTINUE                                                          298900
      IOR=3                                                             299000
      IF(FNORM(R1(1,1)).LT.C(11)) IOR=1                                 299100
      IF(FNORM(R1(1,2)).LT.C(12)) IOR=2                                 299200
      IF(FNORM(R1(1,4)).LT.C(14)) IOR=4                                 299300
      IF(FNORM(R1(1,5)).LT.C(15)) IOR=5                                 299400
      IF(FNORM(R1(1,6)).LT.C(16)) IOR=6                                 299500
      IF(IOR.EQ.NOR) GO TO 1                                            299600
      NOR=IOR                                                           299700
      F=0.D0                                                            299800
      C(122)=2.D0                                                       299900
      RETURN                                                            300000
    1 IF(C(122).EQ.0.D0.AND.F.GT.0.D0) F=0.D0                           300100
      RETURN                                                            300200
      END                                                               300300
```

```
      SUBROUTINE TFRAC(T1,T2,TW,TF)                                     300400
      IMPLICIT REAL*8(A-H,O-Z,S).                                       300500
      TW=T1                                                             300600
      TF=T2                                                             300700
    3 CONTINUE                                                          300800
      IF(TF)1,2,2                                                       300900
    1 CONTINUE                                                          301000
      TW=TW-1.0D0                                                       301100
      TF=TF+1.0D0                                                       301200
      GO TO 3                                                           301300
    2 CONTINUE                                                          301400
      TDUM=IDINT(TF)                                                    301500
      TW=TW TDUM                                                        301600
      TF=TF-TDUM                                                        301700
      RETURN                                                            301800
      END                                                               301900
```

```
      SUBROUTINE TIMEC(T1,T2,T3,T4)                                     302000
      IMPLICIT REAL*8(A-H,O-Z,$)                                        302100
C     T1 IS AN INPUT IN FORM (YEARS FROM 1900)(MONTH OF YEAR)           302200
C     (DAY OF MONTH                                                     302300
C     WRITTEN AS 6501.12 FOR JAN. 12, 1965                              302400
C     T2 IS AN INPUT IN FORM (HOUR OF DAY)(MINUTE OF HOUR)              302500
C     (SECOND OF MINUTE)                                                302600
C     WRITTEN AS 1301.3032 FOR 1PM, 1 MINUTE, 30.32 SECOND              302700
C     T3  IS WHOLE DAYS FROM 1950 OUTPUT                                302800
      T4=0.0D0                                                          302900
      TA=IDINT(T1)                                                      303000
      TA1=TA/100.0D0+.01D0                                              303100
      TY1= IDINT(TA1)                                                   303200
      TY= TY1-60.0D0                                                    303300
      IY=TY                                                             303400
      IF (IY) 15,15,16                                                  303500
   15 CONTINUE                                                          303600
      WRITE (   6,17)                                                   303700
   17 FORMAT (37H EXIT FROM TIMEC. DATE 1960 OR BEFORE)                 303800
      CALL EXIT                                                         303900
   16 CONTINUE                                                          304000
      ND=3652                                                           304100
      K=1                                                               304200
      DO 1 I=1, IY                                                      304300
      KK=K-I                                                            304400
      IF (KK) 2,2,3                                                     304500
    2 CONTINUE                                                          304600
      ND=ND + 366                                                       304700
      K=K+4                                                             304800
      GO TO 1                                                           304900
    3 CONTINUE                                                          305000
      ND=ND +365                                                        305100
    1 CONTINUE                                                          305200
      TY2=TA-TY1*100.0D0+.1D0                                           305300
      IY2=IDINT(TY2)                                                    305400
      IF (IY2) 10,10,11                                                 305500
   11 CONTINUE                                                          305600
      IF (12-IY2) 10,12,12                                              305700
   10 CONTINUE                                                          305800
      WRITE (   6,13)                                                   305900
   13 FORMAT(37H INPUT TIME IS WRONG. EXIT FROM TIMEC)                  306000
      CALL EXIT                                                         306100
   12 CONTINUE                                                          306200
      DO 4 I=1,IY2                                                      306300
      I=I                                                               306400
C           JAN FEB MAR APRIL MAY JUNE JULY AUG SEPT OCT NOV            306500
      GO TO (4,6,7,6,8,6,8,6,6,8,6,8),I                                 306600
    6 CONTINUE                                                          306700
      ND=ND + 31                                                        306800
      GO TO 4                                                           306900
    7 CONTINUE                                                          307000
      IF(KK-1)9,14,9                                                    307100
   14 CONTINUE                                                          307200
      ND=ND +29                                                         307300
      GO TO 4                                                           307400
    9 CONTINUE                                                          307500
      ND=ND +28                                                         307600
      GO TO 4                                                           307700
    8 CONTINUE                                                          307800
      ND=ND +30                                                         307900
    4 CONTINUE                                                          308000
      T81=(T1-TA)*100.000+.100                                          308100
      ND=ND+IDINT(T81)                                                  308200
      ND=ND-1                                                           308300
      T3=ND                                                             308400
      TA=IDINT(T2)                                                      308500
```

```
T4=(T2-TA)/864.0D0                                                    308600
TB=TA/100.0D0+.1D0                                                    308700
TB1=IDINT(TB)                                                         308800
TB2=TA-TB1*100.0D0+.1D0                                               308900
TB3=IDINT(TB2)                                                        309000
T4=T4+TB1/24.0D0+TB3/24.0D0/60.0D0                                    309100
RETURN                                                                309200
END                                                                   309300
```

