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Technical Memorandum No. 33-204

SPODP – Single Precision Orbit Determination Program

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CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

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ABSTRACT

This Technical Memorandum describes the Single Precision Orbit Determination Program which was developed for operation under the data processing system of the Space Flight Operations Facility. Included are sections containing flow diagrams, load maps, the common storage map, input and output descriptions, subroutine writeups, operating instructions, and check cases. The computational methods employed by the program are described in the subroutine documentation.

I. INTRODUCTION

The Single Precision Orbit Determination Program (SPODP; more commonly expressed as ODP) for the IBM 7094 computer was written to meet the specifications of the Jet Propulsion Laboratory for a reliable and accurate method of tracking and predicting the motion of lunar and interplanetary spacecraft. The uses of the ODP may conveniently be separated into real-time and nonreal-time applications.

Real-time applications:

1. To establish a reliable set of orbital elements for the spacecraft.
2. To provide an acquisition ephemeris for the world-wide network of tracking stations.
3. To assist JPL engineers in evaluating the performance of tracking stations and the quality of tracking data.

Nonreal-time applications:

1. To provide a high-speed computing method necessary for orbit determination and tracking data accuracy studies (pre-mission).
2. To provide a high-speed computing method necessary for a sophisticated orbital analysis based on large numbers of observations (post-mission).

In addition to solving for the six initial conditions of the spacecraft's motion, the ODP has the capability of solving for 14 physical constants and the Earth radius, latitude, and longitude of 15 tracking stations. From this set of 66 parameters, a subset containing from one to twenty is extracted by the user. The ODP obtains solutions for the parameters in this subset.

The ODP, since it must have initial estimates of the parameters, is an orbit improvement program. It differentially connects the estimates by means of an over-determined system of equations, employing a modified least-squares method. This procedure may be briefly outlined as follows:

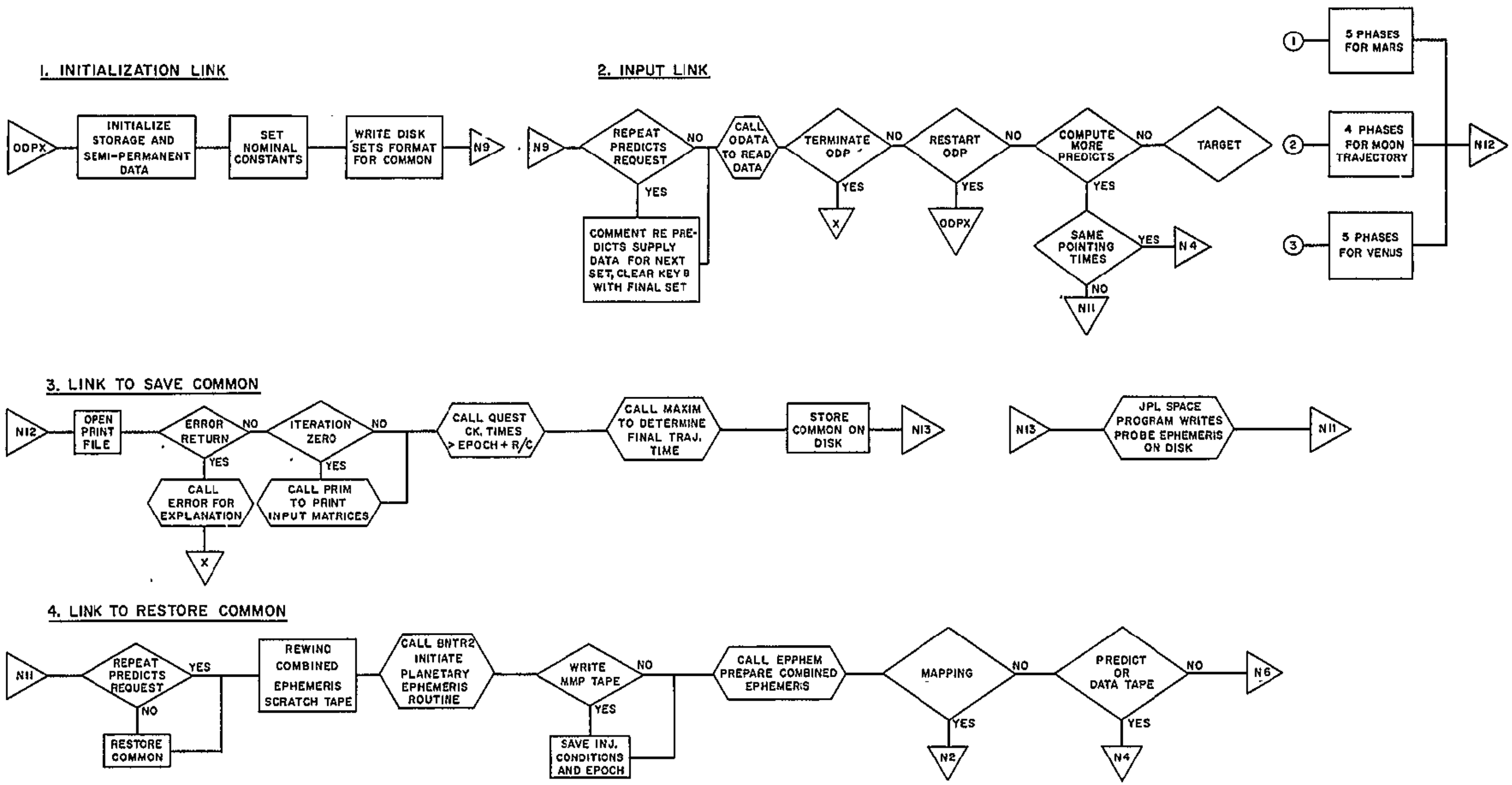
1. Input parameter estimates.
2. Write probe ephemeris file on disk based on orbit estimate.
3. Read i^{th} observation from data file, G_i. This observation may be slant range, range rate, one of four angle types, one of four doppler types, or DSIF ranging.
4. Using probe ephemeris, determine the value of the observation based on orbit estimate, F_i.
5. Obtain the residual $\Delta F_i = G_i - F_i$.
6. Calculate the partials of the observations with respect to the n parameters to be estimated, $\partial F_i/\partial Q_i, \cdots, \partial F_i/\partial Q_n$.
7. Multiply the column matrix of partials by itself to form a matrix J_i^*.
8. Add J_i^* to the accumulated matrix $J^* = J_1^* + J_2^* + \cdots, + J_{i-1}^*$.
9. Multiply the column matrix of partials by the residual to form a column matrix R_i.
10. Add R_i to the accumulated column matrix $R = R_1 + R_2 + \cdots, + R_{i-1}$.
11. Repeat steps 3 through 10 until all observations are processed.
12. Obtain the final J matrix by adding in the <u>a priori</u> uncertainties. $J = J^* + \tilde{\Gamma}^{-1}$.
13. Solve the normal equations $J\Delta Q = R$ for the column matrix of changes to the parameter estimates, ΔQ.
14. Repeat steps 2 through 13 until the procedure converges.

The ODP is written on disk in thirteen links. Each link constitutes a logical section of the overall orbit determination. The linking is accomplished by use of the JPTRAJ source program, which is also used to pass certain information between links.

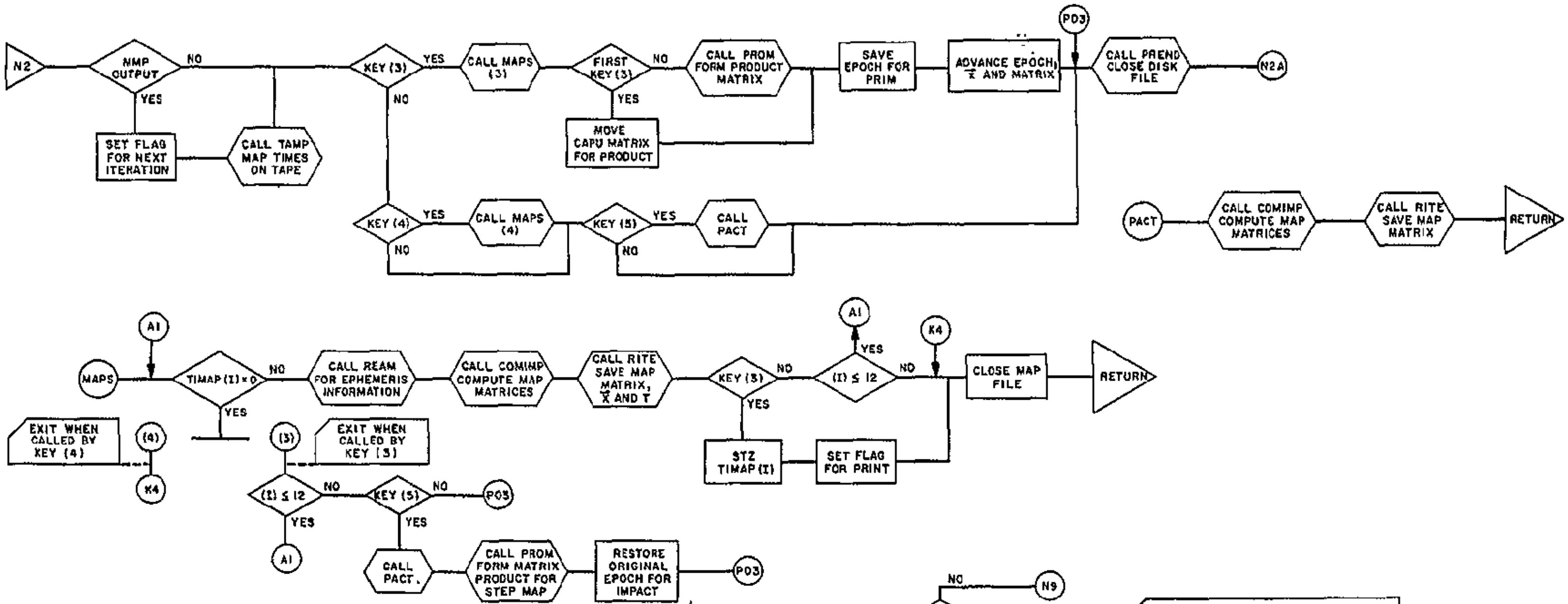
II. FLOW CHARTS

A. LINKS

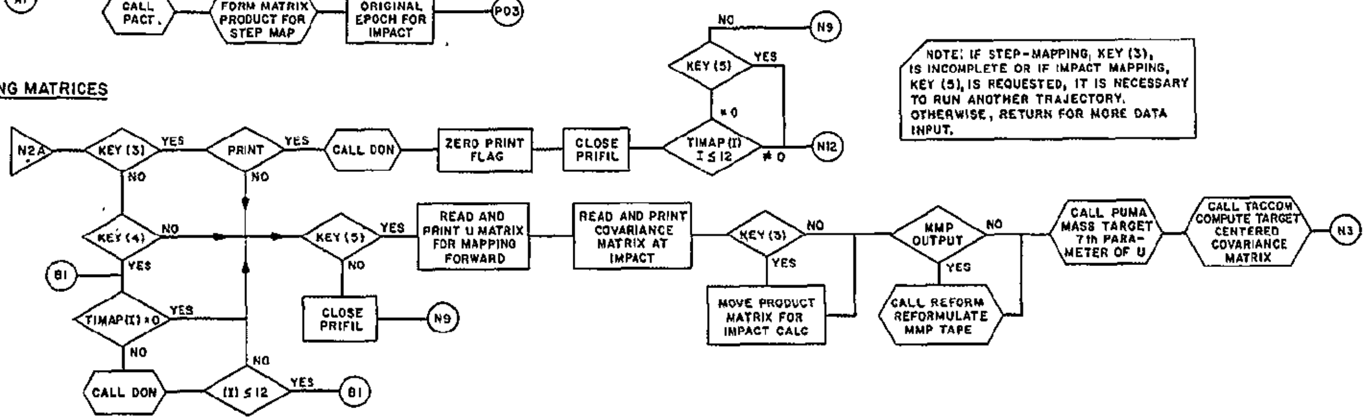
1. Initialization Link
2. Input Link
3. Link to Save COMMON
4. Link to Restore COMMON
5. Link to Compute Mapping Matrices
6. Link to Output Mapping Matrices
7. Link to Compute Closest Approach Parameters
8. Predictions or Data Simulation Link
9. Link to Sort Predictions
10. Data Fitting Link
11. Link to Output Solution
12. Link to Output Residuals and Statistics
13. Link to Output Auxiliary Quantities

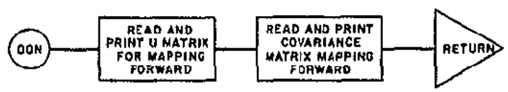

1. INITIALIZATION LINK
ODPX
INITIALIZE STORAGE AND SEMI-PERMANENT DATA
SET NOMINAL CONSTANTS
WRITE DISK SETS FORMAT FOR COMMON
N9
2. INPUT LINK
N9
REPEAT PREDICTS REQUEST
NO
YES
COMMENT RE PREDICTS SUPPLY DATA FOR NEXT SET, CLEAR KEY B WITH FINAL SET
CALL ODATA TO READ DATA
TERMINATE ODP
NO
YES
X
RESTART ODP
NO
YES
ODPX
COMPUTE MORE PREDICTS
NO
YES
SAME POINTING TIMES
YES
N4
NO
N11
TARGET
1
5 PHASES FOR MARS
2
4 PHASES FOR MOON TRAJECTORY
3
5 PHASES FOR VENUS
N12
3. LINK TO SAVE COMMON
N12
OPEN PRINT FILE
ERROR RETURN
NO
YES
CALL ERROR FOR EXPLANATION
X
ITERATION ZERO
NO
YES
CALL PRIM TO PRINT INPUT MATRICES
CALL QUEST CK. TIMES > EPOCH + R/C
CALL MAXIM TO DETERMINE FINAL TRAJ. TIME
STORE COMMON ON DISK
N13
N13
JPL SPACE PROGRAM WRITES PROBE EPHEMERIS ON DISK
N11
4. LINK TO RESTORE COMMON
N11
REPEAT PREDICTS REQUEST
YES
NO
RESTORE COMMON
REWIND COMBINED EPHEMERIS SCRATCH TAPE
CALL BNTR2 INITIATE PLANETARY EPHEMERIS ROUTINE
WRITE MMP TAPE
NO
YES
SAVE INJ. CONDITIONS AND EPOCH
CALL EPPHEM PREPARE COMBINED EPHEMERIS
MAPPING
NO
YES
N2
PREDICT OR DATA TAPE
NO
YES
N4
N6