```
      SUBROUTINE TRAJ(T1D,T1F,R,V,NE)                                   309400
      IMPLICIT REAL*8(A-H,O-Z,$)                                        309500
      COMMON C(1000),IC(50),Z(3),VV(3),NOR                              309600
      COMMON/TIME/TW,TF                                                 309700
      DIMENSION R1(3,8),V1(3,8),R(3),V(3),Y(20),D(20)                   309800
      EQUIVALENCE (C(401),R1(1,1)),(C(425),V1(1,1))                     309900
      J=2                                                               310000
      N=6                                                               310100
      L=0                                                               310200
      C(461)=0.D0                                                       310300
      C(506)=0.D0                                                       310400
      C(590)=T1D                                                        310500
      C(591)=T1F                                                        310600
      C(594)=(C(590)-C(592)+C(591)-C(593))*86400.D0                     310700
      IF(C(594).EQ.0.D0) RETURN                                         310800
      Y(9)=-1.D0                                                        310900
      M=C(763)                                                          311000
      G=DSIGN(120.D0,C(594))                                            311100
      Y(8)=C(764)                                                       311200
    2 DO 1 I=1,6                                                        311300
    1 Y(I)=0.D0                                                         311400
      X=0.D0                                                            311500
      CALL FNOL2(J,N,G,L,M,NE,X,Y,D,DERIV,TERM,OUT)                     311600
      IF(C(122).EQ.1.D0) GO TO 3                                        311700
      IF(C(122).EQ.2.D0) GO TO 6                                        311800
      IF(C(122).EQ.10.D0) RETURN                                        311900
      IF(C(594)-(C(506)+X).LE.0.D0) GO TO 3                             312000
4     CONTINUE                                                          312100
      C(506)=C(506)+X                                                   312200
      C(122)=1.D0                                                       312300
      DO 5 I=1,3                                                        312400
      C(I+499)=R1(I,NOR)                                                312500
    5 C(I+502)=V1(I,NOR)                                                312600
      GO TO 2                                                           312700
    6 CONTINUE                                                          312800
      C(122)=1.D0                                                       312900
      WRITE(6,7) C(NOR+60)                                              313000
    7 FORMAT(20HOBODY CENTER IS NOW A6)                                 313100
      DO 8 I=1,3                                                        313200
      C(I+499)=R1(I,NOR)                                                313300
    8 C(I+502)=V1(I,NOR)                                                313400
      C(506)=C(506)+X                                                   313500
      GO TO 2                                                           313600
    3 CONTINUE                                                          313700
      DO 13 I=1,3                                                       313800
      R(I)=R1(I,NOR)                                                    313900
   13 V(I)=V1(I,NOR)                                                    314000
      C(122)=1.D0                                                       314100
      C(592)=TW                                                         314200
      C(593)=TF                                                         314300
      RETURN                                                            314400
      END                                                               314500
```

APPENDIX B

EXAMPLES

CASE 1 Apoapsis Printout*

Case 1 is an example of the input and output formats for printout at apoapsis. A detailed explanation will be helpful.

INPUT

C array	Variable
750	Semimajor axis of 53500 km.
751	Eccentricity is .86915888
752	True anomaly is 180 deg.
753	Right ascension of node is 45 deg.
754	Inclination to reference plane is 30 deg.
755	Argument of periapsis is 45 deg.
756	Epoch date is March 13, 1971
757	Epoch time is $0^h\ 0^m\ 0^s$
(758)†	Input reference coordinate system is Earth mean equator and equinox of 1950, January 1, 0^h
759	Stop date is March 17, 1971
760	Stop time is 0^h
761	Apoapsis printout is wanted; therefore c(761) is total integration time of 4 days.
(762)†	= 1. for apoapsis printout
763	Apoapsis printout is wanted.
764	Apoapsis printout is wanted.
(765)†	No shadow is wanted
(767)†	Built-in error control used.
(768)†	Include harmonics for Earth, Moon and Mars whichever is the central body.
(769)†	No solar pressure — ignore c(770) through c(774).
775	Input in keplerian elements.
776	Printout at apogee only.
777	Three types of output requested: (1) Central body; mean earth equator and equinox of 1950 (2) Central body; true ecliptic and equinox of date (3) Sun-centered; true ecliptic and equinox of date.

*Apoapsis printout is a form of exact print and requires restarting the integrator

† Built-in value is used; therefore not included in input

OUTPUT

The first block of output shows that shadow times have not been requested and that central body oblateness of the Earth, Moon or Mars, whichever is the central body, is requested. However in this case, no oblateness is calculated since Venus is the central body.

The next block of output is the epoch time and the input transformed into the mean Earth equator and equinox of 1950, January 1 at 0^h, which is the working coordinate system of TRIP.

Next comes the epoch input transformed to those output options specified. In this case, the initial position of the satellite was at apoapsis. This is followed by similar output at the requested times. The output definitions are as follows:

X → DZ	State vector in km and km/sec.
R	Radius magnitude (km)
DEC	Declination of satellite in degrees referenced to the stated coordinate plane
RA	Right ascension or longitude of the satellite in degrees referenced to the stated coordinate plane.
V	Velocity magnitude in km/sec.
PTH	Flight path angle in degrees
AZ	Azimuth in degrees
SMA	Semimajor axis in km
ECC	Eccentricity
INC	Inclination in degrees to the reference plane
LAN	Longitude of the ascending node in degrees
APF	Argument of perifocus in degrees
RCA	Radius of closest approach (periapsis) in km
C3	Twice the total energy per unit mass in km^2/sec^2 $(-\mu/a)$
THET	True anomaly in degrees
APOG	Apoapsis in km
MAN	Mean anomaly in degrees.
PERH	Period in hours
TPER	Time to periapsis in days.

In the final block is the number of integration steps taken. Since printout at apoapsis, periapsis or exact time steps requires restarting the numerical integrator, this is the number of steps taken from the previous output time.

```
                                        OVERLAY INPUT
 750   0.535000000 05      751   0.869158880 00      752   0.180000000 03      753   0.450000000 02
 754   0.300000000 02      755   0.450000000 02      756   0.710313000 04      757   0.0
 759   0.710317000 04      760   0.0                 761   0.400000000 01      763   0.100000000 06
 764   0.0                 766   0.400000000 01      775   0.100000000 01      776   0.100000000 01
 777   0.100101000 03        0   0.0                   0   0.0                   0   0.0

SHADOW IS NOT REQUESTED

HARMONICS OF  EARTH IS      INCLUDED

HARMONICS OF   MOON IS      INCLUDED

HARMONICS OF   MARS IS      INCLUDED

 SOLAR RADIATION PRESSURE IS NOT INCLUDED

INPUT IN MEAN EQ AND EQ OF 1950
 MARCH 13, 1971,  0HRS,  0MIN,  0.  0SEC                                                      JULIAN DATE 2441023.5000000
   X-0.669871810 04     Y-0.933012690 05     Z-0.353553440 05   DX 0.608201270 00   DY 0.436673150-01   DZ-0.230470030 00
   R 0.100000000 06  DEC-0.207048160 02    RA-0.941065980 02     V 0.651868120 00  PTH-0.320874400-04   AZ 0.112207650 03


 MARCH 13, 1971,  0HRS,  0MIN,  0.  0SEC                                                      JULIAN DATE 2441023.5000000

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X-0.669871810 04     Y-0.933012690 05     Z-0.353553440 05,  DX 0.608201270 00   DY 0.436673150-01   DZ-0.230470030 00
   R 0.100000000 06  DEC-0.207048160 02    RA-0.941065980 02     V 0.651868120 00  PTH-0.320874400-04   AZ 0.112207650 03
 SMA 0.535000000 05  ECC 0.869158880 00  INC 0.300000010 02  LAN 0.450000010 02  APF 0.450000010 02  RCA 0.699999990 04
  C3-0.607045790 01 THET-0.180000000 03 APOG 0.100000000 06  MAN 0.180000030 03 PERH 0.378983600 02 TPER-0.789549020 00

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.617861770 04     Y-0.996990830 05     Z 0.668162030 04   DX 0.608463450 00   DY-0.484523430-01   DZ-0.228815760 00
   R 0.100000000 06  DEC 0.268335170 01    RA-0.935462370 02     V 0.651868130 00  PTH-0.320911450-04   AZ 0.110573010 03
 SMA 0.535000000 05  ECC 0.869158860 00  INC 0.207397460 02  LAN 0.935635950 02  APF 0.352603080 03  RCA 0.700000000 04
  C3-0.607045790 01 THET-0.180000000 03 APOG 0.100000000 06  MAN 0.180000030 03 PERH 0.378983610 02 TPER-0.789549030 00

   SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.450202240 08     Y-0.988206570 08     Z 0.122527270 07   DX 0.322372050 02   DY-0.147301730 02   DZ-0.225658840 01
   R 0.108599670 09  DEC 0.646452940 00    RA-0.114692830 03     V 0.355103540 02  PTH 0.264367660-01   AZ 0.936439810 02

NUMBER OF STEPS IS          0.100000000 01


 MARCH 14, 1971, 13HRS, 54MIN, 18. 22SEC                                                      JULIAN DATE 2441025.0793752

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X-0.664766030 04     Y-0.933118520 05     Z-0.353815640 05   DX 0.607400920 00   DY 0.440747550-01   DZ-0.230373010 00
   R 0.100015740 06  DEC-0.207174660 02    RA-0.940749430 02     V 0.651114910 00  PTH 0.142104550-13   AZ 0.112226800 03
 SMA 0.535003590 05  ECC 0.869440520 00  INC 0.300721810 02  LAN 0.450421610 02  APF 0.449956930 02  RCA 0.698447880 04
  C3-0.607041720 01 THET 0.180000000 03 APOG 0.100015740 06  MAN 0.180000000 03 PERH 0.378987420 02 TPER 0.789547120 00