5. LINK TO COMPUTE MAPPING MATRICES



6. LINK TO OUTPUT MAPPING MATRICES



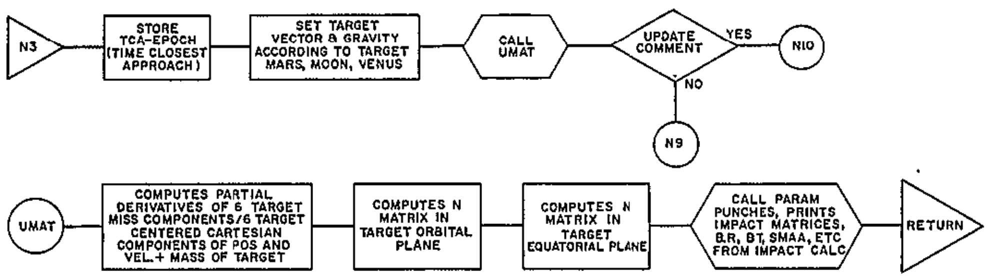


* KEY 3 INDICATES STEP-MAPPING WHERE EPOCH AND INJECTION ARE ADVANCED TO THE TIMES INDICATED

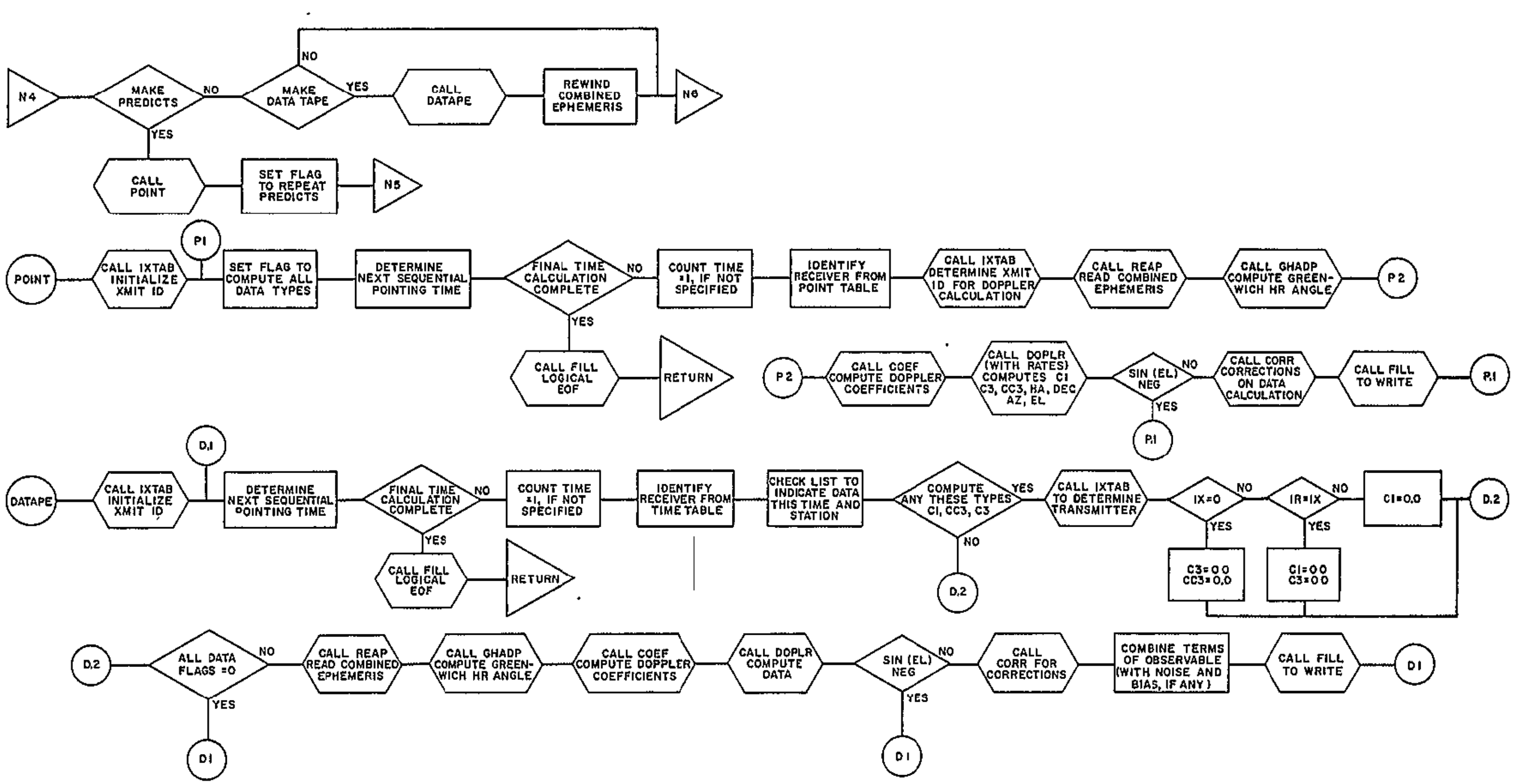
KEY 4 INDICATES MAPPING WHERE CONDITIONS ARE MAPPED AND PRINTED AT TIMES INDICATED

KEY 5 INDICATES IMPACT MAPPING, CLOSEST APPROACH PARAMETERS ARE COMPUTED.

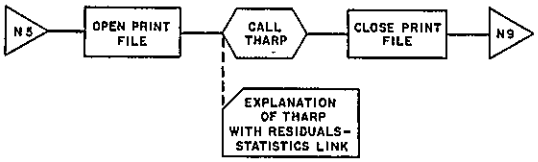
7. LINK TO COMPUTE CLOSEST APPROACH PARAMETERS