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.612744500 04     Y-0.997189570 05     Z 0.666177350 04   DX 0.607660950 00   DY-0.480394460-01   DZ-0.228890890 00
   R 0.100015740 06  DEC 0.267154710 01    RA-0.935162410 02     V 0.651114910 00  PTH-0.867627040-08   AZ 0.110604750 03
 SMA 0.535003590 05  ECC 0.869440520 00  INC 0.207697500 02  LAN 0.935508730 02  APF 0.352447180 03  RCA 0.698447880 04
  C3-0.607041720 01 THET 0.180000000 03 APOG 0.100015740 06  MAN 0.180000000 03 PERH 0.378987420 02 TPER 0.789547120 00

   SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.406627210 08     Y-0.100728030 09     Z 0.967455110 06   DX 0.328386820 02   DY-0.133171390 02   DZ-0.227199380 01
   R 0.108630070 09  DEC 0.499731520 00    RA-0.111983390 03     V 0.355087040 02  PTH 0.587391460-01   AZ 0.936691740 02

NUMBER OF STEPS IS          0.383000000 03


 MARCH 16, 1971,  3HRS, 4MIN, 38.373SEC                                                       JULIAN DATE 2441026.6282747

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X-0.659378710 04     Y-0.933205540 05     Z-0.354079690 05   DX 0.606692110 00   DY 0.445049000-01   DZ-0.230281810 00
   R 0.100029630 06  DEC-0.207306130 02    RA-0.940416930 02     V 0.650450930 00  PTH-0.122989040-09   AZ 0.112243470 03
 SMA 0.535006860 05  ECC 0.869688730 00  INC 0.300422130 02  LAN 0.450818050 02  APF 0.449951880 02  RCA 0.697174210 04
  C3-0.607038020 01 THET 0.180000000 03 APOG 0.100029630 06  MAN 0.180000000 03 PERH 0.378990890 02 TPER 0.789566350 00

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.607363500 04     Y-0.997371590 05     Z 0.664102860 04   DX 0.606969060 00   DY-0.476147430-01   DZ-0.228977000 00
   R 0.100029630 06  DEC 0.265928060 01    RA-0.934846890 02     V 0.650450930 00  PTH-0.870274290-08   AZ 0.110634670 03
 SMA 0.535006860 05  ECC 0.869688730 00  INC 0.207979040 02  LAN 0.935393000 02  APF 0.352691820 03  RCA 0.697174220 04
  C3-0.607038020 01 THET 0.180000000 03 APOG 0.100029630 06  MAN 0.180000000 03 PERH 0.378990890 02 TPER 0.789566350 00

   SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.362265340 08     Y-0.102440880 09     Z 0.667809780 06   DX 0.333821140 02   DY-0.118795420 02   DZ-0.228365190 01
   R 0.108659840 09  DEC 0.352134900 00    RA-0.109675790 03     V 0.355063840 02  PTH 0.907168590-01   AZ 0.938879270 02

NUMBER OF STEPS IS          0.391000000 03


 MARCH 16, 1971, 23HRS, 59MIN, 59.999SEC                                                      JULIAN DATE 2441027.4999999

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X-0.196063730 05     Y-0.126283150 05     Z 0.287765900 04   DX-0.196477190 01   DY-0.412951190 01   DZ-0.880776350 00
   R 0.234965010 05  DEC 0.703628790 01    RA-0.147212000 03     V 0.466645130 01  PTH 0.594311200 02   AZ 0.119280970 03
 SMA 0.534845100 05  ECC 0.869842220 00  INC 0.300494310 02  LAN 0.451033200 02  APF 0.446970140 02  RCA 0.696142460 04
  C3-0.607221610 01 THET 0.120847250 03 APOG 0.100007990 06  MAN 0.117424970 02 PERH 0.378819020 02 TPER 0.515723000-01

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.195496540 05     Y-0.109493360 05     Z 0.764905200 04   DX-0.192916470 01   DY-0.414602470 01   DZ 0.628849480 00
   R 0.234965010 05  DEC 0.189984710 02    RA-0.151461940 03     V 0.466645130 01  PTH 0.594311200 02   AZ 0.985407460 02
 SMA 0.534845110 05  ECC 0.869842220 00  INC 0.208110080 02  LAN 0.935407770 02  APF 0.352510400 03  RCA 0.696142590 04
  C3-0.607221600 01 THET 0.120847250 03 APOG 0.100007400 06  MAN 0.117426940 02 PERH 0.378819030 02 TPER 0.515723000-01

   SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.338608140 08     Y-0.103183000 09     Z 0.521361490 06   DX 0.311115910 02   DY-0.152034970 02   DZ-0.143201640 01
   R 0.108596610 09  DEC 0.275060390 00    RA-0.108161630 03     V 0.366595920 02  PTH 0.794396820 01   AZ 0.922896210 02

NUMBER OF STEPS IS          0.267000000 03
```

CASE 2 Periapsis Printout*

The only difference here from case 1 is the input array c(776), which now requests output at periapsis. Notice that the initial position was at periapsis.

*Periapsis printout is a form of exact print and requires restarting the integrator.

```
                                   OVERLAY INPUT
  750   0.535000000D 05     751   0.869158880 00     752   1.0                  753   0.450000000D 02
  754   0.300000000D 02     755   0.450000000D 02    756   0.710313000D 04      757   0.0
  759   0.710317000D 04     760   0.0                761   0.400000000D 01      763   0.100000000D 04
  764   0.0                 766   0.400000000D 01    775   0.100000000D 01      776  -0.100000000D 01
  777   0.100101000D 08       0   0.0                  0   0.0                    0   0.0

SHADOW IS NOT REQUESTED

HARMONICS OF  EARTH IS      INCLUDED

HARMONICS OF   MOON         INCLUDED

HARMONICS OF   MARS IS      INCLUDED

 SOLAR RADIATION PRESSURE IS NOT INCLUDED

INPUT IN MEAN EQ AND EQ OF 1950
 MARCH 13, 1971,  0HRS,  0MIN,  0.  0SEC                                                       JULIAN DATE 2441023.50000000
   X 0.668910820 03    Y 0.653108880 04    Z 0.247687380 04   DX-0.868858920 01   DY-0.623813050 00   DZ 0.329243130 01
   R 0.699999990 04  DEC 0.207048120 02   RA 0.858933970 02    V 0.931240190 01  PTH 0.805947830-06   AZ 0.677923450 02


 MARCH 13, 1971,  0HRS,  0MIN,  0.  0SEC                                                       JULIAN DATE 2441023.50000000

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X 0.668910820 03    Y 0.653108880 04    Z 0.247687380 04   DX-0.868858920 01   DY-0.623813050 00   DZ 0.329243130 01
   R 0.699999990 04  DEC 0.207048120 02   RA 0.858933970 02    V 0.931240190 01  PTH 0.805947830-06   AZ 0.677923450 02
 SMA 0.535000000 05  ECC 0.869158860 00  INC 0.300000010 02  LAN 0.450000010 02  APF 0.450000010 02  RCA 0.699999990 04
  C3-0.607045790 01 THET 0.0             APOG 0.100000000 06  MAN 0.595118400-16 PERH 0.378983600 02 TPER 0.0

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X 0.432503800 03    Y 0.697893570 04   Z-0.327713630 03   DX-0.869233480 01   DY 0.692182460 00   DZ 0.326879630 01
   R 0.699999990 04  DEC-0.268335340 01   RA 0.864537590 02    V 0.931240190 01  PTH 0.797243720-06   AZ 0.694269890 02
 SMA 0.535000040 05  ECC 0.869158890 00  INC 0.207397440 02  LAN 0.935635950 02  APF 0.352603080 03  RCA 0.699999990 04
  C3-0.607045740 01 THET 0.0             APOG 0.100000010 06  MAN 0.360000000 03 PERH 0.378983650 02 TPER 0.0

  SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.450136130 08    Y-0.987139790 08    Z 0.122026960 07   DX 0.229314070 02   DY-0.139895380 02   DZ 0.124102360 01
   R 0.108499600 09  DEC 0.644402690 00   RA-0.114513000 03    V 0.268904580 02  PTH 0.689686030 01   AZ 0.874133590 02

NUMBER OF STEPS IS       0.100000000 01


 MARCH 14, 1971, 13HRS, 55MIN, 15.398SEC                                                       JULIAN DATE 2441025.08003933

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X 0.664299100 03    Y 0.651453760 04    Z 0.247091360 04   DX-0.869736010 01   DY-0.631128590 00   DZ 0.329875530 01
   R 0.698671540 04  DEC 0.207174730 02   RA 0.859264000 02    V 0.932329530 01  PTH-0.295653550-07   AZ 0.677728620 02
 SMA 0.534995650 05  ECC 0.869643560 00  INC 0.300220800 02  LAN 0.450422060 02  APF 0.449952630 02  RCA 0.698671540 04
  C3-0.607050500 01 THET-0.117943660-05 APOG 0.100014450 06  MAN 0.360000000 03 PERH 0.378979200 02 TPER-0.170924640-09

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X 0.627969270 03    Y 0.696398620 04   Z-0.325557910 03   DX-0.870106380 01   DY 0.687940140 00   DZ 0.327750870 01
   R 0.698671540 04  DEC-0.267152690 01   RA 0.864833310 02    V 0.932329590 01  PTH-0.382215450-07   AZ 0.693950690 02
 SMA 0.534995890 05  ECC 0.869643570 00  INC 0.207699240 02  LAN 0.935503250 02  APF 0.352447310 03  RCA 0.698671540 04
  C3-0.607050450 01 THET-0.162553660-05 APOG 0.100016660 06  MAN 0.360000000 03 PERH 0.378979240 02 TPER-0.246002970-09

  SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.406543140 08    Y-0.100622110 09    Z 0.962350540 06   DX 0.235299990 02   DY-0.125805540 02   DZ 0.123440010 01
   R 0.108528660 09  DEC 0.497503490 00   RA-0.112000170 03    V 0.267105780 02  PTH 0.614779600 01   AZ 0.873896080 02

NUMBER OF STEPS IS       0.214000000 03


 MARCH 16, 1971,  3HRS, 50MIN, 33. 365SEC                                                      JULIAN DATE 2441026.66010457

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X 0.659660290 03    Y 0.650367230 04    Z 0.246764760 04   DX-0.870502820 01   DY-0.638501770 00   DZ 0.330427590 01
   R 0.697124460 04  DEC 0.207306360 02   RA 0.859974020 02    V 0.933292270 01  PTH 0.359271370-14   AZ 0.677558140 02
 SMA 0.534992140 05  ECC 0.869664370 00  INC 0.300427350 02  LAN 0.450818440 02  APF 0.449963270 02  RCA 0.697126860 04
  C3-0.607054710 01 THET-0.674767330-06 APOG 0.100027180 06  MAN 0.360000000 03 PERH 0.378979250 02 TPER-0.101844900-09

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X 0.623376020 03    Y 0.695005560 04   Z-0.323436020 03   DX-0.870872870 01   DY 0.683327980 00   DZ 0.328590630 01
   R 0.697124640 04  DEC-0.265923290 01   RA 0.865144270 02    V 0.933292270 01  PTH-0.867001050-08   AZ 0.693649910 02
 SMA 0.534992180 05  ECC 0.869696380 00  INC 0.207982370 02  LAN 0.935381440 02  APF 0.352402070 03  RCA 0.697126860 04
  C3-0.607054440 01 THET-0.194327140-05 APOG 0.100027190 06  MAN 0.360000000 03 PERH 0.378975300 02 TPER-0.208719960-09

  SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.362142810 08    Y-0.102395650 09    Z 0.662009740 06   DX 0.240668080 02   DY-0.111473820 02   DZ 0.123107410 01
   R 0.108557090 09  DEC 0.349723600 00   RA-0.109680720 03    V 0.265517870 02  PTH 0.437448570 01   AZ 0.873637790 02

NUMBER OF STEPS IS       0.212000000 03


 MARCH 16, 1971, 23HRS, 59MIN, 59.999SEC                                                       JULIAN DATE 2441027.50000000

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X-0.396986600 04    Y-0.928745640 05    Z-0.369154730 05   DX 0.613496780 00   DY 0.174879040 00   DZ-0.180109110 00
   R 0.998002940 05  DEC-0.217387590 02   RA-0.924352690 02    V 0.663056190 00  PTH-0.105901900 02   AZ 0.111607620 03
 SMA 0.535151090 05  ECC 0.849775870 00  INC 0.300595130 02  LAN 0.450999990 02  APF 0.449941730 02  RCA 0.696693440 04
  C3-0.606874410 01 THET-0.178396690 03 APOG 0.100061260 06  MAN 0.191339870 03 PERH 0.378144140 02 TPER-0.740122490 00

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.362975080 04    Y-0.994752910 05    Z 0.363999600 04   DX 0.613726170 00   DY 0.919919000-01   DZ-0.234812820 00
   R 0.998002940 05  DEC 0.209502950 01   RA-0.919787320 02    V 0.663056140 00  PTH-0.105901900 02   AZ 0.110719870 03
 SMA 0.535151090 05  ECC 0.849775870 00  INC 0.208132090 02  LAN 0.935251850 02  APF 0.352510440 03  RCA 0.696693470 04
  C3-0.606874410 01 THET-0.178996690 03 APOG 0.100061260 06  MAN 0.191339870 03 PERH 0.378144140 02 TPER-0.740122490 00

  SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.338319940 08    Y-0.103272760 09    Z 0.517909440 06   DX 0.356473000 02   DY-0.109954180 02   DZ-0.229372270 01
   R 0.108874440 09  DEC 0.272799530 00   RA-0.108198710 03    V 0.356440790 02  PTH-0.102201240 00   AZ 0.937874410 02

NUMBER OF STEPS IS       0.700000000 02
```

CASE 3 Printout at Exact Intervals[†]

This case represents printout requested at intervals of exactly 1-1/2 days. While this feature may be extremely useful in some cases, it is inefficient in that it requires the integrator to restart after every printout.

The differences in input are:

(1) c(761) is 1.5 since printout is wanted at exactly 1.5 day intervals.

(2) c(762) is 2., which is the total days (4) divided by Δt (1.5) and truncated. Note that c(762)* $\Delta t \neq 4$ and therefore TRIP gives a final printout after 4 days which is at the requested stop time.

(3) c(776) uses the built-in value of 0. since printout is not wanted at perigee or apogee.

[†]Do not request exact printout and printout at apoapsis or periapsis in the same run. TRIP can not handle this multiple type output.