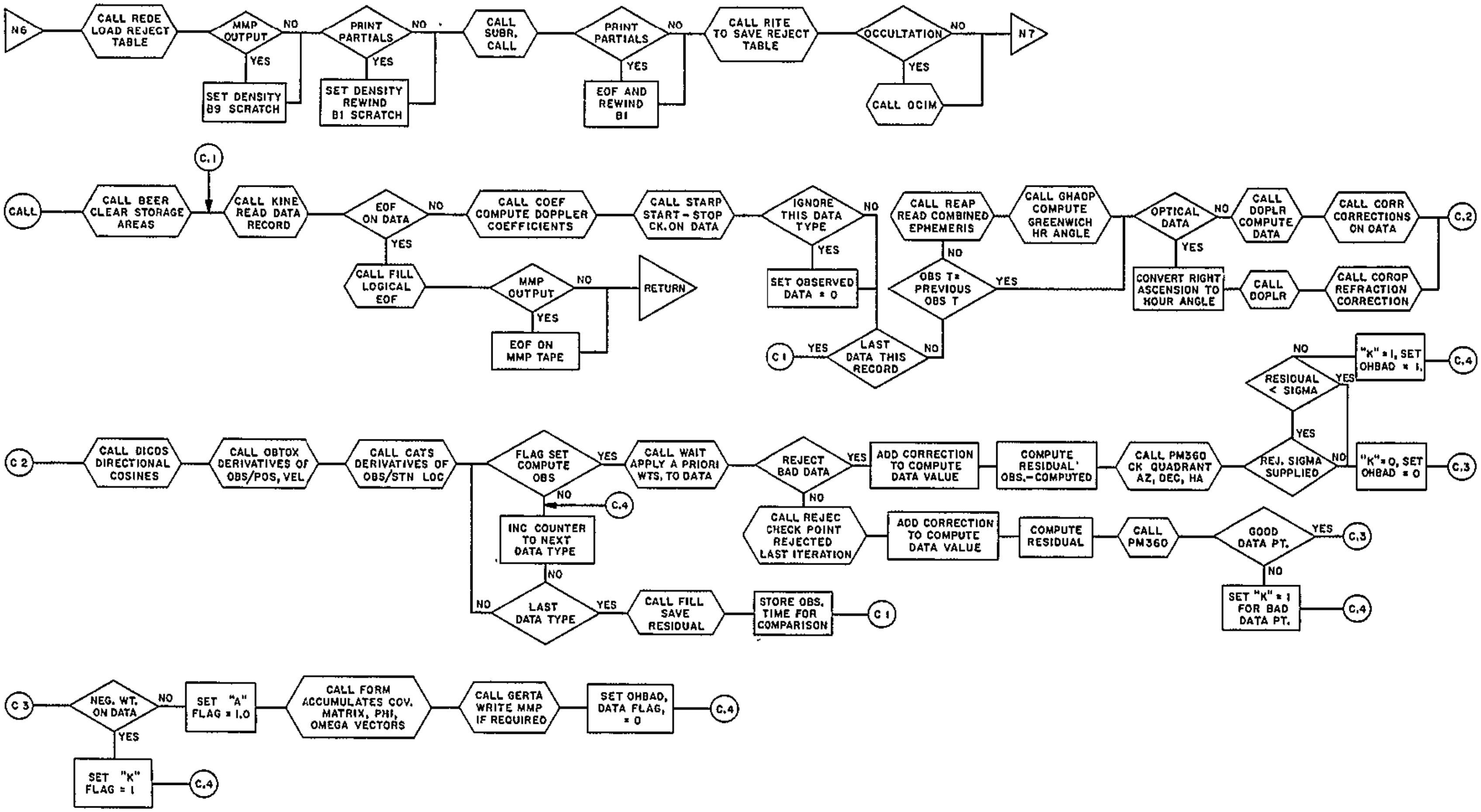
8 PREDICTIONS OR DATA SIMULATION LINK



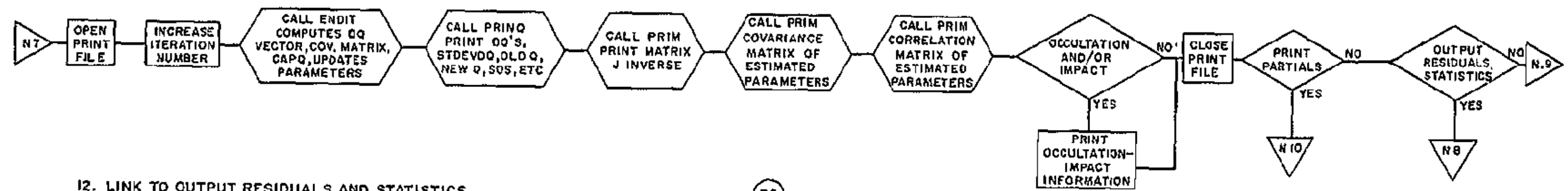
9. LINK TO SORT PREDICTIONS



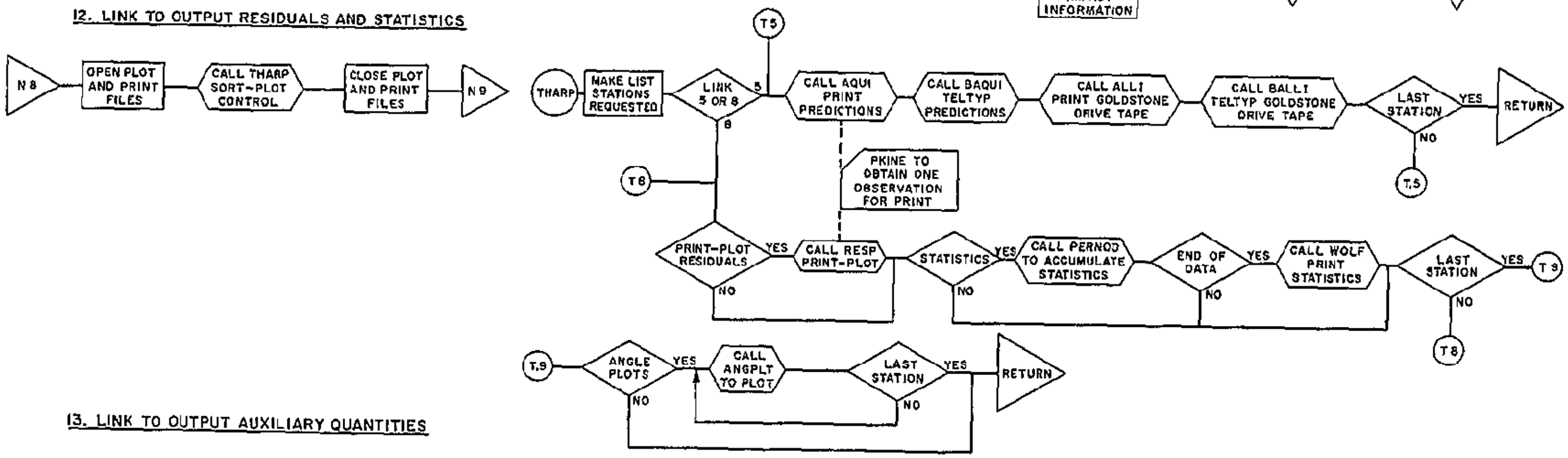
10. DATA FITTING LINK



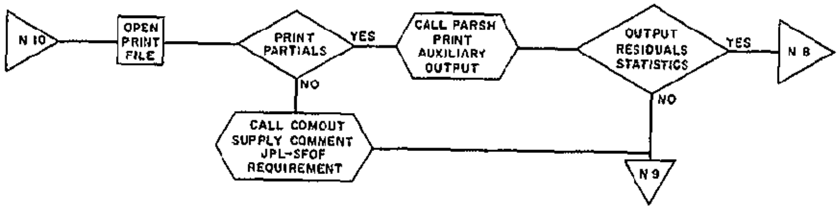
11. LINK TO OUTPUT SOLUTION



12. LINK TO OUTPUT RESIDUALS AND STATISTICS



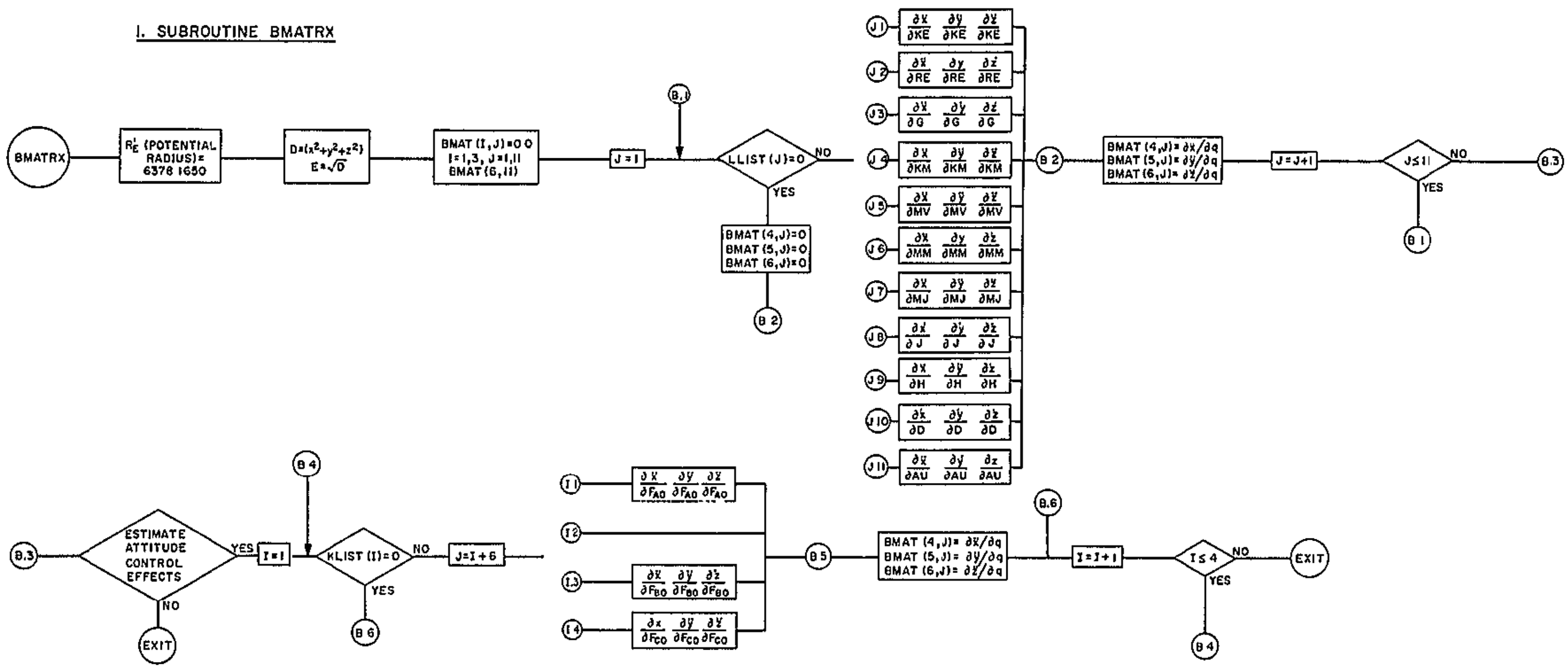
13. LINK TO OUTPUT AUXILIARY QUANTITIES



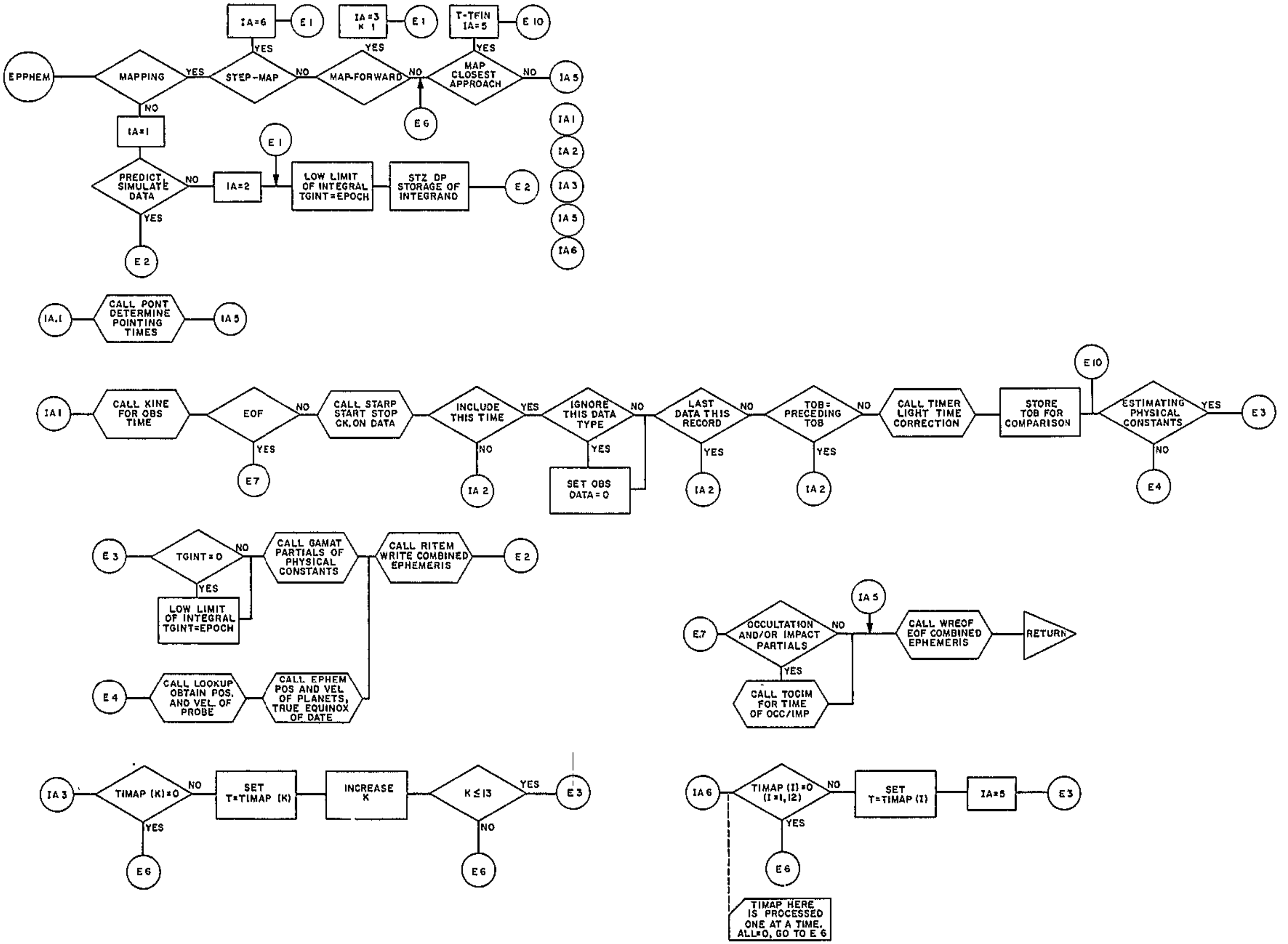
B. SUBROUTINES

1. BMATRX
2. EPPHEM
3. GAMAT
4. LOOKUP
5. MAXIM

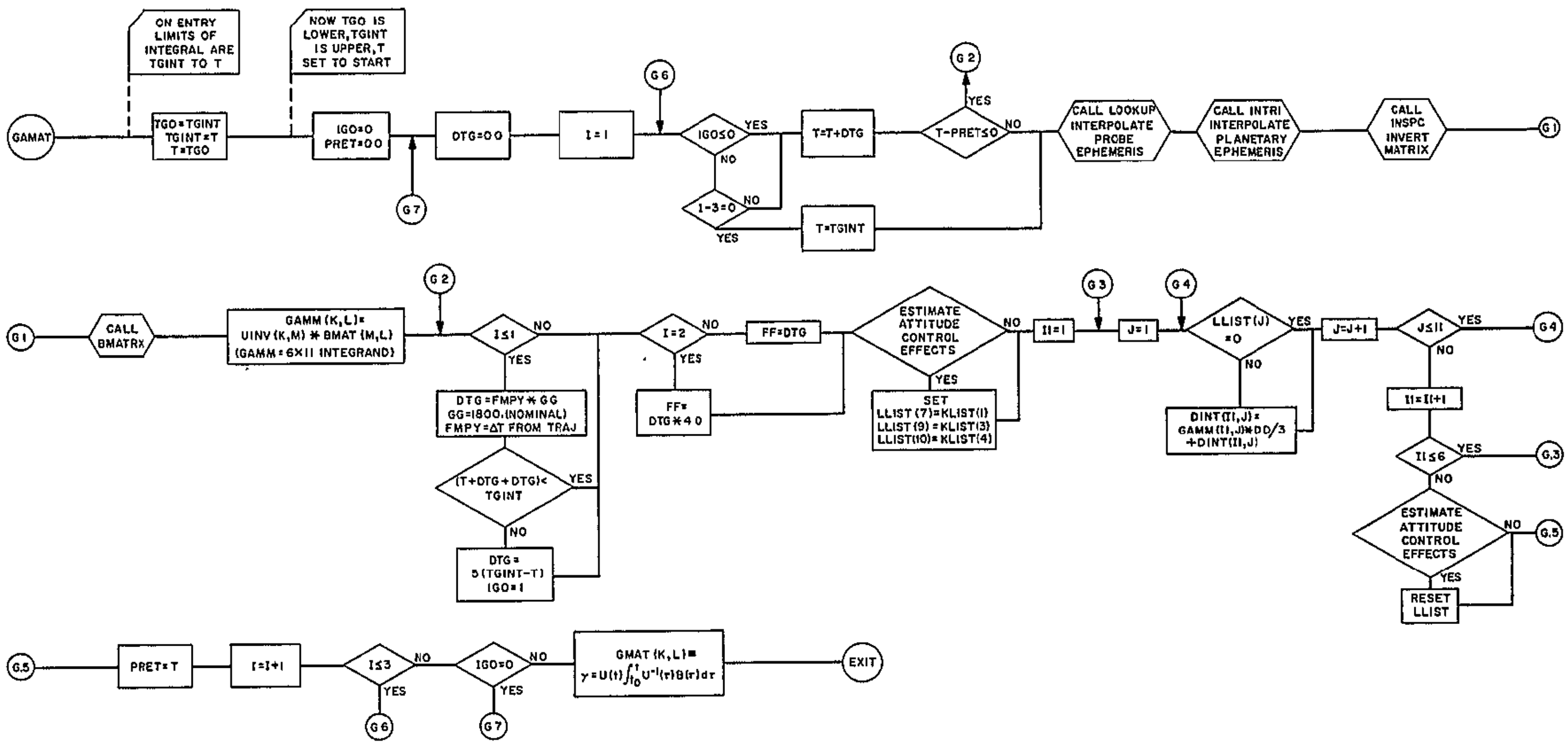
I. SUBROUTINE BMATRX



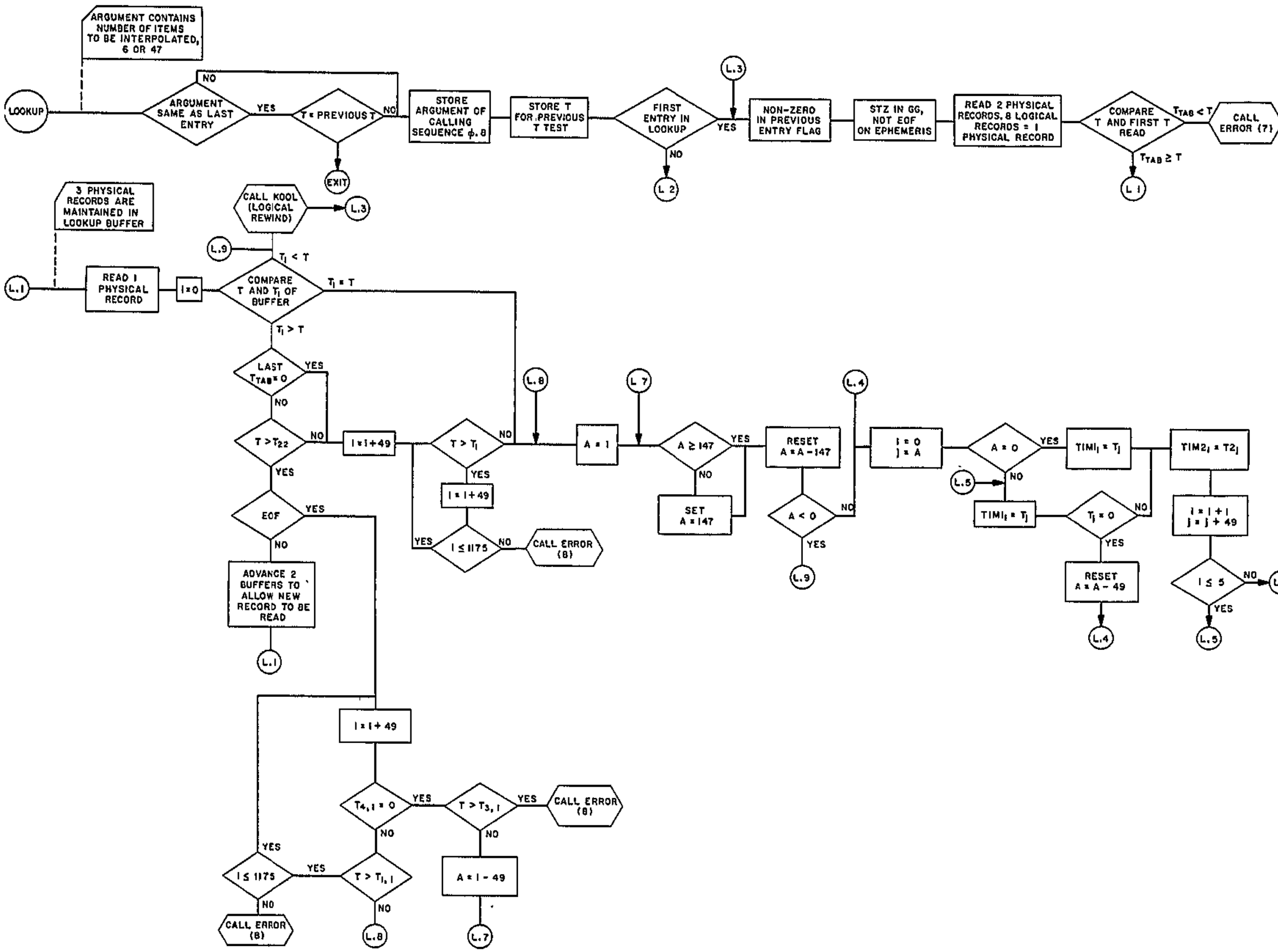
2. SUBROUTINE EPPHEM



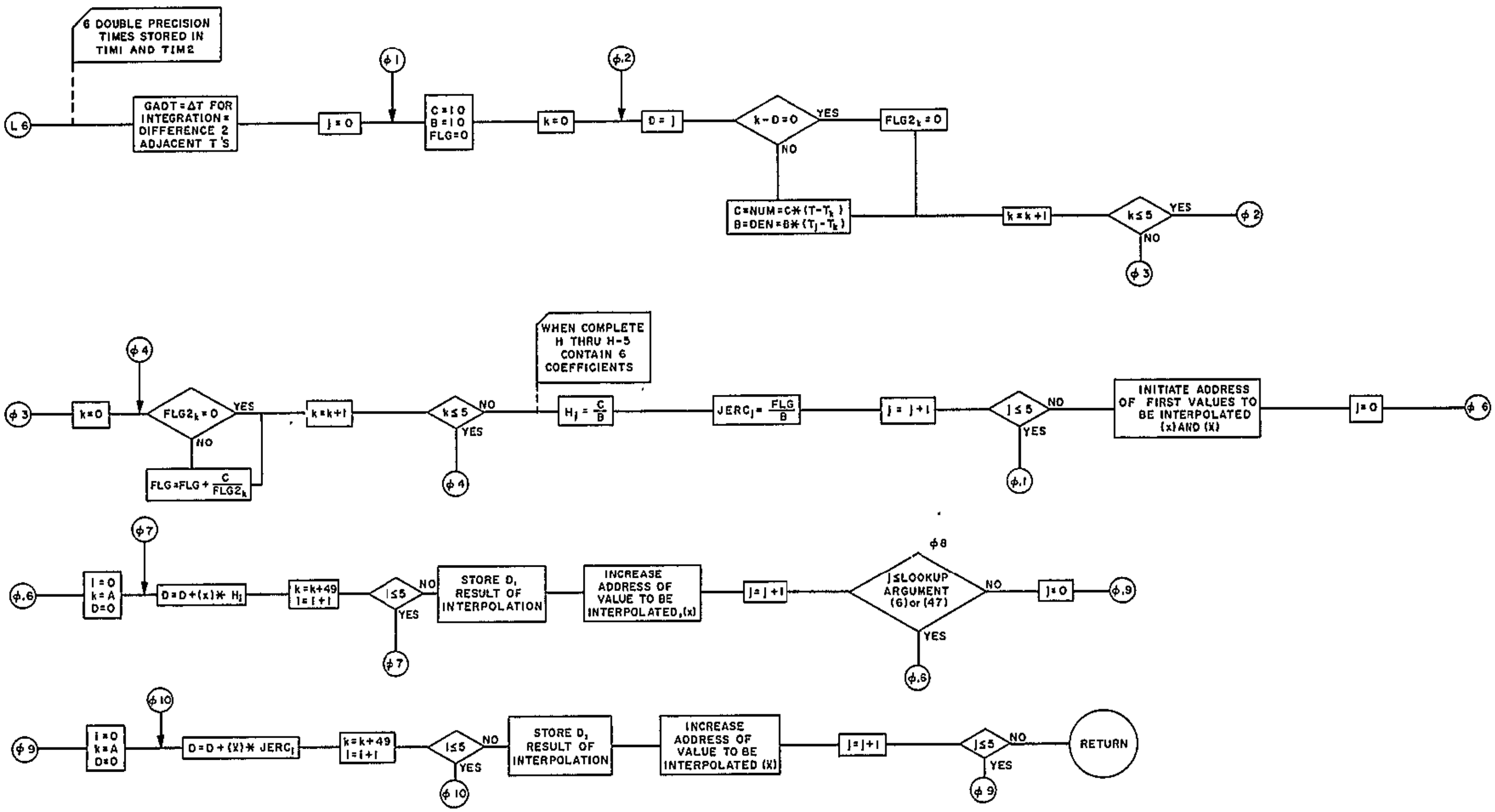
3. SUBROUTINE GAMAT



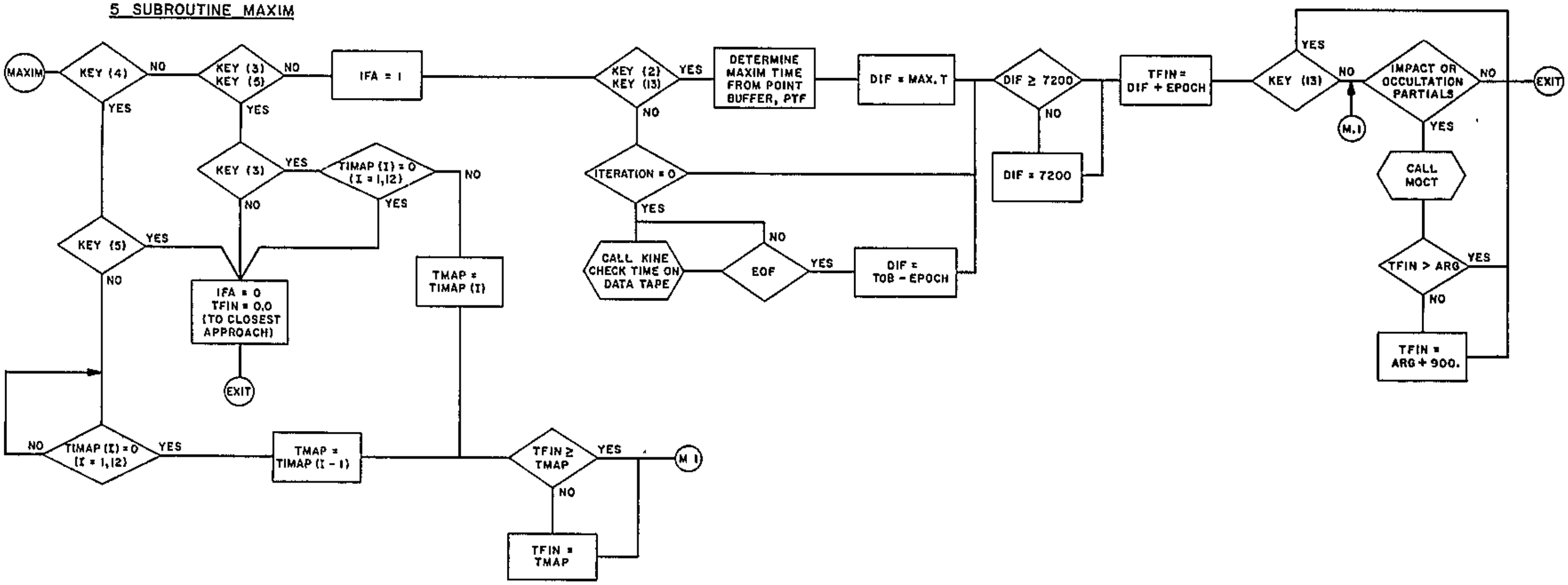
4. SUBROUTINE LOOKUP



4. SUBROUTINE LOOKUP, p 2



5 SUBROUTINE MAXIM



III. PHYSICAL LIMITATIONS

A. DISK AND TAPE USAGE UNDER SFOF

The ODP uses tape unit B6 for the planetary ephemeris (EPHEM) tape and tape unit A4 for the combined ephemeris scratch tape. Disk allocation is restricted to the 2800 record block named JPLODP.