```
                                          OVERLAY INPUT
   750   0.535000000 05     751   0.869158880 00     752   0.0               753   0.450000000 02
   754   0.300000000 02     755   0.450000000 02     756   0.710313000 04    757   0.0
   759   0.710317000 04     760   0.0                761   0.150000000 01    762   0.200000000 01
   763   0.100000000 06     764   0.0                766   0.400000000 01    775   0.100000000 01
   777   0.100101000 08       0   0.0                  0   0.0               0    0.0

SHADOW IS NOT REQUESTED

HARMONICS OF  EARTH IS     INCLUDED

HARMONICS OF   MOON IS     INCLUDED

HARMONICS OF   MARS IS     INCLUDED

 SOLAR RADIATION PRESSURE IS NOT INCLUDED

INPUT IN MEAN EQ AND EQ OF 1950
 MARCH 13, 1971,  0HRS,  0MIN,  0.  0SEC                                                 JULIAN DATE 2441023.5000000
   X 0.466910820 03    Y 0.653108680 04    Z 0.247487380 04   DX-0.868858920 01   DY-0.623813050 00   DZ 0.329243130 01
   R 0.699999990 04  DEC 0.207068120 02   RA 0.858933970 02    V 0.931240190 01  PTH 0.805947830-06   AZ 0.677923450 02


 MARCH 13, 1971,  0HRS,  0MIN,  0.  0SEC                                                 JULIAN DATE 2441023.5000000

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X 0.466910820 03    Y 0.653108680 04    Z 0.247487380 04   DX-0.868858920 01   DY-0.623813050 00   DZ 0.329243130 01
   R 0.699999990 04  DEC 0.207068120 02   RA 0.858933970 02    V 0.931240190 01  PTH 0.805947830-06   AZ 0.677923450 02
 SMA 0.535000000 05  ECC 0.869158880 00  INC 0.300000010 02  LAN 0.450000010 02  APE 0.450000010 02  RCA 0.699999990 04
  C3-0.607045790 01 THET 0.0            APOG 0.100000000 06  MAN 0.595118400-16 PERH 0.379983600 02 TPER 0.0

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X 0.432503800 03    Y 0.697893570 04    Z-0.327713630 03   DX-0.869233480 01   DY 0.692182460 00   DZ 0.326879630 01
   R 0.699999990 04  DEC-0.268335340 01   RA 0.866537890 02    V 0.931240190 01  PTH 0.797243720-06   AZ 0.694269890 02
 SMA 0.535000040 05  ECC 0.869158890 00  INC 0.207397460 02  LAN 0.935635950 02  APE 0.352403030 03  RCA 0.699999990 04
  C3-0.607045740 01 THET 0.0            APOG 0.100000010 06  MAN 0.360000000 03 PERH 0.379983650 02 TPER 0.0

   SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.450136130 08    Y-0.987139790 08    Z 0.122026340 07   DX 0.229514070 02   DY-0.139895390 02   DZ 0.124102360 01
   R 0.108499600 09  DEC 0.644402490 00   RA-0.114513000 03    V 0.268904580 02  PTH 0.689486030 01   AZ 0.874133550 02

NUMBER OF STEPS IS       0.100000000 01


 MARCH 14, 1971, 11HRS, 59MIN, 59.999SEC                                                 JULIAN DATE 2441024*********

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X 0.206043790 05    Y-0.186791551 06    Z-0.159706030 05   DX-0.638309320 00   DY 0.334764890 01   DZ 0.162784430 01
   R 0.319422370 05  DEC-0.299987260 02   RA-0.426724930 02    V 0.377660190 01  PTH-0.573302640 02   AZ 0.887567830 02
 SMA 0.534990260 05  ECC 0.869441570 00  INC 0.300220800 02  LAN 0.450421480 02  APE 0.449952080 02  RCA 0.698474900 04
  C3-0.607056850 01 THET-0.132842960 03 APOG 0.100013300 06  MAN 0.341752260 03 PERH 0.378973260 02 TPER-0.800394120-01

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X 0.205267080 05    Y-0.233861700 05    Z-0.722088620 04   DX-0.657706410 00   DY 0.371557620 01   DZ 0.161702570 00
   R 0.319422370 05  DEC-0.130652810 02   RA-0.487232230 02    V 0.377660190 01  PTH-0.573302640 02   AZ 0.106288860 03
 SMA 0.534990270 05  ECC 0.869441570 00  INC 0.207699030 02  LAN 0.935502750 02  APE 0.352447240 03  RCA 0.698474900 04
  C3-0.607056840 01 THET-0.132842960 03 APOG 0.100013300 06  MAN 0.341752260 03 PERH 0.378973260 02 TPER-0.800394120-01

   SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.408570080 08    Y-0.100560650 09    Z 0.949581030 06   DX 0.315440930 02   DY-0.962512730 01   DZ-0.168072430 01
   R 0.108547690 09  DEC 0.501233370 00   RA-0.112111560 03    V 0.330334670 02  PTH-0.516301150 01   AZ 0.932319100 02

NUMBER OF STEPS IS       0.163000000 03


 MARCH 15, 1971, 23HRS, 59MIN, 59.999SEC                                                 JULIAN DATE 2441026.5000000

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X 0.217610310 05    Y-0.383157610 05    Z-0.245506680 05   DX 0.927106060-01   DY 0.262723580 01   DZ 0.953264740 00
   R 0.504331920 05  DEC-0.291301980 02   RA-0.606286800 02    V 0.260935700 01  PTH-0.603688440 02   AZ 0.976935790 02
 SMA 0.535000470 05  ECC 0.869686160 00  INC 0.300426960 02  LAN 0.450812370 02  APE 0.449932320 02  RCA 0.697168960 04
  C3-0.607045260 01 THET-0.148501420 03 APOG 0.100028600 06  MAN 0.323500410 03 PERH 0.378984100 02 TPER-0.160101420 00

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X 0.219751740 05    Y-0.446061450 05    Z-0.728065310 04   DX 0.791702690-01   DY 0.260656670 01   DZ-0.910816910-01
   R 0.504331920 05  DEC-0.830035490 01   RA-0.638743590 02    V 0.260935700 01  PTH-0.603688440 02   AZ 0.109137620 03
 SMA 0.535000470 05  ECC 0.869688160 00  INC 0.207979720 02  LAN 0.935377380 02  APE 0.352490860 03  RCA 0.697168970 04
  C3-0.607045260 01 THET-0.148501320 03 APOG 0.100028600 06  MAN 0.323500410 03 PERH 0.379994110 02 TPER-0.160101420 00

   SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.366477610 08    Y-0.102272730 09    Z 0.884065680 06   DX 0.328024180 02   DY-0.937086830 01   DZ-0.214459240 01
   R 0.108595640 09  DEC 0.360919980 00   RA-0.109723210 03    V 0.341820280 02  PTH-0.379699430 01   AZ 0.935811190 02

NUMBER OF STEPS IS       0.193000000 03


 MARCH 16, 1971, 23HRS, 59MIN, 59.999SEC                                                 JULIAN DATE 2441027.5000000

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X-0.396965620 04    Y-0.928762910 05    Z-0.363155320 05   DX 0.613695750 00   DY 0.174890750 00   DZ-0.180102530 00
   R 0.998000500 05  DEC-0.213398510 02   RA-0.926350220 02    V 0.663059790 00  PTH-0.105994560 02   AZ 0.111682530 03
 SMA 0.535150100 05  ECC 0.869775960 00  INC 0.300455130 02  LAN 0.450999580 02  APE 0.449941680 02  RCA 0.696894100 04
  C3-0.606875530 01 THET-0.178396690 03 APOG 0.100061080 06  MAN 0.191361110 03 PERH 0.379163110 02 TPER-0.240114080 00

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.362936650 04    Y-0.996750050 05    Z 0.369083740 04   DX 0.613225050 00   DY 0.920103010-01   DZ-0.236813580 00
   R 0.998000500 05  DEC 0.208496170 01   RA-0.919705000 02    V 0.663059790 00  PTH-0.105994560 02   AZ 0.110713130 03
 SMA 0.535150100 05  ECC 0.869775960 00  INC 0.208132050 02  LAN 0.995251890 02  APE 0.352514740 03  RCA 0.696894100 04
  C3-0.606875530 01 THET-0.178396690 03 APOG 0.100061080 06  MAN 0.191361110 03 PERH 0.379163110 02 TPER-0.240114090 00

   SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.338319960 08    Y-0.103772780 09    Z 0.917388670 06   DX 0.336472810 02   DY-0.109696000 02   DZ-0.224937290 01
   R 0.108674660 09  DEC 0.272736490 00   RA-0.108138710 03    V 0.354680480 02  PTH-0.108309650 00   AZ 0.937074430 02

NUMBER OF STEPS IS       0.183000000 03
```

CASE 4 Printout At Approximate Intervals

This case requests printout at approximately 1.5 day intervals. This means that printout is obtained at the first step of the integrator beyond the time actually requested. This type of printout does not require the numerical integrator to restart and is therefore much more efficient than any of the types discussed in cases 1-3. Where possible it should be used instead of the exact printouts.

The differences in input are

(1) c(761) is set equal to the total time of 4 days.
(2) c(762) use the built-in value of 1. and therefore does not appear in the input.
(3) c(763) uses the built-in value of 0. and therefore does not appear in the input.
(4) c(764) is set to 1.5 days in seconds.

Note that the printout of the number of integration steps taken is cumulative and represents the number of total steps taken from epoch, whereas in the exact printouts of cases 1 through 3 it represents the steps taken from the last printout.