B. DEBUGGING FACILITIES

Snaps may be inserted in links ODPX, LA2A, LA3, LA5, LA7, LA8, LA10, and LA12, as these links contain subroutine PROUT.

Octal correctors may be inserted in any link through the JPTRAJ source deck.

IV. INPUT AND STORAGE ALLOCATION

Primary input to the ODP is a deck of control and data cards, which are described in detail in Section IV. A. These cards contain the parameter estimates, the desired options, and all variables which are not a function of each observation. Subroutine CARDS is used for card input.

Also input to the ODP is a file on disk containing the tracking data, and a planetary ephemeris tape. The data file is written on disk by the Orbit Data Generator Program, ODG, while the ephemeris tape is the standard JPL EPHEM system tape. The system routine DCP is used for disk reading and subroutine TAPIO is used for reading the planetary ephemeris tape.

A. CARD INPUT

```
        EPOCH                                                          101

*               EPOCH ASSOCIATED WITH THE TRAJECTORY, WHERE
M               YY=  LAST TWO DIGITS OF THE YEAR
*               MM=  MONTH OF THE YEAR
*                0=  ZERO
*               DD=  DAYS
*               HH=  HOURS
*               NN=  MINUTES
*               SS=  SECONDS
*               FFF= MILLISECONDS

YYMMODDHH,NNSSFFF


        GEOCENTRIC POSITION AND VELOCITY AT EPOCH                      102

*       SYMBOLS ALLOWED
X,Y,Z,DX,DY,DZ


        INPUT OTHER-OPTIONS AND CONSTANTS                              103

* SYMBOL ALLOWED              EXPLANATION AND/OR NOMINAL

KE                            K(EARTH) (398603.2KM3/SEC2)
RE                            EARTH RADIUS (6378.3149KM)
KM                            K(MOON)
MV                            MASS RATIO VENUS (2.4471118E-6)
MM                            MASS RATIO MARS (3.2383420E-7)
MJ                            MASS RATIO JUPITER (9.5475420E-4)
J                             COEF. SECOND HARMONIC (1.62345E-3)
H                             COEF. THIRD HARMONIC (-.575E-5)
D                             COEF. FOURTH HARMONIC (.7875E-5)
AJ                            ASTRONOMICAL UNIT (1.49599E8KM)
C                             VELOCITY OF LIGHT (299792.5KM/SEC)
RI(I)                         STATION RANGE
LA(I)                         STATION LATITUDE (GEOCENTRIC)
LO(I)                         STATION LONGITUDE
*               RI(1)=6372.2599  LA(1)=-35.066620  LO(1)=243.20507
*               RI(2)=6372.0341  LA(2)=35.20807    LO(2)=243.15082
*               RI(3)=6371.6686  LA(3)=-35.219630  LO(3)=148.98028
*               RI(4)=6372.6040  LA(4)=-31.211875  LO(4)=136.88727
*               RI(5)=6375.4980  LA(5)=-25.739277  LO(5)=27.685181
*               RI(6)=6376.3091  LA(6)=17.0355     LO(6)=298.2072
*               RI(7)=6377.8013  LA(7)=-7.8991     LO(7)=345.5876
*               RI(8)=6376.1150  LA(8)=18.064939   LO(8)=292.91122
*               RI(9)=6375.6810  LA(9)=-25.7904    LO(9)=28.3580
*               RI(10)=6374.05   LA(10)=-24.75336  LO(10)=113.71605
*               RI(11)=6372.05   LA(11)=32.1709    LO(11)=295.3465
*               RI(12)=6371.6586 LA(12)=-35.21963  LO(12)=148.98028
*               RI(13)=6370.0868 LA(13)=40.23800   LO(13)=355.7505
*               RI(14)=6375.9450 LA(14)=18.823066  LO(14)=204.31472
*               RI(15)=6380.1990 LA(15)=10.668     LO(15)=0.0



NSDISP(I)                     NORTH-SOUTH DISPLACEMENT, DEG
EWDISP(I)                     EAST-WEST DISPLACEMENT, DEG
INDEX(I)                      INDEX OF REFRACTION (340.0)
DRIFT                         TRANSPONDER DRIFT, CPS/SEC
STEP                          INITIAL TRAJECTORY STEP SIZE, SEC
ENERGY                        POWERED FLIGHT ENERGY
DTBURN                        POWERED FLIGHT DURATION
MOTOR                         MOTOR COUNT
JETON                         JETON FOR A.C.
JETOFF                        JETOFF FOR A.C.
PREDID                        IDENTIFICATION FOR PREDICTS
READ ORBIT FROM DISK          ORBIT STORED ON DISK IN LINK 6
READ MATRIX FROM DISK         MATRIX STORED ON DISK IN LINK 6
SOLAR PRESSURE OFF
LIGHT TIME OFF
REFRACTION AND VERTICAL OFF
MSP OUTPUT
PHI VECTOR OUTPUT
UPDATE COMENT                 TO WRITE DISK FOR M/C AND SPACE
DJT                           E.T.-U.T., SEC (35.)
FUELWT                        WEIGHT OF FUEL, LB.
RTFUEL                        FLOW RATE, LB/SEC
THRUST                        THRUST, LB
BRNMU                         BIAS ANGLE, DEG
RSTOP                         TARGET RADIUS, KM (MARS,3400.0)
*                                                (MOON,1738.09)
*                                                (VENUS,6200.0)
RAND                          INPUT FOR RANDOM NUMBER, OCTAL (1)
RMAX                          MAXIMUM SLANT RANGE FOR DATA, DEG
ELMIN                         MINIMUM ELEVATION ANGLE FOR DATA, DEG
DATA SIGMA OUTPUT             RESIDUAL PRINT REPLACED BY
*                             STANDARD DEVIATIONS
REM CONSTRAINT                RE IS DETERMINED BY THE RELATION
*                             RE/M= CUBE ROOT (86.315745(KE+KM))
*                             KE AND KM PARITALS ARE CONSISTENT
*                             WITH THE CONSTRAINT
RADOPT                        RADIATION PRESSURE OPTION  (1.031E8)

FLRES                         NON-ZERO, RESIDUALS IN FLOATING PT.

PUNMAT                        PUNCH MATRIX, N
                 1 INPUT J MATRIX OF ESTIMATED PARAMETERS
                 2 INPUT COVARIANCE MATRIX OF CONSIDERED PARAMETERS
                 3 J INVERSE
                 4 COVARIANCE MATRIX OF ESTIMATED PARAMETERS
                 5 CORRELATION MATRIX OF ESTIMATED PARAMETERS
                 6 COVARIANCE MATRIX AT IMPACT
                 7 (ALREADY PUNCHED)
                 8 J MATRIX
                 9 INPUT COVARIANCE MATRIX OF ESTIMATED PARAMETERS
                10 CORRELATIONS BASED ON J MATRIX
                11 U PRODUCT MATRIX

*                TO CHANGE AREA, MASS, GAMMA B OF SPACECRAFT
ARMARS                        (11.12)
MSMARS                        (259.00)
GBMARS                        (.096)
ARMOON                        (2.789)
MSMOON                        (340.20)
```

```
GMMOON                       (0.0)
ARVEN                        (3.83)
MSVEN                        (198.22)
GMVEN                        (.383)

*               THE FOLLOWING ARE DOPPLER COEFFICIENTS AND
*               FREQUENCIES WHICH ARE A FUNCTION OF THE
*               BAND. NOMINALLY, STATIONS 1,2, AND 3 ARE
*               S BAND, 4 AND 5 ARE L-S BAND.

*                            L-BAND     L-S BAND    S BAND

TFREQ  TRANSPONDER FREQ      960.0E6    20.00E6     20.00E6
XFREQ  TRANSMITTER FREQ      29.66E6    2290.0E6    2290.0E6

DOP1(1)         (C1)         930.15E6   9.375E6     1.0E6
DOP1(2)         (C1)         .96875     .3125       1.0
DOP1(3)         (CC3)        .1E6       9.375E6     1.0E6
DOP1(4)         (CC3)        32.359559561 32.57918552 104.25339367
DOP1(5)         (C3)         930.15     9.375E6     1.0E6
DOP1(6)         (C3)         31.348314605 32.57918552 104.25339367

DOP2(I)         SAME AS ABOVE FOR STATION 2
DOP3(I)         SAME AS ABOVE FOR STATION 3
DOP4(I)         SAME AS ABOVE FOR STATION 4
DOP5(I)         SAME AS ABOVE FOR STATION 5

INFRQ  GROUND STATION INJECTION FREQUENCY, CPS (23.6279142E6)
SYNFRQ GROUND STATION SYNTHESIZER FREQUENCY, CPS (22.04209265E6)

L      FOLLOWED BY STATION ID TO ALTER STATION BAND
S      FOLLOWED BY STATION ID TO ALTER STATION BAND
LS     FOLLOWED BY STATION ID TO ALTER STATION BAND


       ESTIMATE THESE PARAMETERS                                    (04

       CONSIDER THESE PARAMETERS                                    (05

*               THESE CARDS ARE FOLLOWED BY LISTS OF PARAMETER NAMES
                WHICH TELL THE ODP TO ESTIMATE (CONSIDER) THE
*               CORRESPONDING PARAMETER.  NO NUMERIC DATA REQUIRED.
*               LIST OF PARAMETER NAMES WHICH CAN BE ESTIMATED
*               (CONSIDERED).
*       SYMBOLS ALLOWED

X,Y,Z,DX,DY,DZ,KE,RE,G,KM,MV,MM,MJ,J,H,D,AU,C,RI(I),LA(I),LO(I)
*               OR
X,Y,Z,DX,DY,DZ,KE,RE,G,KM,MV,MM,FA,J,FB,FC,AU,C,RI(I),LA(I),LO(I)


       REJECTION SIGMAS                                             (06

*               THE ABOVE-CARD IS FOLLOWED BY DATA INDICATING WHICH OF
*               THE OBSERVABLES ARE TO BE CHECKED FOR POSSIBLE REJECTION
*               OF BAD POINTS.  IF A SYMBOL IS ACCOMPANIED BY A NUMERICAL
*               VALUE THE OBSERVATION WILL BE REJECTED IF THE ABSOLUTE
*               VALUE OF THE RESIDUAL EXCEEDS THE INPUT VALUE.
*       SYMBOLS ALLOWED




                R(I),DR(I),EL(I),AZ(I),DEC(I),HA(I),C1(I),CC3(I),
                C3(I),DI(I),RU(I)


                INVERSE COVARIANCE MATRIX OF ESTIMATED PARAMETERS     (07
                COVARIANCE MATRIX OF ESTIMATED PARAMETERS             (10
                COVARIANCE MATRIX OF CONSIDERED PARAMETERS            (11

*               PROVISION IS MADE TO ENTER ONE OF THREE
*               MATRICES IN ONE OF THREE WAYS

*               TO ENTER THE DIAGONAL TERM OF THE MATRIX
DIAG=

*               TO ENTER THE MATRIX BY ROW
R01=
*              .(CONTINUE ON FOLLOWING CARD, IF NECESSARY)
R02=
R03=

*               TO ENTER WITH NO SYMBOLS SUPPLY A
*               FORTRAN TYPE ARRAY FOR A 20X20 MATRIX


       DELETE THESE DATA TYPES                                      (13

*               SYMBOLS ALLOWED AS IN (06 ABOVE


       STATISTICS AND RESIDUALS FOR THESE DATA TYPES                (14

*               DESIGNATION OF AT LEAST ONE DATA TYPE PER
*               STATION IS NECESSARY FOR THE CALCULATION OF
*               STATISTICS. INCLUDE ALL DATA TYPES FOR WHICH
*               STATISTICS AND RESIDUALS ARE DESIRED. THE
*               VERTICAL PLOTTING SCALE CAN BE DEFINED AS
*               R(I)=10., THE HORIZONTAL SCALE CAN BE DEFINED
*               AS NHR=1.5. THIS LATTER IS NOMINALLY 1. HOUR
*               A MAXIMUM OF 8 DATA TYPES PER STATION MAY BE
*               REQUESTED.
*               SYMBOLS ALLOWED AS FOLLOWS

                R(I),DR(I),EL(I),AZ(I),DEC(I),HA(I),C1(I),CC3(I)
                C3(I),DI(I),RU(I),NHR


       NOMINAL VALUES CORRESPONDING TO COVARIANCE MATRIX            (15

*               IF A COVARIANCE MATRIX FOR THE ESTIMATED PARAMETERS
*               OR ITS INVERSE IS ENTERED THE VALUES OF THE
*               ESTIMATED PARAMETERS ASSOCIATED WITH MATRIX MAY
*               ALSO BE ENTERED. THESE VALUES FOLLOW THIS CONTROL
*               CARD AND MUST BE IN THE SAME ORDER AS THE
*               PARAMETERS IN THE MATRIX.
*               IF NOMINAL VALUES FOR THE PARAMETERS ARE NOT
*               ENTERED THE PROGRAM WILL SET THE NOMINAL
*               VALUES TO THE INITIAL ESTIMATE OF THE PARAMETERS.
*               NO SYMBOLS ARE ALLOWED.
```

```
        WEIGHTS BY DATA TYPE AND STATION                              (16

•               NOMINALLY THE ODP COMPUTES THE WEIGHT FOR EACH DATA
•               TYPE FROM INFORMATION THE ODG  PUTS ON THE TRACKING
•               DATA FILE.  THE OPERATOR CAN OVERRIDE THIS FEATURE BY
•               FOLLOWING THE ABOVE CARD WITH WEIGHTS (SIGMA RATHER
•               THAN SIGMA SQUARED) FOR ANY OR ALL OF THE DATA TYPES.
•               WEIGHTS MUST BE SPECIFIED IN THIS MANNER WHEN FITTING
•               AN ODP-SIMULATED DATA FILE.
•               THE USER MAY ALSO INPUT OCTAL WEIGHT CODES, E.G.,
•               CC3(2)=314333/8
•               SYMBOLS ALLOWED

                R(I),DR(I),EL(I),AZ(I),DEC(I),HA(I),C1(I),CC3(I)
                C3(I),DI(I),RU(I)


        POINTING TIMES, SAMPLE RATE, COUNT TIMES                      (17

•               AS THE NAME SUGGESTS, DATA FOLLOWING THIS CONTROL
•               CARD DEFINES THE AMOUNT OF OUTPUT OBTAINED WHEN THE
•               PROGRAM IS PREPARING A DATA FILE OR COMPUTING POINT-
•               ING PREDICTIONS.  A SYMBOLIC NAME IS ASSOCIATED WITH
•               EACH OF THE 15 POSSIBLE TRACKING STATIONS, AND EACH
•               NAME MAY BE FOLLOWED BY ONE, TWO, OR THREE GROUPS OF
•               DATA.  THE FORMAT OF EACH GROUP IS AS FOLLOWS, FIRST
•               TIME, LAST TIME, SAMPLE RATE, COUNT TIME.  POINTING
•               PREDICTIONS (OR A DATA FILE) WILL BE GENERATED FOR
•               THE INDICATED STATION IF THE PROBE IS ABOVE STATION'S
•               HORIZON ANYTIME BETWEEN THE FIRST TIME AND THE LAST
•               TIME.  THE INTERVAL BETWEEN PREDICTIONS IS DEFINED BY
•               THE SAMPLE RATE AND ANY REQUESTED DOPPLER CAL-
•               CULATIONS WILL BE BASED ON THE INDICATED COUNT TIME.
•               THE TWO TIMES ARE GREENWICH TIME AND ARE COMPOSED OF
•               TWO WORDS EACH, AS DEFINED ELSEWHERE.  THE SAMPLE
•               RATE AND THE COUNT TIME ARE GIVEN AS FLOATING POINT
•               SECONDS.  AS AN EXAMPLE,
JETMTS=620702103,0,620702104,0,10.,5.,620702107,0,620702109,0,30.,30.
•               INSTRUCTS THE PROGRAM TO GENERATE POINTING PREDICTS FOR
•               THE MTS EVERY 10 SEC BETWEEN 030000Z AND 040000Z ON JULY
•               21, 1962 WITH A DOPPLER AVERAGING TIME OF 5 SEC.
•               POINTING PREDICTIONS WILL ALSO BE GENERATED FOR
•               070000Z TO 090000Z ON THE SAME DAY BUT WITH A 30-SEC
•               SAMPLE RATE AND 30-SEC DOPPLER AVERAGING TIME.
•               SYMBOLS ALLOWED

                JETGLV,JETGL2,CANJET,DONJET,JOBJET,ANTGUA,ASCENS,PUERTO,
                PRETOR,JODREL,TOCAPE,BAHAMA,SANSAL,HAWAII,TRINID


        DATA FILE SIGMA                                               (21

•               IF A DATA FILE IS BEING PREPARED THE DATA TYPES
•               FOLLOWING THIS CARD WILL BE ENTERED ON THE ODP DATA
•               FILE.  IF NUMERIC FIELD APPEARS WITH A SYMBOL THE
•               PROGRAM WILL PUT A NORMALLY DISTRIBUTED RANDOM NUMBER
•               WITH MEAN ZERO ON THE CALCULATED VALUE OF THE DATA


---------------------------------------------------------   -  --------

•               TYPE.  THE ONE-SIGMA VALUE OF THE DISTRIBUTION IS SET
•               TO THE VALUE FOLLOWING THE SYMBOLIC NAME OF THE DATA
•               TYPE.  IF NO NUMERIC FIELD FOLLOWS A SYMBOL THE
•               ONE-SIGMA VALUE OF THE DISTRIBUTION IS SET TO ZERO.
•               SYMBOLS ALLOWED

                R(I),DR(I),EL(I),AZ(I),DEC(I),HA(I),C1(I),CC3(I)
                C3(I),DI(I),RU(I)


        DATA FILE BIAS                                                (22

•               SAME AS THE ABOVE EXCEPT THAT THE NUMERIC FIELD
•               INDICATES THE CONSTANT THE ODP WILL ADD TO THE
•               CALCULATED VALUE OF EACH DATA TYPE.


        PAGE HEADING                                                  (23

•               UP TO 11 BCD WORDS MAY FOLLOW THIS CONTROL CARD.
•               THE COMMENT MUST BE INITIATED WITH A LEFT PARENT-
•               THESIS AND CLOSED WITH RIGHT PARENTHESIS.  THE
•               COMMENT WILL BE PRINTED ABOVE VARIOUS OUTPUT GROUPS.


        MAP COVARIANCE MATRIX TO                                      (24

•               THIS CARD IS FOLLOWED BY UP TO 12 MONOTONICALLY IN-
•               CREASING GREENWICH TIMES.  THE COVARIANCE MATRIX
•               FROM THE PREVIOUS ITERATION WILL BE MAPPED FORWARD TO
•               THESE TIMES.
•               SYMBOLS ALLOWED, NONE


        TRANSMITTER ID TABLE                                          (26

•               THE DATA FOLLOWING THIS CONTROL CARD DEFINES THE
•               TRANSMITTING STATION AS A FUNCTION OF TIME.  THIS
•               DATA IS REQUIRED ONLY WHEN GENERATING DATA FILES OR
•               POINTING PREDICTIONS SINCE THE ODG  IDENTIFIES THE
•               TRANSMITTER FOR EACH TIME POINT APPEARING ON THE ODP
•               DATA FILE.  THE FORMAT OF THE TRANSMITTER TABLE IS,
•               IX(1),FREQ(1),TIME(1),IX(2),FREQ(2).....IX IS A FIXED
•               NUMBER, FREQ IS A FLOATING POINT NUMBER.
•               THE INTERPRETATION OF THE TABLE IS AS FOLLOWS,
•               STATION IX(I) IS TRANSMITTING WITH A FREQ(I) UNTIL
•               TIME(I),THEN STATION IX(I+1) IS TRANSMITTING WITH A
•               FREQ(I+1) UNTIL TIME(I+1),ETC. IX(I)=0 IS INTERPRETED
•               AS  THE TRANSPONDER AND TIME(I)=0 IS INTERPRETED AS
•               INFINITY.  WHEN GENERATING A DATA FILE ONLY ONE TYPE
•               OF DOPPLER WILL BE ALLOWED PER TIME POINT.  IF ALL
•               THREE DOPPLER TYPES ARE REQUESTED FOR A RECEIVING
•               STATION (SEE DATA FILE SIGMA CONTROL CARDS), THE
•               FOLLOWING RULES DETERMINE THE DOPPLER TYPE THAT WILL
•               APPEAR.

•               1. IF ELEVATION AT STATION IX IS NEGATIVE SET IX=0
•               2. IF IX=0 OMIT CC3 AND C3
•               3.IF IX+IR+0 OMIT C1 AND CC3 WHERE IR IS THE RECEIVER
```

```
*              4. IF IX=IR OMIT C1 AND C3
*              SYMBOLS ALLOWED, NONE

*              RESTRICTIONS
*              A MAXIMUM OF 134 IX-TIME PAIRS IS ALLOWED


       OFFLINE CONTROL                                            127

*              WHEN ANY OPTION OTHER THAN A DATA FITTING
*              ITERATION IS DESIRED KEY CONTROL IS NECESSARY
*              THIS CONTROL CARD MUST BE PRESENT EACH ITERATION TO SET
*              THE KEYS FOR THAT ITERATION.  THE CARDS FOR EACH
*              ITERATION MUST BE FOLLOWED BY AN END DATA CARD.
* SYMBOL ALLOWED             OPTION                 NEED CONTROL CARDS
KEY(2)           SIMULATE ODG  DATA FILE            1,2,17,21
KEY(3)           STEP-MAP, FORWARDS EPOCH           1,2,24
KEY(4)           MAP FORWARD TO INPUT TIME          1,2,24
KEY(5)           MAP TO ENCOUNTER                   1,2
KEY(6)           REJECT BAD POINTS                  1,2,6
KEY(8)           REPEAT PREDICTS
KEY(12)          PREDICTS PREPARED FOR TELETYPE 1,2,17,KEY(13)
                 TRANSMISSION
KEY(13)          POINTING PREDICTIONS               1,2,17
KEY(14)          STATISTICS                         1,2,14
KEY(15)          ANGLE PLOTS                        1,2
KEY(16)          RESIDUALS                          1,2,14
KEY(17)          TIME PLOTS                         1,2,14
TERMINATE JOB    MUST BE INCLUDED TO END JOB
RESTART ODP      TO INITIALIZE ODP FROM BEGINNING


       BURN START TIME                                            130

*              THIS TIME, IN THE USUAL GREENWICH FORMAT, DENOTES THE
*              BEGINNING OF THE POWERED FLIGHT.


       SPHERICAL INJECTION CONDITIONS                             131

*              IN PLACE OF CARTESIAN INJECTION CONDITIONS, THE USER
*              MAY INPUT SPHERICAL CONDITIONS UNDER THIS CONTROL
*              CARD.  THE SPHERICAL CONDITIONS ARE TRANSFORMED TO
*              CARTESIAN CONDITIONS AT INPUT TIME.
*              SYMBOLS ALLOWED

               RAD,LAT,LONG,VE,ELE,AZE


       OCCULTATION TIMES                                          132

*              THIS DATA TYPE IS INPUT BY CARD, RATHER THAN THROUGH
*              THE ODG.   TWO OCCULTATION TIMES APPEAR ON EACH CARD.
*              THE FORMAT IS OCCX=T1,T2,WEIGHT,REJECTION SIGMA, WHERE
*              T1 AND T2 ARE GREENWICH TIMES IN THE USUAL FORMAT.
*              RESTRICTIONS
*              ONLY STATIONS 1 THROUGH 5 PERMITTED.  IF ONLY ONE
*              TIME IS TO BE USED THEN T2 MUST BE 0,0.
*              SYMBOLS ALLOWED



               OCC1,OCC2,OCC3,OCC4,OCC5


       IMPACT TIMES                                               133

*              SAME AS OCCULTATION TIME, EXCEPT THAT ONLY ONE TIME
*              PER STATION IS INPUT.  THE FORMAT IS IMPX=T,WEIGHT,
*              REJECTION SIGMA.
*              RESTRICTIONS
*              ONLY STATIONS 1 THROUGH 5 PERMITTED
*              SYMBOLS ALLOWED

               IMP1,IMP2,IMP3,IMP4,IMP5


       START AND STOP TIMES                                       134

*              THIS INPUT PERMITS THE FITTING OF DATA ONLY DURING THE
*              INTERVAL BETWEEN T-START AND T-STOP.  UP TO THREE PAIRS
*              MAY BE INPUT IN THE USUAL GMT FORMAT.


       END DATA                                                   100

*              THIS CARD MUST TERMINATE EACH SET OF CONTROL DATA
*              READ BY THE ODP.
```