```
                                   OVERLAY INPUT
  750   0.535000000 05     751   0.869158880 00     752   0.0               753   0.450000000 02
  754   0.300000000 02     755   0.450000000 02     756   0.710313000 04    757   0.0
  759   0.710317000 04     760   0.0                761   0.400000000 01      0   0.0
  764   0.129600000 06     766   0.600000000 01     775   0.100000000 01    777   0.100101000 04

SHADOW IS NOT REQUESTED

HARMONICS OF  EARTH IS     INCLUDED

HARMONICS OF   MOON IS     INCLUDED

HARMONICS OF   MARS IS     INCLUDED

 SOLAR RADIATION PRESSURE IS NOT INCLUDED

INPUT IN MEAN EQ AND EQ OF 1950
 MARCH 13, 1971,  0HRS,  0MIN,  0.  0SEC                                                    JULIAN DATE 2441023.5000000
   X 0.668910820 03    Y 0.653108880 04    Z 0.247487380 04   DX-0.868856920 01   DY-0.623813050 00   DZ 0.329243130 01
   R 0.699999990 04  DEC 0.207068120 02   RA 0.858933970 02    V 0.931240190 01  PTH 0.805947830-06   AZ 0.677923450 02


 MARCH 13, 1971,  0HRS,  0MIN,  0.  0SEC                                                    JULIAN DATE 2441023.5000000

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X 0.668910820 03    Y 0.653106880 04    Z 0.247487380 04   DX-0.868858920 01   DY-0.623813050 00   DZ 0.329243130 01
   R 0.699999990 04  DEC 0.207068120 02   RA 0.858933970 02    V 0.931240190 01  PTH 0.805947830-06   AZ 0.677923450 02
 SMA 0.535000000 05  ECC 0.869158880 00  INC 0.300000010 02  LAN 0.450000010 02  APF 0.650000010 02  RCA 0.699999900 04
  C3-0.607045790 01 THET 0.0            APOG 0.100000000 06  MAN 0.595118400-16 PERH 0.378983600 02 TPER 0.0

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X 0.432503800 03    Y 0.697893570 04    Z-0.327713630 03   DX-0.869233480 01   DY 0.692182460 00   DZ 0.326879630 01
   R 0.699999990 04  DEC-0.268335340 01   RA 0.864537590 02    V 0.931240190 01  PTH 0.797243720-06   AZ 0.694269890 02
 SMA 0.535000040 05  ECC 0.869158890 00  INC 0.207397440 02  LAN 0.935635950 02  APF 0.352403080 03  RCA 0.699999900 04
  C3-0.607045740 01 THET 0.0            APOG 0.100000010 06  MAN 0.360000000 03 PERH 0.378983650 02 TPER 0.0

   SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.450136130 08    Y-0.987139790 08    Z 0.122076340 07   DX 0.229314070 02   DY-0.139895380 02   DZ 0.124102360 01
   R 0.108499600 09  DEC 0.644402490 00   RA-0.114513000 03    V 0.268904580 02  PTH 0.689486030 01   AZ 0.874133550 02

NUMBER OF STEPS IS       0.100000000 01


 MARCH 14, 1971, 12HRS,  2MIN, 39.668SEC                                                    JULIAN DATE 2441025.0018457

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X 0.202999620 05    Y-0.181429300 05    Z-0.157088590 05   DX-0.671640900 00   DY 0.337761670 01   DZ 0.165367830 01
   R 0.314328270 05  DEC-0.299841010 02   RA-0.417885000 02    V 0.382018060 01  PTH-0.571586480 02   AZ 0.884148750 02
 SMA 0.534989960 05  ECC 0.869441640 00  INC 0.300220800 02  LAN 0.450421530 02  APF 0.449952300 02  RCA 0.698474080 04
  C3-0.607057210 01 THET-0.132250410 03 APOG 0.100013250 06  MAN 0.342173040 03 PERH 0.378972910 02 TPER-0.781936410-01

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X 0.204191820 05    Y-0.227886680 05    Z-0.719417960 04   DX-0.691034590 00   DY 0.375315680 01   DZ 0.173435810 00
   R 0.314328270 05  DEC-0.132300310 02   RA-0.481389140 02    V 0.382018060 01  PTH-0.571586480 02   AZ 0.106155950 03
 SMA 0.534989950 05  ECC 0.869441640 00  INC 0.207699050 02  LAN 0.935502800 02  APF 0.352447270 03  RCA 0.698476090 04
  C3-0.607057200 01 THET-0.132250410 03 APOG 0.100013250 06  MAN 0.342173060 03 PERH 0.378972920 02 TPER-0.781936920-01

   SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.408519800 08    Y-0.100561960 09    Z 0.949282840 06   DX 0.315114420 02   DY-0.958587960 01   DZ-0.186900690 01
   R 0.108547220 09  DEC 0.501077740 00   RA-0.112108800 03    V 0.329901990 02  PTH-0.520882290 01   AZ 0.932155930 02

NUMBER OF STEPS IS       0.162000000 03


 MARCH 16, 1971,  0HRS,  2MIN, 25.910SEC                                                    JULIAN DATE 2441026.5016887

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X 0.217539570 05    Y-0.379615680 05    Z-0.244113030 05   DX 0.866174690-01   DY 0.244142650 01   DZ 0.962353910 00
   R 0.501021500 05  DEC-0.291587220 02   RA-0.601850300 02    V 0.262561390 01  PTH-0.803566200 02   AZ 0.975749270 02
 SMA 0.535001120 05  ECC 0.869688240 00  INC 0.300626980 02  LAN 0.450812550 02  APF 0.449932180 02  RCA 0.697169380 04
  C3-0.607044530 01 THET-0.148286620 03 APOG 0.100028530 06  MAN 0.323884440 03 PERH 0.378984790 02 TPER-0.158417240 00

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X 0.219861140 05    Y-0.444256450 05    Z-0.729371860 04   DX 0.709305570-01   DY 0.262316760 01   DZ-0.863708670-01
   R 0.501021500 05  DEC-0.837069090 01   RA-0.636699950 02    V 0.262561390 01  PTH-0.803566200 02   AZ 0.109107810 03
 SMA 0.535001120 05  ECC 0.869688260 00  INC 0.207979810 02  LAN 0.935377600 02  APF 0.352690850 03  RCA 0.697169380 04
  C3-0.607044520 01 THET-0.148286620 03 APOG 0.100028530 06  MAN 0.323884440 03 PERH 0.378984790 02 TPER-0.158417240 00

   SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.366429750 08    Y-0.102224100 09    Z 0.683752990 06   DX 0.327967930 02   DY-0.935272090 01   DZ-0.214189130 01
   R 0.108595310 09  DEC 0.360756090 00   RA-0.109720590 03    V 0.341495700 02  PTH-0.581810810 01   AZ 0.935778680 02