B. LOAD MAPS AND COMMON STORAGE MAP

```
ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY.
    (DFMP)      (DFAD)      (DFSB)      READB       WRITEB

   THE NAME OF THIS PROGRAM IS *LA2          2/22/65

  ENTRY NAME   ENTRY ADD.   TRANSFER VECTORS   LOAD ADD.    OCTAL LENGTH    DECIMAL LENGTH    COMMON BREAK
  - **PCB       22302          EPOX            22300          00011           00009
                               COMAP
    COKAP       22322          OFFSYS          22311          00273           00187
                               TYPRYT
                               TAMP
                               PROM
                               FLOT
                               REAM
                               COMIMP
                               DCP
                               FLAK
    PRAMS       22606          DCP             22604          00043           00035
                               FLAK
    COMIMP      22660          PRAMS           22647          01357           00751             47055
                               (DFMP)
                               (DFAD)
                               MAMUL
                               (DFSB)
    ADD         24226          *NONE*          24226          00050           00040
    ARSIN       24306          *NONE*          24276          00144           00100             77152
    ARCOS       24302
    QARSIN      24300
    QARCOS      24276
    ERRARS      24427
    ERRARC      24433
    ARTAN       24442          *NONE*          24442          00103           00067             77152
    DAYS        24550          FIX             24545          00041           00033
                               FLOAT
                               ADD
    ERROR       24606          *NONE*          24606          00011           00009
    FIXT        24620          FIXTT           24617          00007           00007
    FIXTT       24626          *NONE*          24626          00312           00202             50031
    FLOT        24734
    FIX         25115
    FLOAT       25121
    DAYE        25131
    FLAT        25142          ERROR           25140          00102           00066
    FLAPR       25170          TYPRYT
    FLAK        25177
    INSPC       25246          *NONE*          25242          00310           00200             50031
    MAMUL       25556          *NONE*          25552          00130           00088             77461
    PNUT        25710          SIN             25702          00336           00222             50001
                               COS
    PROM        26244          *NONE*          26240          00156           00110             77461
    QUIZ        26416          *NONE*          26416          00003           00003
    REAP        26424          READB           26421          02543           01379
    REAM        26424          FLAT
                               ERROR
    ROT         31170          *NONE*          31164          00266           00182             50031
    OFFSYS      31452          *NONE*          31452          00010           00008
    ENDSYS      31453
    FINSYS      31454
    SCHAIN      31455
    PGSTRT      31456
    PGSTOP      31457
    DCP         31460
    TYPRYT      31461
    SIN         31462          *NONE*          31462          00242           00162
    COS         31465
    QSIN        31471
    QCOS        31473
    TAMP        31736          WRITEB          31724          00126           00086
    EPOX        32032          FLAT
    (DFAD)      32052          *NONE*          32052          00121           00081             77776
    (DFSB)      32072
    (DFMP)      32112
    (DFDP)      32140
    READD       32174          (IOU)           32173          00365           00245
    READB       32176
    WRITED      32201
    WRITEB      32203
    BSREC       32412
    BSFILE      32415
    REWIND      32420
    UNLOAD      32423
    ENDFIL      32426
    SETLOW      32404
    SETHI       32407
    (UNIT)      32555
    TAPEIO      32555
    (IOU)       32563          *NONE*          32560          00030           00024

  *LA2    * JUST LOADED.

   UNUSED CORE LIES FROM   32610   THROUGH   47055,  LEAVING   14246  OCTAL OR   05310   DECIMAL LOCATIONS.
```

ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,

DEFINE	ATTACH	OPEN	CLOSE	(DFMP)	(DFAD)	SQRT	FGDOUT	PROUT	WRITED
ENDFIL	REWIND	READB	(DFSB)						