NUMBER OF STEPS IS       0.345000000 03


 MARCH 16, 1971, 23HRS, 59MIN, 59.999SEC                                                    JULIAN DATE 2441027.5000000

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X-0.306996080 04    Y-0.928746620 05    Z-0.563156740 05   DX 0.613496260 00   DY 0.176879960 00   DZ-0.180110440 00
   R 0.998003750 05  DEC-0.219387420 02   RA-0.924959140 02    V 0.663055020 00  PTH-0.108597860 02   AZ 0.111862640 03
 SMA 0.535151420 05  ECC 0.869775940 00  INC 0.300995140 02  LAN 0.450999380 02  APF 0.449961230 02  RCA 0.696849890 04
  C3-0.606874040 01 THET-0.178996730 03 APOG 0.100061920 06  MAN 0.191339990 03 PERH 0.378144610 02 TPER-0.740124530 00

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.342983760 04    Y-0.998753070 05    Z 0.363102470 04   DX 0.613223440 00   DY 0.918870790-01   DZ-0.234812590 00
   R 0.998003760 05  DEC 0.208504660 01   RA-0.919707760 02    V 0.663055020 00  PTH-0.108597860 02   AZ 0.180713120 03
 SMA 0.535151420 05  ECC 0.869775940 00  INC 0.208132090 02  LAN 0.935291850 02  APF 0.352519400 03  RCA 0.696849890 04
  C3-0.606874040 01 THET-0.178996730 03 APOG 0.100061920 06  MAN 0.191339990 03 PERH 0.378144510 02 TPER-0.740124530 00

   SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.330319940 08    Y-0.103272760 09    Z 0.417908470 06   DX 0.394523800 02   DY-0.109654220 02   DZ-0.224937220 01
   R 0.108674440 09  DEC 0.227298550 00   RA-0.108158710 03    V 0.356680790 02  PTH-0.108274840 00   AZ 0.937076400 02

NUMBER OF STEPS IS       0.535000000 03
```

CASE 5 First and Last Point Printout

This case represents the most efficient type of run but also the one that gives the least information, being useful only when the final point is all that is desired. Note that the total steps taken will be the same as for case 4. The differences in input from case 4 are:

(1) c(763) is again set to 100 000.

(2) c(764) is set to 0.

```
                                   [illegible] INPUT
  750   0.53500000D 05      751   [illegible]             752   0.0                       753   0.45000000D 02
  754   0.30000000D 02      755   0.45000000D 02          756   0.71031300D 04            757   0.0
  759   0.71031700D 04      760   0.0                     761   [illegible] 03            763   0.10000000D 06
  764   0.0                 766   0.40000000D 01          775   0.10000000D 01            777   [illegible]

SHADOW IS NOT REQUESTED

HARMONICS OF  EARTH IS     INCLUDED

HARMONICS OF  MOON IS      INCLUDED

HARMONICS OF  MARS IS      INCLUDED

 SOLAR RADIATION PRESSURE IS NOT INCLUDED

INPUT IN MEAN EQ AND EQ OF 1950
 MARCH 13, 1971,  0HRS,  0MIN,  0.  0SEC                                                          JULIAN DATE 2441023.50000000
   X 0.46891082D 03    Y 0.65310888D 04    Z 0.24748739D 04   DX=0.86885892D 01   DY=0.62381305D 00   DZ 0.32924313D 01
   R 0.69999999D 04  DEC 0.20704812D 02   RA 0.85893307D 02    V 0.93124019D 01  PTH 0.80594743D-06   AZ 0.67792345D 02


 MARCH 13, 1971,  0HRS,  0MIN,  0.  0SEC                                                          JULIAN DATE 2441023.50000000

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X 0.46891082D 03    Y 0.65310888D 04    Z 0.24748739D 04   DX=0.86895292D 01   DY=0.62381305D 00   DZ 0.32924313D 01
   R 0.69999999D 04  DEC 0.20704812D 02   RA 0.85893307D 02    V 0.93124019D 01  PTH 0.80594763D-06   AZ 0.67792345D 02
 SMA 0.53500000D 05  ECC 0.86915868D 00  INC 0.30000001D 02  LAN 0.45000001D 02  APF 0.45000001D 02  RCA 0.69999999D 04
  C3-0.60704579D 01 THET 0.0             APOG 0.10000000D 06  MA  0.59511840D-16 PERR 0.37898360D 02 TPER 0.0

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X 0.43250380D 03    Y 0.69789357D 04    Z-0.32771363D 03   DX-0.86923348D 01   DY 0.69218246D 00   DZ 0.32687963D 01
   R 0.69999999D 04  DEC-0.26833534D 01   RA 0.86453759D 02    V 0.93124019D 01  PTH 0.79724372D-06   AZ 0.69426989D 02
 SMA 0.53500004D 05  ECC 0.86915889D 00  INC 0.20739764D 02  LAN 0.93563596D 02  APF 0.35246308D 03  RCA 0.69999999D 04
  C3-0.60704574D 01 THET 0.0             APOG 0.10000001D 06  MA  0.36000000D 03 PERR 0.37898365D 02 TPER 0.0

   SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.45013613D 08    Y-0.98713979D 08    Z 0.12202634D 07   DX 0.22931407D 02   DY-0.13989538D 02   DZ 0.12410236D 01
   R 0.10849960D 09  DEC 0.64440249D 00   RA-0.11451300D 03    V 0.26800458D 02  PTH 0.68969603D 01   AZ 0.87913355D 02

NUMBER OF STEPS IS        0.10000000D 01


 MARCH 16, 1971, 23HRS, 59MIN, 59.999SEC                                                          JULIAN DATE 2441027.50000000

 VENUS CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X-0.39499688D 04    Y-0.92874642D 05    Z-0.36315476D 05   DX 0.61369426D 00   DY 0.17487586D 00   DZ-0.18011664D 00
   R 0.99800375D 05  DEC-0.21338742D 02   RA-0.92435316D 02    V 0.66305502D 00  PTH-0.10557960D 02   AZ 0.11168766D 03
 SMA 0.53515142D 05  ECC 0.86977594D 00  INC 0.30055514D 02  LAN 0.45009939D 02  APF 0.44996123D 02  RCA 0.69689588D 04
  C3-0.60687604D 01 THET-0.17839673D 03 APOG 0.10006132D 06  MAV 0.19133935D 03 PERR 0.37914451D 02 TPER-0.76012453D 00

 VENUS CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.34298376D 04    Y-0.99675307D 05    Z 0.36310257D 06   DX 0.61322366D 00   DY 0.91987973D-01   DZ-0.23481253D 00
   R 0.99800376D 05  DEC 0.20850460D 01   RA-0.91970776D 02    V 0.66305502D 00  PTH-0.10557960D 02   AZ 0.11071312D 03
 SMA 0.53515142D 05  ECC 0.86977596D 00  INC 0.20813205D 02  LAN 0.93525185D 02  APF 0.35251963D 03  RCA 0.69689589D 04
  C3-0.60687604D 01 THET-0.17839673D 03 APOG 0.10006132D 06  MAV 0.19133935D 03 PERR 0.37914451D 02 TPER-0.76012453D 00

   SUN CENTERED TRUE ECLIPTIC AND EQUINOX OF DATE
   X-0.33831994D 08    Y-0.10327276D 09    Z 0.51730867D 06   DX 0.33652380D 02   DY-0.10965422D 02   DZ-0.22937220D 01
   R 0.10867446D 09  DEC 0.27273855D 00   RA-0.10813871D 03    V 0.35458075D 02  PTH-0.10827486D 00   AZ 0.93707640D 02

NUMBER OF STEPS IS        0.53500000D 03
```

CASE 6 Shadow Printout

This case is for an Earth satellite and includes printout of latitude and longitude of the satellite as well as shadow times. Note that, as explained earlier in the section on known bugs, the satellite was in shadow at the start and therefore the first shadow times are incorrect. This is obvious since the times show the spacecraft entering umbra first! The second sequence of shadow times is correct. Note also, that the oblateness effects of the Earth were included here. The input data differences from the previous cases are:

(1) c(750) through c(755) are now state vector components.
(2) c(758) shows that the state vector is referenced to the true Earth equator and equinox of date.
(3) c(761), c(762) (built-in value), c(763), c(764) indicate that only the first and last points are requested.
(4) c(765) indicates that shadow times are requested from the outset
(5) c(766) is the built-in value indicating the Earth is the central body
(6) c(775) is the built-in value indicating input is cartesian state vector.
(7) c(777) is the built-in values for output options.