THE NAME OF THIS PROGRAM IS 'LAZA ' 2/22/65

ENTRY NAME	ENTRY ADD.	TRANSFER VECTORS	LOAD ADD.	OCTAL LENGTH	DECIMAL LENGTH	COMMON BREAK
**PCB	22302	MAPOUT	22301	00007	00007	
MAPOUT	22324	DEFINE	22310	01564	00884	
		ATTACH				
		OPEN				
		TYPRYT				
		OFFSYS				
		CLOSE				
		DCP				
		FLAK				
		PRAN				
		PRIN				
		REFORM				
		TACCON				
AAT	24102	(DFMP)	24074	00116	00078	77461
		(DFAD)				
BIBCD	24237	'NONE'	24212	00055	00045	
DIAGO	24274	SQRT	24267	00105	00069	50031
ERROR	24374	'NONE'	24374	00011	00009	
FIXT	24406	FIXTT	24405	00007	00007	
FIXTT	24414	'NONE'	24414	00312	00202	50031
FLOT	24522					
FIX	24703					
FLOAT	24707					
DAYE	24717					
FLAT	24730	ERROR	24726	00101	00065	
FLAPR	24756	TYPRYT				
FLAK	24765					
NORMAY	25036	SQRT	25027	00251	00169	77461
PRIN	25321	FGDOUT	25300	01423	00787	50001
PRAN	25310	PROUT				
		BIBCD				
		FLAPR				
		PRIME				
		NORMAY				
		PRIT				
		DIAGO				
PRIME	26730	WRITEB	26723	00177	00127	
REFORM	26751	FLAT				
		ENDFIL				
		REWIND				
		READB				
PRIT	27124	FIXT	27122	00036	00030	
		BIBCD				
QUIZ	27160	'NONE'	27160	00002	00002	
OFFSYS	27162	'NONE'	27162	00010	00008	
ENDSYS	27163					
FINSYS	27164					
SCHAIN	27165					
PGSTRT	27166					
PGSTOP	27167					
DCP	27170					
TYPRYT	27171					
TAPR	27172	'NONE'	27172	00002	00002	
SCALE	27200	'NONE'	27174	00043	00035	77461
TACCON	27250	SCALE	27237	01617	00911	47055
		(DFMP)				
		(DFAD)				
		AAT				
		(DFSB)				
(DFAD)	31056	'NONE'	31056	00120	00080	77776
(DFSB)	31076					
(DFMP)	31116					
(DFDP)	31144					
SQRT	31176	'NONE'	31176	00054	00044	77773
PROUT	31266	OUTUS	31252	03031	01561	
FGDOUT	32532	ACTIND				
PRCNV	31633	BFLG				
PROUT2	31404	RESTKA				
PROUT3	31417	REQIND				
TSXA	33441	WRITE				
TSXB	34231	PRCON				
		RGGSAV				
		RGGSTR				
		CKIND				
		CKACT				
READD	34304	(IOU)	34303	00365	00245	
READB	34306					
WRITED	34311					
WRITEB	34313					
BSREC	34522					
BSFILE	34525					
REWIND	34530					
UNLOAD	34533					
ENDFIL	34536					
SETLOW	34514					
SETHI	34517					
(UNIT)	34665					
TAPEIO	34665					
(IOU)	34673	'NONE'	34670	00030	00024	
OUTUS	34722	RGGSAV	34720	02320	01232	
BFLG	35556	RGGSTR				
ENDOUT	35307					
CKIND	37151					
CKACT	37214					
REQIND	37150					
ACTIND	37147					
RESTKA	37145					
PL1CON	37230					
PL2CON	37231					
PL3CON	37232					
PRCON	37233					
RGGSAV	37240	'NONE'	37240	00133	00091	
RGGSTR	37322					
IOCS	37374	CLOCK	37373	04335	02269	
DEFINE	37375					
JOIN	37400					
ATTACH	37403					
CLOSE	37406					
OPEN	37411					
READ	37414					
WRITE	37417					
COPY	37422					
REW	37425					
WEF	37430					
BSR	37433					
BSF	37436					

```
   STASH       37441
   CLOCK       43733          'NONE'     43730          00106          00070
   MINUTE      43730
   XMIN        43730

  'LA2A   ' JUST LOADED.

    UNUSED CORE LIES FROM   44036   THROUGH   47055,  LEAVING   03020  OCTAL OR   01552   DECIMAL LOCATIONS.


ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,
     DEFINE      ATTACH      OPEN        CLOSE       WRITEB      ENDFIL      FGDOUT      SQRT        PROUT       LOG

    THE NAME OF THIS PROGRAM IS 'LA3    '       2/22/65

  ENTRY NAME   ENTRY ADD.   TRANSFER VECTORS   LOAD ADD.    OCTAL LENGTH    DECIMAL LENGTH    COMMON BREAK
    **PCB        22302           OZ            22301          00006           00006
   OZ            22316           DEFINE        22307          01367           00759
                                 ATTACH
                                 OPEN
                                 TYPRYT
                                 OFFSYS
                                 UMAT
                                 CLOSE
   ARTAN         23676           'NONE'        23676          00103           00067            77152
   FIXT          24002           FIXTT         24001          00007           00007
   FIXTT         24010           'NONE'        24010          00312           00202            50031
   FLOT          24116
   FIX           24277
   FLOAT         24303
   DAYE          24313
   ERROR         24322           'NONE'        24322          00012           00010
   FLAT          24336           ERROR         24334          00101           00065
   FLAPR         24364           TYPRYT
   FLAK          24373
   GERPU         24440           WRITEB        24435          00100           00064
                                 FLAT
                                 ENDFIL
   ORBEQ         24544           ARTAN         24535          00167           00119            77461
                                 COS
                                 SIN
   PARAM         24732           FGDOUT        24724          01320           00720
                                 SQRT
                                 FIXT
                                 PROUT
                                 INORM
                                 ORBEQ
   QUIZ          26244           'NONE'        26244          00002           00002
   OFFSYS        26246           'NONE'        26246          00010           00008
   ENDSYS        26247
   FINSYS        26250
   SCHAIN        26251
   PGSTRT        26252
   PGSTOP        26253
   DCP           26254
   TYPRYT        26255
   SIN           26256           'NONE'        26256          00243           00163
   COS           26261
   QSIN          26265
   QCOS          26267
   INORM         26526           SQRT          26521          00252           00170            77461
   UMAT          27004           SQRT          26773          03221           01681            77461
                                 LOG
                                 GERPU
                                 ARTAN
                                 PARAM
   LOG           32222           'NONE'        32214          00066           00054            77774
   LOG10         32214
   SQRT          32302           'NONE'        32302          00054           00044            77773
   PROUT         32372           OUTUS         32356          03031           01561
   FGDOUT        33636           ACTIND
   PRCNV         32537           BFLG
   PROUT2        32510           RESTKA
   PROUT3        32523           REQIND
   TSXA          34545           WRITE
   TSXB          35335           PRCON
                                 RGGSAV
                                 RGGSTR
                                 CKIND
                                 CKACT
   READD         35410           (IOU)         35407          00365           00245
   READB         35412
   WRITED        35415
   WRITEB        35417
   BSREC         35626
   BSFILE        35631
   REWIND        35634
   UNLOAD        35637
   ENDFIL        35642
   SETLOW        35620
   SETHI         35623
   (UNIT)        35771
   TAPEIO        35771
   (IOU)         35777           'NONE'        35774          00030           00024
   OUTUS         36026           RGGSAV        36024          02320           01232
   BFLG          36662           RGGSTR
   ENDOUT        36413
   CKIND         40255
  /CKACT         40320
   REQIND        40254
   ACTIND        40253
   RESTKA        40251
   PL1CON        40334
   PL2CON        40335
   PL3CON        40336
   PRCON         40337
   RGGSAV        40344           'NONE'        40344          00133           00091
   RGGSTR        40426
   IOCS          40500           CLOCK         40477          04335           02269
   DEFINE        40501
   JOIN          40504
   ATTACH        40507
```

```
CLOSE        40512
OPEN         40515
READ         40520
WRITE        40523
COPY         40526
REW          40531
WEF          40534
BSR          40537
BSF          40542
STASH        40545
CLOCK        45037              *NONE*      45034          00106            00070
MINUTE       45034
XMIN         45034

*LA3    * JUST LOADED.

 UNUSED CORE LIES FROM   45142   THROUGH   50031,  LEAVING   02670  OCTAL OR   01464   DECIMAL LOCATIONS.
```

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ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,
     REWIND     (DFAD)     (DFMP)     (DFSB)      SQRT        DMOD        (DFOP)      EXP(3       READB

      THE NAME OF THIS PROGRAM IS *LA4    *      2/22/65

   ENTRY NAME   ENTRY ADD.   TRANSFER VECTORS   LOAD ADD.     OCTAL LENGTH    DECIMAL LENGTH    COMMON BREAK
    **PCB        22302          PREDA           22301          00007            00007
   PREDA         22314          TYPRYT          22310          00050            00040
                                POINT
                                DATAPE
                                REWIND
   ABDD          22360          *NONE*          22360          00030            00024
   ADD           22410          *NONE*          22410          00050            00040
   ARSIN         22470          *NONE*          22460          00144            00100             77152
   ARCOS         22464
   QARSIN        22462
   QARCOS        22460
   ERRARS        22611
   ERRARC        22615
   ARTAN         22624          *NONE*          22624          00102            00066             77152
   COEF          22736          (DFAD)          22726          00770            00504             50031
                                (DFMP)
                                (DFSB)
                                QUIZ
   CORR          23724          SQRT            23716          00274            00188             47675
                                SIN
   DATAPE        24230          IXTAB           24212          00447            00295             50031
                                OFFSYS
                                (DFAD)
                                REAP
                                GHADP
                                COEF
                                DOPLR
                                CORR
                                NO2F
                                FILT
   DAYS          24664          FIX             24661          00041            00033
                                FLOAT
                                ADD
   DNAME         24735          *NONE*          24722          00014            00012
   STPREG        24736          *NONE*          24736          00003            00003
   ODOFF         24737
   SPHX          24740
   DOPLR         24756          RATES           24741          01313            00715             50031
                                DMOD
                                VEC
                                ABDD
                                (DFMP)
                                (DFAD)
                                SQRT
                                ARTAN
                                ARSIN
   ERROR         26254          *NONE*          26254          00012            00010
   FILL          26270          RITE            26266          00277            00191             50001
   FILT          26552          PISA
   FIXT          26566          FIXTT           26565          00007            00007
   FIXTT         26574          *NONE*          26574          00312            00202             50031
   FLOT          26702
   FIX           27063
   FLOAT         27067
   DAYE          27077
   FLAT          27110          ERROR           27106          00102            00066
   FLAPR         27136          TYPRYT
   FLAK          27145
   GHADP         27222          (DFOP)          27210          00320            00208             50031
                                (DFSB)
                                (DFMP)
                                (DFAD)
                                DMOD
                                COS
   IXTAB         27530          *NONE*          27530          00066            00054
   NO2F          27616          *NONE*          27616          00050            00040
   PNUT          27674          SIN             27666          00337            00223             50001
                                COS
   POINT         30242          IXTAB           30225          00305            00197             50031
                                COEF
                                OFFSYS
                                (DFAD)
                                REAP
                                GHADP
                                DOPLR
                                CORR
                                FILL
   QUIZ          30532          *NONE*          30532          00003            00003
   RATES         30546          COS             30535          00662            00434             50031
                                SIN
                                SQRT
                                ARSIN
                                EXP(3
   REAP          31422          READB           31417          02543            01379
   REAM          31422          FLAT
                                ERROR
   ROT           34166          *NONE*          34162          00266            00182             50031
   OFFSYS        34450          *NONE*          34450          00010            00008
   ENDSYS        34451
   FINSYS        34452
   SCHAIN        34453
```

```
PGSTRT      34454
PGSTOP      34455
DCP         34456
TYPRYT      34457
SIN         34460      'NONE'     34460      00242      00162
COS         34463
QSIN        34467
QCOS        34471
VEC         34722      'NONE'     34722      00017      00015      50031
REDE        34742      DCP        34741      00421      00273
RITE        34745
PISA        35171
EXP(3       35362      'NONE'     35362      00136      00094      77773
(DFAD)      35520      'NONE'     35520      00120      00080      77776
(DFSB)      35540
(DFMP)      35560
(DFDP)      35606
DMOD        35640      'NONE'     35640      00060      00048      77776
SQRT        35720      'NONE'     35720      00055      00045      77773
READD       35776      (IOU)      35775      00365      00245
READB       36000
WRITED      36003
WRITEB      36005
BSREC       36214
BSFILE      36217
REWIND      36222
UNLOAD      36225
ENDFIL      36230
SETLOW      36206
SETHI       36211
(UNIT)      36357
TAPEIO      36357
(IOU)       36365      'NONE'     36362      00030      00024

'LA4    ' JUST LOADED.

 UNUSED CORE LIES FROM   36412   THROUGH   47675,  LEAVING   11264  OCTAL OR   04788   DECIMAL LOCATIONS.
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```
ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,
   DEFINE     ATTACH     OPEN      CLOSE      PROUT      FGDOUT     TELTYP     ENDOUT

    THE NAME OF THIS PROGRAM IS 'LA5    '      2/22/65

 ENTRY NAME   ENTRY ADD.  TRANSFER VECTORS  LOAD ADD.     OCTAL LENGTH    DECIMAL LENGTH    COMMON BREAK
   **PCB.  ,    22302           SORT        22301          00006           00006
   SORT         22316           TYPRYT      22307          02055           01069
                                DEFINE
                                ATTACH
                                OPEN
                                THARP
                                CLOSE
                                FLAK
   BIBCD        24411           'NONE'      24364          00054           00044
   DNAME        24453           'NONE'      24440          00014           00012
   AQUI         24512           PROUT       24454          00741           00481            50031
   ALLI         24472           FGDOUT
   BALLI        24467           PKINE
   BAQUI        24464           FIXT
                                DAYE
                                TELTYP
                                ENDOUT
                                BIBCD
   PERNOD       25421           KINE        25415          00007           00007
   WOLF         25420
   RESP         25416
   ANGPLT       25417
   MONRED       25424           'NONE'      25424          00002           00002
   ERROR        25426           'NONE'      25426          00012           00010
   FILL         25442           RITE        25440          00277           00191            50001
   FILT         25724           PISA
   FIXT         25740           FIXTT       25737          00007           00007
   FIXTT        25746           'NONE'      25746          00312           00202            50031
   FLOT         26054
   FIX          26235
   FLOAT        26241
   DAYE         26251
   FLAT         26262           ERROR       26260          00102           00066
   FLAPR        26310           TYPRYT
   FLAK         26317
   KINE         26364           REDE        26362          00216           00142            50001
                                ERROR
   QUIZ         26600           'NONE'      26600          00002           00002
   OFFSYS       26602           'NONE'      26602          00010           00008
   ENDSYS       26603
   FINSYS       26504
   SCHAIN       26605
   PGSTRT       26606
   PGSTOP       26607
   DCP          26610
   TYPRYT       26511
   THARP        26526           OFFSYS      26612          00573           00379
   PKINE        26733           KINE
                                AQUI
                                ALLI
                                BAQUI
                                BALLI
                                PERNOD
                                RESP
                                WOLF
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                                ANGPLT
                                BIBCD
                                TYPRYT
 REDE        27406              DCP          27405         00422          00274
 RITE        27411
 PISA        27635
 TELTYP      30036              PROUT2       30027         01101          00577
 SCCTTY      30253              ACTIND
                                PROUT3
                                TSXA
                                RGGSAV
                                RGGSTR
                                TSXB
 PROUT       31144              OUTUS        31130         03032          01562
 FGDOUT      32410              ACTIND
 PRCNV       31311              BFLG
 PROUT2      31262              RESTKA
 PROUT3      31275              REQIND
 TSXA        33317              WRITE
 TSXB        34107              PRCON
                                RGGSAV
                                RGGSTR
                                CKIND
                                CKACT
 OUTUS       34164              RGGSAV       34162         02320          01232
 BFLG        35020              RGGSTR
 ENDOUT      34551
 CKIND       36413
 CKACT       36456
 REQIND      36412
 ACTIND      36411
 RESTKA      36407
 PL1CON      36472
 PL2CON      36473
 PL3CON      36474
 PRCON       36475
 RGGSAV      36502              *NONE*       36502         00133          00091
 RGGSTR      36564
 IOCS        36636              CLOCK        36635         04335          02269
 DEFINE      36637
 JOIN        36642
 ATTACH      36645
 CLOSE       36650
 OPEN        36653
 READ        36656
 WRITE       36661
 COPY        36664
 REW         36667
 WEF         36672
 BSR         36675
 BSF         36700
 STASH       36703
 CLOCK       43175              *NONE*       43172         00106          00070
 MINUTE      43172
 XMIN        43172

*LA5   * JUST LOADED.

  UNUSED CORE LIES FROM   43300   THROUGH   50001,  LEAVING   04502  OCTAL OR   02370   DECIMAL LOCATIONS.


ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,
     SETHI      REWIND      ENDFIL      (DFSB)      (DFAD)      (DFMP)      SQRT      EXP(3      DMOD      (DFDP)
     WRITEB     READB

  THE NAME OF THIS PROGRAM IS *LA6    *      2/22/65

 ENTRY NAME   ENTRY ADD.   TRANSFER VECTORS   LOAD ADD.    OCTAL LENGTH    DECIMAL LENGTH    COMMON BREAK
   **PCB       22302           FIT             22301         00006            00006
   FIT         22320           REDE            22307         00735            00477
                               TYPRYT
                               SETHI
                               REWIND
                               CALL
                               ENDFIL
                               RITE
                               OCIM
                               FLAK
   ABDD        23244           *NONE*          23244         00030            00024
   ADD         23274           *NONE*          23274         00050            00040
   ARSIN       23354           *NONE*          23344         00144            00100             77152
   ARCOS       23350
   QARSIN      23346
   QARCOS      23344
   ERRARS      23475
   ERRARC      23501
   ARTAN       23510           *NONE*          23510         00103            00067             77152
   BEER        23614           REJEC           23613         00071            00057             47675
   CALL        23736           BEER            23704         00523            00339             51235
                               KINE
                               COEF
                               STARP
                               (DFSB)
                               REAP
                               GHADP
                               DOPLR
                               COROP
                               CORR
                               DICOS
                               OBTOX
                               CATS
                               OFFSYS
                               WAIT
                               QUIZ
                               REJEC
                               PM360
                               FORM
                               GERTA
                               FILL
                               GREOF
   CATS        24436           VEC             24427         00645            00421             47675
                               ABDD
                               COS
   COEF        25304           (DFAD)          25274         00770            00504             50031
                               (DFMP)
                               (DFSB)
                               QUIZ
   COL         26272           COS             26264         00406            00262             50031
                               SQRT
   COROP       26702           SQRT            26672         00170            00120             50031
                               EXP(3
                               ARTAN
```

		SIN				
CORR	27070	SQRT	27062	00275	00189	47675
		SIN				
DAYS	27362	FIX	27357	00041	00033	
		FLOAT				
		ADD				
DECOD *	27420	*NONE*	* 27420	00040	00032	50031
DICOS	27466	SIN	27460	00173	00123	50031
*		COS				
DOPLR	27670	RATES	27653	01313	00715	50031
		DMOD				
		VEC				
		ABDD				
		(DFMP)				
		(DFAD)				
		SQRT				
		ARTAN				
		ARSIN				
ERROR	31166	*NONE*	31166	00012	00010	
FILL	31202	RITE	31200	00277	00191	50001
FILT	31464	PISA				
FIXT	31500	FIXTT	31477	00007	00007	
FIXTT	31506	*NONE*	31506	00312	00202	50031
FLOT	31614					
FIX	31775					
FLOAT	32001					
DAYE	32011					
FLAT	32022	ERROR	32020	00101	00065	
FLAPR	32050	TYPRYT				
FLAK	32057					
FORM	32132	PARLEY	32121	01066	00566	50031
		(DFMP)				
		(DFAD)				
		(DFDP)				
		SQRT				
GERTA	33212	WRITEB	33207	00215	00141	
GREOF	33332	FLAT				
		ENDFIL				
GHADP	33436	(DFDP)	33424	00321	00209	50031
		(DFSB)				
		(DFMP)				
		(DFAD)				
		DMOD				
		COS				
IMPAR	33752	FORM	33745	00177	00127	50031
INSPC	34150	*NONE*	34144	00310	00200	50031
KINE	34456	REDE	34454	00216	00142	50001
		ERROR				
OBTOX	34676	*NONE*	34672	00275	00189	50031
OCIM	35174	IMPAR	35167	00222	00146	
		OCPAR				
		READB				
		FLAT				
		ERROR				
OCPAR	35416	FORM	35411	00515	00333	50031
PARLEY	36130	WRITEB	36126	00044	00036	
		FLAT				
PM360	36176	*NONE*	36172	00050	00040	50001
PNUT	36250	SIN	36242	00336	00222	50001
		COS				
QUIZ	36600	*NONE*	36600	00003	00003	
RATES	36614	COS	36603	00662	00434	50031
		SIN				
		SQRT				
		ARSIN				
		EXP(3				
REAP	37470	READB	37465	02543	01379	
REAM	37470	FLAT				
		ERROR				
REJEC	42230	*NONE*	42230	00056	00046	46711
RECO	42302					
ROT	42312	*NONE*	42306	00266	00182	50031
OFFSYS	42574	*NONE*	42574	00010	00008	
ENDSYS	42575					
FINSYS	42576					
SCHAIN	42577					
PGSTRT	42600					
PGSTOP	42601					
OCP	42602					
TYPRYT	42603					
SIN	42604	*NONE*	42604	00242	00162	
COS	42607					
QSIN	42613					
QCOS	42615					
STARP	43046	*NONE*	43046	00030	00024	
VEC	43076	*NONE*	43076	00020	00016	50031
WAIT	43130	COL	43116	00346	00230	50031
		DECOD				
		SQRT				
		WOCT				
		COS				
		ERROR				
WOCT	43464	*NONE*	43464	00013	00011	
REDE	43500	OCP	43477	00421	00273	
RITE	43503					
PISA	43727					
EXP(3	44120	*NONE*	44120	00136	00094	77773
(DFAD)	44256	*NONE*	44256	00120	00080	77776
(DFSB)	44276					
(DFMP)	44316					
(DFDP)	44344					
DMOD	44376	*NONE*	44376	00060	00048	77776
SQRT	44456	*NONE*	44456	00055	00045	77773
READD	44534	(IOU)	44533	00365	00245	
READB	44536					
WRITED	44541					
WRITEB	44543					
BSREC	44752					
BSFILE	44755					
REWIND	44760					
UNLOAD	44763					
ENDFIL	44766					
SETLOW	44744					
SETHI	44747					
(UNIT)	45115					
TAPEIO	45115					
(IOU)	45123	*NONE*	45120	00030	00024	

*LA6 * JUST LOADED.

UNUSED CORE LIES FROM 45150 THROUGH 46711. LEAVING 01542 OCTAL OR 00866 DECIMAL LOCATIONS.

ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,

DEFINE	ATTACH	OPEN	CLOSE	FGDOUT	PROUT	SQRT	(DFSB)	(DFMP)	(DFAD)
CLOCK	(DFDP)								

THE NAME OF THIS PROGRAM IS 'LAT ' 2/22/65

ENTRY NAME	ENTRY ADD.	TRANSFER VECTORS	LOAD ADD.	OCTAL LENGTH	DECIMAL LENGTH	COMMON BREAK
**PCB	22302 .	APRIOR	22300	00012	00010	
		PRINT				
PRINT	22330	DEFINE	22312	02514	01356	
		ATTACH				
		OPEN				
		ENDIT				
		RITE				
		OFFSYS				
		PRINO				
		PRIM				
		CLOSE				
		REDE				
		FGDOUT				
		FIXT				
		PROUT				
		FLAK				
BIBCD	25053	*NONE*	25026	00055	00045	
DIAG	25110	SQRT	25103	00106	00070	50031
DIAGO	25216	SQRT	25211	00105	00069	50031
ONAME	25331	*NONE*	25316	00014	00012	
ENDIT	25346	(DFSB)	25332	01474	00828	50031
		(DFMP)				
		(DFAD)				
		PRIM				
		SQRT				
		STPREG				
		REVRT				
		NOUT				
ERROR	27026	*NONE*	27026	00011	00009	
FIXT	27040	FIXTT	27037	00007	00007	
FIXTT	27046	*NONE*	27046	00312	00202	50031
FLOT	27154					
FIX	27335					
FLOAT	27341					
DAYE	27351					
FLAT	27362	ERROR	27360	00101	00065.	
FLAPR	27410	TYPRYT				
FLAK	27417					
NORMAY	27466	SQRT	27461	00251	00169	77461
NOUT	27734	PROUT	27732	00100	00064	
BLEW	27776	TYPRYT				
BUKEY	30032	*NONE*	30032	00040	00032	
OPKEY	30036					
COKEY	30053					
AFKEY	30060					
PRIM	30113	FGDOUT	30072	01424	00788	50001
PRAN	30102	PROUT				
		BIBCD				
		FLAPR				
		PRIME				
		NORMAY				
		PRIT				
		DIAGO				
TAMP	31517	*NONE*	31516	00005	00005	
PRIME	31520					
TAPR	31521					
DIAGO	******					
PRINO	31532	FGDOUT	31523	00435	00285	50031
PRIT	31763	DIAG				
APRIOR	32154	CLOCK				
		PROUT				
		FLAPR				
		FIXT				
		BIBCD				
QUIZ	32160	*NONE*	32160	00002	00002	
REVRT	32170	COKEY	32162	00206	00134	50031
		BLEW				
OFFSYS	32370	*NONE*	32370	00010	00008	
ENDSYS	32371					
FINSYS	32372					
SCHAIN	32373					
PGSTRT	32374					
PGSTOP	32375					
OCP	32376					
TYPRYT	32377					
STPREG	32410	(DFAD)	32400	02055	01069	71757
		(DFDP)				
		DSQRT				
		(DFMP)				
DSQRT	34456	ERROR	34455	00106	00070	77776
REDE	34564	OCP	34563	00421	00273	
RITE	34567					
PISA	35013					
(DFAD)	35204	*NONE*	35204	00120	00080	77776
(DFSB)	35224					
(DFMP)	35244					
(DFDP)	35272					
SQRT	35324	*NONE*	35324	00054	00044	77773
CLOCK	35403	*NONE*	35400	00106	00070	
MINUTE	35400					
XMIN	35400					
PROUT	35522	OUTUS	35506	03032	01562	
FGDOUT	36766	ACTIND				
PRCNV	35667	BFLG				
PROUT2	35640	RESTKA				
PROUT3	35653	REQIND				
TSXA	37675	WAITE				
TSXB	40465	PRCON				
		RGGSAV				
		RGGSTR				
		CKIND				
		CKACT				
OUTUS	40542	RGGSAV	40540	02320	01232	
BFLG	41376	RGGSTR				
ENDOUT	41127					
CKIND	42771					
CKACT	43034					
REQIND	42770					
ACTIND	42767					
RESTKA	42765					
PL1CON	43050					
PL2CON	43051					
PL3CON	43052					
PACON	43053					
RGGSAV	43060	*NONE*	43060	00133	00091	
RGGSTR	43142					
IOCS	43214	CLOCK	43213	04335	02269	
DEFINE	43215					
JOIN	43220					
ATTACH	43223					

```
CLOSE      43226
OPEN       43231
READ       43234
WRITE      43237
COPY       43242
REW        43245
WEF        43250
BSR        43253
BSF        43256
STASH      43261

'LA7    ' JUST LOADED.

  UNUSED CORE LIES FROM    47550   THROUGH    50001,  LEAVING   00232  OCTAL OR    00154   DECIMAL LOCATIONS.



ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,
    DEFINE     ATTACH     OPEN       CLOSE       WEF          WRITE       FGDOUT      PROUT       SQRT

  THE NAME OF THIS PROGRAM IS 'LAB    '       2/22/65

 ENTRY NAME   ENTRY ADD.  TRANSFER VECTORS  LOAD ADD.       OCTAL LENGTH      DECIMAL LENGTH     COMMON BREAK
   **PCB       22302          RESID         22301             00007             00007
  CLOCK        22310          'NONE'        22310             00002             00002
  RESID        22320          DEFINE        22312             01301             00705
                              ATTACH
                              OPEN
                              TYPRYT
                              THARP
                              CLOSE
  ANGPLT       23520          PKINE         23613             00577             00383              51235
                              FIXT
                              BIBCD
                              CXPLOT
                              DIFD
  BIBCD        24437          'NONE'        24412             00054             00044
  CXPLOT       24470          WEF           24466             03320             01744
  XXXFSR       25327          WRITE
  CDC          25675
  PLTONE       24521
  BET          24472
  DIFD         30006          'NONE'        30006             00026             00022
  DNAME        30047          'NONE'        30034             00015             00013
  BALLI        30056          KINE          30051             00007             00007
  BAQUI        30057
  ALLI         30052
  AQUI         30053
  JUDY         30054
  ERROR        30060          'NONE'        30060             00011             00009
  FIXT         30072          FIXTT         30071             00007             00007
  FIXTT        30100          'NONE'        30100             00312             00202              50031
  FLOT         30206
  FIX          30367
  FLOAT        30373
  DAYE         30403
  FLAT         30414          ERROR         30412             00102             00066
  FLAPR        30442          TYPRYT
  FLAK         30451
  KINE         30516          REDE          30514             00215             00141              50001
                              ERROR
  PERNOD       30736          FIXT          30731             00503             00323              51235
  WOLF         31067          FGDOUT
                              PROUT
                              SQRT
                              COLA
  QUIZ         31434          'NONE'        31434             00002             00002
  RESP         31450          CDC           31436             01564             00884              50001
  COLA         32736          FGDOUT
                              CXPLOT
                              PKINE
                              PERNOD
                              FIXT
                              PROUT
                              FLAPR
                              BIBCD
                              ERROR
  OFFSYS       33222          'NONE'        33222             00010             00008
  ENDSYS       33223
  FINSYS       33224
  SCHAIN       33225
  PGSTRT       33226
  PGSTOP       33227
  DCP          33230
  TYPRYT       33231
  STATID       33232          'NONE'        33232             00020             00016
  THARP        33266          OFFSYS        33252             00573             00379
  PKINE        33373          KINE
                              AQUI
                              ALLI
                              BAQUI
                              BALLI
                              PERNOD
                              RESP
                              WOLF
                              ANGPLT
                              BIBCD
                              TYPRYT
  REDE         34046          DCP           34045             00421             00273
  RITE         34051
  PISA         34275
  SQRT         34466          'NONE'        34466             00054             00044              77773
  PROUT        34556          OUTUS         34542             03032             01562
  FGDOUT       36022          ACTIND
  PRCNV        34723          BFLG
  PROUT2       34674          RESTKA
  PROUT3       34707          REQIND
  TSXA         36731          WRITE
  TSXB         37521          PRCON
                              RGGSAV
                              RGGSTR
                              CKIND
                              CKACT
  OUTUS        37576          RGGSAV        37574             02320             01232
  BFLG         40432          RGGSTR
  ENDOUT       40163
  CKIND        42025
  CKACT        42070
  REQIND       42024
  ACTIND       42023
```

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      RESTKA     42021
      PL1CON     42104
      PL2CON     42105
      PL3CON     42106
      PRCON      42107
      RGGSAV     42114           *NONE*       42114          00133            00091
      RGGSTR     42176
      IOCS       42250           CLOCK        42247          04335            02269
      DEFINE     42251
      JOIN       42254
      ATTACH     42257
      CLOSE      42262
      OPEN       42265
      READ       42270
      WRITE      42273
      COPY       42276
      REW        42301
      WEF        42304
      BSR        42307
      BSF        42312
      STASH      42315

     *LAB    * JUST LOADED.

       UNUSED CORE LIES FROM   46604   THROUGH   50001,  LEAVING   01176  OCTAL OR   00638   DECIMAL LOCATIONS.


ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,
      REWIND     ENDFIL     SQRT       (DFDP)     (DFSB)     (DFMP)     (DFAD)     DMOD       DEFINE     ATTACH
      OPEN       CLOSE      EXP(3      RGGSAV     RGGSTR     CLOCK      READ

       THE NAME OF THIS PROGRAM IS *LA9    *       2/22/65

    ENTRY NAME   ENTRY ADD.  TRANSFER VECTORS  LOAD ADD.    OCTAL LENGTH   DECIMAL LENGTH   COMMON BREAK
      MODPH1       22460          TYPRYT        22300          01322           00722
      ODOFF        22414          ODATA
      READS        22306          REWIND
                                  OFFSYS
                                  ENDFIL
                                  ERROR
      TELTP1       23624          *NONE*        23622          00003           00003
      TELTYP       23623
      (UNIT)       23622
      FIXT         23526          FIXTT         23625          00010           00008
      DIAG         23642          SQRT          23635          00105           00069            50031
      ERROR        23744          TYPRYT        23742          00442           00290
                                  ONLIN
      FIXTT        24404          *NONE*        24404          00312           00202            50031
      FLOT         24512
      FIX          24673
      FLOAT        24677
      DAYE         24707
      GHADP        24730          (DFDP)        24716          00320           00208            50031
                                  (DFSB)
                                  (DFMP)
                                  (DFAD)
                                  DMOD
                                  COS
      QUIZ         25236          *NONE*        25236          00002           00002
      OFFSYS       25240          *NONE*        25240          00010           00008
      ENDSYS       25241
      FINSYS       25242
      SCHAIN       25243
      PGSTRT       25244
      PGSTOP       25245
      DCP          25246
      TYPRYT       25247
      SIN          25250          *NONE*        25250          00243           00163
      COS          25253
      QSIN         25257
      QCOS         25261
      SPHX         25522          COS           25513          00323           00211            50031
                                  SIN
                                  GHADP
      STPREG       26046          (DFAD)        26036          02055           01069            71757
                                  (DFDP)
                                  DSQRT
                                  (DFMP)
      DSQRT        30114          ERROR         30113          00106           00070            77776
      REDE         30222          DCP           30221          00422           00274
      RITE         30225
      PISA         30451
      ODATA        30666          TYPRYT        30643          03305           01733            50001
      ONLIN        30770          DEFINE
      ......       31136          ATTACH
                                  OPEN
                                  CARDS
                                  OFFSYS
                                  ERROR
                                  FINSYS
                                  CLOSE
                                  ODOFF
                                  READS
                                  MODPH1
                                  FLOT
                                  SPHX
                                  STPREG
                                  DIAG
                                  REDE
                                  DCP
                                  EXP(3
      CARDS        34154          RGGSAV        34150          02266           01206
      CRDCON       34430          RGGSTR
      CRDCNV       34450          CLOCK
                                  READ
      EXP(3        36436          *NONE*        36436          00136           00094            77773
      (DFAD)       36574          *NONE*        36574          00120           00080            77776
      (DFSB)       36614
      (DFMP)       36634
      (DFDP)       36662
      DMOD         36714          *NONE*        36714          00060           00048            77776
      SQRT         36774          *NONE*        36774          00054           00044            77773
      CLOCK        37053          *NONE*        37050          00107           00071
      MINUTE       37050
      XMIN         37050
      READD        37160          (IDU)         37157          00365           00245
      READB        37162
      WRITED       37165
```

```
WRITEB     37167
BSREC      37376
BSFILE     37401
REWIND     37404
UNLOAD     37407
ENDFIL     37412
SETLOW     37370
SETHI      37373
(UNIT)     ******
TAPEIO     37541
(IOU)      37547          'NONE'     37544        00030        00024
RGGSAV     37574          'NONE'     37574        00133        00091
RGGSTR     37656
IOCS       37730          CLOCK      37727        04335        02269
DEFINE     37731
JOIN       37734
ATTACH     37737
CLOSE      37742
OPEN       37745
READ       37750
WRITE      37753
COPY       37756
REW        37761
WEF        37764
BSR        37767
BSF        37772
STASH      37775

'LA9    ' JUST LOADED.

  UNUSED CORE LIES FROM   44264   THROUGH   50001,  LEAVING   03516  OCTAL OR   01870   DECIMAL LOCATIONS.


ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,
   FGDOUT      DEFINE      ATTACH      OPEN       CLOSE       COMENT      READB       PROUT

  THE NAME OF THIS PROGRAM IS 'LA10  '      2/22/65

ENTRY NAME  ENTRY ADD.  TRANSFER VECTORS  LOAD ADD.    OCTAL LENGTH    DECIMAL LENGTH    COMMON BREAK
  **PCB       22302          PARSH        22301          00006            00006
  PARSH       22316          FGDOUT       22307          01226            00662
                             DEFINE
                             ATTACH
                             OPEN
                             COMOUT
                             WASH
                             CLOSE
  COMOUT      23536          COMENT       23535          00016            00014
  FIXT        23554          FIXTT        23553          00007            00007
  FIXTT       23562          'NONE'       23562          00312            00202             50031
  FLOT        23670
  FIX         24051
  FLOAT       24055
  DAYE        24065
  FLAT        24076          ERROR        24074          00102            00066
  FLAPR       24124          TYPRYT
  FLAK        24133
  ERROR       24176          'NONE'       24176          00011            00009
  WASH        24214          READB        24207          00623            00403
                             FLAT
                             FIXT
                             PROUT
                             FLAPR
  OFFSYS      25032          'NONE'       25032          00010            00008
  ENDSYS      25033
  FINSYS      25034
  SCHAIN      25035
  PGSTRT      25036
  PGSTOP      25037
  DCP         25040
  TYPRYT      25041
  PROUT       25056          OUTUS        25042          03031            01561
  FGDOUT      26322          ACTIND
  PRCNV       25223          BFLG
  PROUT2      25174          RESTKA
  PROUT3      25207          REQIND
  TSXA        27231          WRITE
  TSXB        30021          PRCON
                             RGGSAV
                             RGGSTR
                             CKIND
                             CKACT
  READD       30074          (IOU)        30073          00365            00245
  READB       30076
  WRITED      30101
  WRITEB      30103
  BSREC       30312
  BSFILE      30315
  REWIND      30320
  UNLOAD      30323
  ENDFIL      30326
  SETLOW      30304
  SETHI       30307
  (UNIT)      30455
  TAPEIO      30455
  (IOU)       30463          'NONE'       30460          00030            00024
  OUTUS       30512          RGGSAV       30510          02320            01232
  BFLG        31346          RGGSTR
  ENDOUT      31077
  CKIND       32741
  CKACT       33004
  REQIND      32740
  ACTIND      32737
  RESTKA      32735
  PL1CON      33020
  PL2CON      33021
  PL3CON      33022
  PRCON       33023
  RGGSAV      33030          'NONE'       33030          00133            00091
  RGGSTR      33112
  IOCS        33164          CLOCK        33163          04336            02270
  DEFINE      33165
  JOIN        33170
  ATTACH      33173
  CLOSE       33176
  OPEN        33201
  READ        33204
  WRITE       33207
```