```
                                    OVERLAY 1 OUT
 750  -0.60233886D 04      751   0.44335[illegible] 03      752  -0.26647468D 04        0    0.0
 753  -0.19974716D 01      754  -0.10240190D 02      755   0.27891272D 01        0    0.0
 756   0.71031000D 04      757   0.17060000D 04      758   0.50000000D 01        0    0.0
 759   0.71031600D 04      760   0.17060000D 04      761   0.40000000D 03      763    0.10000000D 06
 764   0.0                 765   0.0                   0   0.0                    0    0.0

SHADOW IS REQUESTED

HARMONICS OF  EARTH IS     INCLUDED

HARMONICS OF   MOON IS     INCLUDED

HARMONICS OF   MARS IS     INCLUDED

 SOLAR RADIATION PRESSURE IS NOT INCLUDED

INPUT IN MEAN EQ AND EQ OF 1950
 MARCH 10, 1971, 17HRS,  5MIN, 59.999SEC                                                     JULIAN DATE 2441021.21250000
   X-0.60267703D 04     Y 0.47207734D 03     Z-0.26722306D 04    DX-0.20406749D 01    DY-0.10238251D 02    DZ 0.27937168D 01
   R 0.66095109D 04  DEC-0.23847320D 02    RA 0.17552116D 03     V 0.10806989D 02  PTH 0.71412335D-06    AZ 0.73582150D 02


 MARCH 10, 1971, 17HRS,  5MIN, 59.999SEC                                                     JULIAN DATE 2441021.21250000

 EARTH CENTERED   TRUE EARTH EQUATOR AND EQUINOX OF DATE
   X-0.60233886D 04     Y 0.44334886D 03     Z-0.26864768D 04    DX-0.19974716D 01    DY-0.10240190D 02    DZ 0.27891272D 01
   R 0.66095109D 04  DEC-0.23966001D 02    RA 0.17579036D 03     V 0.10806989D 02  PTH 0.78403980D-06    AZ 0.73594402D 02
 SMA 0.10423670D 06  ECC 0.93659133D 00  INC 0.28767109D 02  LAN 0.22985461D 03  APF 0.30243082D 03  RCA 0.66095109D 04
  C3-0.38240197D 01 THET 0.0              APOG 0.20186389D 06  MAN 0.36000000D 03 PERH 0.93033203D 02 TPER 0.0

 EARTH CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X-0.60267703D 04     Y 0.47207734D 03     Z-0.26722306D 04    DX-0.20406789D 01    DY-0.10238251D 02    DZ 0.27937168D 01
   R 0.66095109D 04  DEC-0.23847320D 02    RA 0.17552116D 03     V 0.10806989D 02  PTH 0.71412335D-06    AZ 0.73582150D 02
 SMA 0.10423669D 06  ECC 0.93659132D 00  INC 0.28677591D 02  LAN 0.22943659D 03  APF 0.30259687D 03  RCA 0.66095109D 04
  C3-0.38240202D 01 THET-0.16675650D-05 APOG 0.20186387D 06  MAN 0.36000000D 03 PERH 0.93033184D 02 TPER-0.22988878D-04

EARTH FIXED LATITUDE(DEG)-0.23966001D 02   LONGITUDE(DEG) 0.11157053D 03

NUMBER OF STEPS IS       0.10000000D 01

PROBE ENTERED EARTH PENUMBRA. TIME AND ORBIT ARE GIVEN BELOW
 MARCH 10, 1971, 17HRS, 16MIN, 23.134SEC                                                     JULIAN DATE 2441021.21971221

PROBE ENTERED EARTH UMBRA. TIME AND ORBIT ARE GIVEN BELOW
 MARCH 10, 1971, 17HRS, 16MIN, 17.222SEC                         INCORRECT                   JULIAN DATE 2441021.21964378

PROBE HAS LEFT EARTH PENUMBRA. TIME AND ORBIT ARE GIVEN BELOW
 MARCH 10, 1971, 17HRS, 16MIN, 23.214SEC                                                     JULIAN DATE 2441021.21971313

PROBE HAS LEFT EARTH UMBRA. TIME AND ORBIT ARE GIVEN BELOW
 MARCH 10, 1971, 17HRS, 16MIN, 17.301SEC                                                     JULIAN DATE 2441021.21964469

PROBE ENTERED EARTH PENUMBRA. TIME AND ORBIT ARE GIVEN BELOW
 MARCH 14, 1971, 13HRS,  8MIN, 58.649SEC                                                     JULIAN DATE 2441025.04789030

PROBE ENTERED EARTH UMBRA. TIME AND ORBIT ARE GIVEN BELOW
 MARCH 14, 1971, 13HRS,  9MIN,  3.905SEC                                                     JULIAN DATE 2441025.04796187

PROBE HAS LEFT EARTH UMBRA. TIME AND ORBIT ARE GIVEN BELOW
 MARCH 14, 1971, 13HRS, 29MIN, 14.175SEC                                                     JULIAN DATE 2441025.06198962

PROBE HAS LEFT EARTH PENUMBRA. TIME AND ORBIT ARE GIVEN BELOW
 MARCH 14, 1971, 13HRS, 29MIN, 20.287SEC                                                     JULIAN DATE 2441025.06204037


 MARCH 14, 1971, 17HRS,  5MIN, 59.999SEC                                                     JULIAN DATE 2441025.21250000

 EARTH CENTERED   TRUE EARTH EQUATOR AND EQUINOX OF DATE
   X 0.38553026D 05     Y-0.33618691D 05     Z 0.26438814D 05    DX 0.26991758D 01    DY-0.73081724D 00    DZ 0.13952991D 01
   R 0.58525363D 05  DEC 0.29070716D 02    RA-0.41088079D 02     V 0.31251406D 01  PTH 0.66958050D 02    AZ 0.90108811D 02
 SMA 0.10529762D 06  ECC 0.93576683D 00  INC 0.29070002D 02  LAN 0.22468708D 03  APF 0.30369537D 03  RCA 0.66415671D 04
  C3-0.38550519D 01 THET 0.14650036D 03 APOG 0.20015369D 06  MAN 0.14869521D 02 PERH 0.91912125D 02 TPER 0.15817099D 00

 EARTH CENTERED   CENTRAL BODY MEAN EARTH EQUATOR AND EQUINOX OF 1950
   X 0.38650788D 05     Y-0.33602056D 05     Z 0.26357099D 05    DX 0.26985645D 01    DY-0.74367911D 00    DZ 0.13497172D 01
   R 0.58529363D 05  DEC 0.28982473D 02    RA-0.41318879D 02     V 0.31251406D 01  PTH 0.66958080D 02    AZ 0.90200493D 02
 SMA 0.10539762D 06  ECC 0.93576683D 00  INC 0.28983106D 02  LAN 0.22826757D 03  APF 0.30386198D 03  RCA 0.66415570D 04
  C3-0.38550519D 01 THET 0.14650036D 03 APOG 0.20015369D 06  MAN 0.14868521D 02 PERH 0.91912124D 02 TPER 0.15817099D 00

EARTH FIXED LATITUDE(DEG) 0.29070716D 02   LONGITUDE(DEG)-0.10925127D 03

NUMBER OF STEPS IS       0.71100000D 03
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