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  COPY      33212
  REW       33215
  WEF       33220
  BSR       33223
  BSF       33226
  STASH     33231
  COMENT    37522           CLOCK        37521          03177          01663
  CLOCK     42723           *NONE*       42720          00106          00070
  MINUTE    42720
  XMIN      42720

*LA10  * JUST LOADED.

  UNUSED CORE LIES FROM   43026   THROUGH   50031,  LEAVING   05004  OCTAL OR   02564   DECIMAL LOCATIONS.



ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY.
  REWIND    SQRT      (DFSB)    READB     BSREC     (DFAD)    (DFMP)    (DFOP)    DMOD      WRITEB
  ENDFIL

  THE NAME OF THIS PROGRAM IS *LA11  *      2/22/65

ENTRY NAME   ENTRY ADD.   TRANSFER VECTORS   LOAD ADD.   OCTAL LENGTH   DECIMAL LENGTH   COMMON BREAK
  **PCB      22304           EPOX            22300        00022          00018
                             TRADE
                             TAPEX
                             LOCO
  LOCO       22332           REDE            22322        00165          00117
  TRADE      22455           REWIND
  EPOX       22466           XOOL
                             BNTR2
                             INTR1
                             TYPRYT
                             EPPHEM
                             FLAK
  ACE        22514           SQRT            22507        00067          00055            47675
  BMATRX     22610           SQRT            22576        01432          00794            47675
                             G1G2
                             RCAL
                             RCOM
                             RSIG
                             ACE
  ERROR      24230           *NONE*          24230        00012          00010
  ADD        24242           *NONE*          24242        00050          00040
  ARSIN      24322           *NONE*          24312        00144          00100            77152
  ARCOS      24316
  QARSIN     24314
  QARCOS     24312
  ERRARS     24443
  ERRARC     24447
  ARTAN      24456           *NONE*          24456        00103          00067            77152
  DAYS       24564           FIX             24561        00042          00034
                             FLOAT
                             ADD
  EPPHEM     24644           QUIZ            24623        00604          00388            47675
                             PONT
                             KINE
                             STARP
                             (DFSB)
                             TIMER
                             LOOKUP
                             INTR1
                             XOOL
                             GAMAT
                             RITEM
                             TOCIN
                             WREOF
  FIXT       25430           FIXTT           25427        00007          00007
  FIXTT      25436           *NONE*          25436        00312          00202            50031
  FLOT       25544
  FIX        25725
  FLOAT      25731
  DAYE       25741
  FLAT       25752           ERROR           25750        00102          00066
  FLAPR      26000           TYPRYT
  FLAK       26007
  G1G2       26056           *NONE*          26052        00266          00182            50001
  EPHEM      26344           REWIND          26340        01452          00810
  TAPEX      27524           READB
                             BSREC
  PNUT       30020           SIN             30012        00336          00222            50001
                             COS
  ROT        30354           *NONE*          30350        00266          00182            50031
  GAMAT      30652           (DFAD)          30636        00614          00396            47675
                             (DFSB)
                             LOOKUP
                             INTR1
                             INSPC
                             BMATRX
                             (DFMP)
                             (DFOP)
  GHADP      31464           (DFOP)          31452        00320          00208            50031
                             (DFSB)
                             (DFMP)
                             (DFAD)
                             DMOD
                             COS
  INSPC      31776           *NONE*          31772        00310          00200            50031
  BNTR2      36365           EPHEM           32302        04214          02188
  INTR1      36406           PNUT
                             ROT
                             ERROR
  KINE       36520           REDE            36516        00200          00128            50001
                             ERROR
  LOOKUP     36720           ERROR           36716        00463          00307            47777
  KOOL       37250           REDE
  PONT       37414           OFFSYS          37401        00311          00201            51235
                             (DFAD)
                             TIMER
                             LOOKUP
                             INTR1
                             GAMAT
                             RITEM
```

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QUIZ        37712       'NONE'    37712      00003      00003
RCAL        37722       SQRT      37715      00240      00160      50031
RCOM        40162       SQRT      40155      00133      00091      50031
WREOF       40431       FLAT      40310      02520      01360
RITEM       40314       WRITEB
                        ENDFIL
                        REWIND
RSIG        43034       'NONE'    43030      00064      00052      47675
OFFSYS      43114       'NONE'    43114      00010      00008
ENDSYS      43115
FINSYS      43116
SCHAIN      43117
PGSTRT      43120
PGSTOP      43121
DCP         43122
TYPRYT      43123
SIN         43124       'NONE'    43124      00242      00162
COS         43127
QSIN        43133
QCOS        43135
STARP       43366       'NONE'    43366      00031      00025
TIMER       43426       (DFSB)    43417      00142      00098      50031
                        LOOKUP
                        SQRT
TOCIM       43600       OFFSYS    43561      01126      00598
                        TIMER
                        LOOKUP
                        INTR1
                        SQRT
                        KOOL
                        GAMAT
                        CHADP
                        COS
                        SIN
                        ARSIN
                        ARCOS
                        WRITEB
                        FLAT
                        RITE
REDE        44710       DCP       44707      00421      00273
RITE        44713
PISA        45137
(DFAD)      45330       'NONE'    45330      00120      00080      77776
(DFSB)      45350
(DFMP)      45370
(DFDP)      45416
DMOD        45450       'NONE'    45450      00060      00048      77776
SQRT        45530       'NONE'    45530      00055      00045      77773
READD       45606       (IOU)     45605      00365      00245
READB       45610
WRITED      45613
WRITEB      45615
BSREC       46024
BSFILE      46027
REWIND      46032
UNLOAD      46035
ENDFIL      46040
SETLOW ,    46016
SETHI       46021
(UNIT)      46167
TAPEIO      46167
(IOU)       46175       'NONE'    46172      00030      00024

'LA11  ' JUST LOADED.

  UNUSED CORE LIES FROM   46222   THROUGH   47675,  LEAVING   01454  OCTAL OR   00812   DECIMAL LOCATIONS.


ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,
   DEFINE     ATTACH     OPEN      CLOSE      SQRT      PROUT     (DFSB)     (DFAD)     FGDOUT     EXIT

  THE NAME OF THIS PROGRAM IS 'LA12  '     2/22/65

ENTRY NAME  ENTRY ADD.  TRANSFER VECTORS  LOAD ADD.   OCTAL LENGTH   DECIMAL LENGTH   COMMON BREAK
  **PCB      22302          SAVCOM        22301        00123           00083
 SAVCOM      22440          DEFINE        22424        02154           01132
                            ATTACH
                            OPEN
                            PRIM
                            QUFST
                            MAXIM
                            OFFSYS
                            TYPRYT
                            RITE
                            CLOSE
                            ERROR
                            FLAK
 BIBCD       24625          'NONE'        24600        00055           00045
 DIAGO       24662          SQRT          24655        00105           00069            50031
 ERROR       24766          TYPRYT        24762        00544           00356
                            PROJT
                            ENDSYS
                            RECOV
 FLAT        25530          ERROR         25526        00102           00066
 FLAPR       25556          TYPRYT
 FLAK        25565
 KINE        25632          REDE          25630        00215           00141            50001
                            ERROR
 MAXIM       26056          QUIZ          26045        00473           00315            50001
                            KINE
                            (DFSB)
                            (DFAD)
                            MOCT
 MOCT        26544          'NONE'        26540        00107           00071
 NORMAY      26654          SQRT          26647        00252           00170            77461
 APRED       27204          FIXT          27121        00143           00099
 UPREJ       27231
 OPERA       27122
 BUKEY       27264          'NONE'        27264        00040           00032
 OPKEY       27270
 COKEY       27305
 AFKEY       27312
 PRIM        27345          FGDOUT        27324        01424           00788            50001
 PRAM        27334          PROUT
                            BIBCD
                            FLAPR
                            PRIME
                            NORMAY
                            PRIT
                            DIAGO
 TAMP        30751          'NONE'        30750        00004           00004
 PRIME       30752
 TAPR        30753
 DIAGO       ******
```

PRIT	30756	FIXT	30754	00035	00029	
		BIBCD				
QUEST	31020	SQRT	31011	00165	00117	47675
		ERROR.				
		EXIT				
QUIZ	31176	'NONE'	31176	00002	00002	
RECOV	31200	'NONE'	31200	00002	00002	
SETUP	31204	RITE	31202	00105	00069	50031
		ENDSYS				
FIXT	31310	FIXTT	31307	00007	00007	
FIXTT	31316	'NONE'	31316	00312	00202	50031
FLOT	31424					
FIX	31605					
FLOAT	31611					
DAYE	31621					
OFFSYS	31630	'NONE'	31630	00011	00009	
ENDSYS	31631					
FINSYS	31632					
SCHAIN	31633					
PGSTRT	31634					
PGSTOP	31635					
DCP	31636					
TYPRYT	31637					
REDE	31642	DCP	31641	00421	00273	
RITE	31645					
PISA	32071					
EXIT	32263	'NONE'	32262	00210	00136	
EXSEL	32366					
EXITFN	32274					
ERRDMP	32262					
(DFAD)	32472	'NONE'	32472	00120	00080	77776
(DFSB)	32512					
(DFMP)	32532					
(DFDP)	32560					
SQRT	32612	'NONE'	32612	00054	00044	77773
PROUT	32702	OUTUS	32666	03032	01562	
FGDOUT	34146	ACTIND				
PRCNV	33047	BFLG				
PROUT2	33020	RESTKA				
PROUT3	33033	REQIND				
TSXA	35055	WRITE				
TSXB	35645	PRCON				
		RGGSAV				
		RGGSTR				
		CKIND				
		CKACT				
OUTUS	35722	RGGSAV	35720	02320	01232	
BFLG	36556	RGGSTR				
ENDOUT	36307					
CKIND	40151					
CKACT	40214					
REQIND	40150					
ACTIND	40147					
RESTKA	40145					
PL1CON	40230					
PL2CON	40231					
PL3CON	40232					
PRCON	40233					
RGGSAV	40240	'NONE'	40240	00133	00091	
RGGSTR	40322					
IOCS	40374	CLOCK	40373	04335	02269	
DEFINE	40375					
JOIN	40400					
ATTACH	40403					
CLOSE	40406					
OPEN	40411					
READ	40414					
WRITE	40417					
COPY	40422					
REW.	40425					
WEF	40430					
BSR	40433					
BSF	40436					
STASH	40441					
CLOCK	44733	'NONE'	44730	00106	00070	
MINUTE	44730					
XMIN	44730					

'LA12 ' JUST LOADED.

UNUSED CORE LIES FROM 45036 THROUGH 47675, LEAVING 02640 OCTAL OR 01440 DECIMAL LOCATIONS.

ENTRY POINTS TO SUBROUTINES REQUESTED FROM LIBRARY,
DEFINE ATTACH OPEN PROUT CLOSE (DFDP) (DFSB) (DFMP) (DFAD) DMOD
SQRT

THE NAME OF THIS PROGRAM IS 'ODPX ' 2/22/65

ENTRY NAME	ENTRY ADD.	TRANSFER VECTORS	LOAD ADD.	OCTAL LENGTH	DECIMAL LENGTH	COMMON BREAK
FIRST	22312	FDATA	22301	02070	01080	
		DEFINE				
		ATTACH				
		OPEN				
		PROUT				
		NOMNL				
		RITE				
		CLOSE				
		FLAK				
**PCB	24372	FIRST	24371	00007	00007	
ERROR	24400	'NONE'	24400	00012	00010	
FDATA	24412	'NONE'	24412	01117	00591	
FIXT	25532	FIXTT	25531	00007	00007	
FIXTT	25540	'NONE'	25540	00312	00202	50031
FLOT	25646					
FIX	26027					
FLOAT	26033					
DAYE	26043					
GHADP	26064	(DFDP)	26052	00320	00208	50031
		(DFSB)				
		(DFMP)				
		(DFAD)				
		DMOD				
		COS				
NOMNL	26376	'NONE'	26372	00763	00499	47777
NORMAY	27362	SQRT	27355	00251	00169	77461
QUIZ	27626	'NONE'	27626	00002	00002	
OFFSYS	27630	'NONE'	27630	00010	00008	
ENDSYS	27631					
FINSYS	27632					

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SCHAIN   27533
PGSTRI   27634
PGSTOP   27635
DCP      27636
TYPRYT   27637
SIN      27640        'NONE'     27640        00243        00163
COS      27643
QSIN     27647
QCOS     27651
REDE     30104        DCP        30103        00421        00273
RITE     30107
PISA     30333
FLAT     30526        ERROR      30524        00102        00066
FLAPR    30554        TYPRYT
FLAK     30563
(DFAD)   30626        'NONE'     30626        00120        00080        77776
(DFSB)   30646
(DFMP)   30666
(DFDP)   30714
OKBQ     30746        'NONE'     30746        00060        00048        77776
SQRT     31026        'NONE'     31026        00054        00044        77773
PROUT    31116        OUTUS      31102        03032        01562
FGDOUT   32362        ACTIND
PRCNV    31263        BFLG
PROUT2   31234        RESTKA
PROUT3   31247        REQIND
TSXA     33271        WRITE
TSXB     34061        PRCON
                      RGGSAV
                      RGGSTR
                      CKIND
                      CKACT
OUTUS    34136        RGGSAV     34134        02320        01232
BFLG     34772        RGGSTR
ENDOUT   34523
CKIND    36365
CKACT    36430
REQIND   36364
ACTIND   36363
RESTKA   36361
PL1CON   36444
PL2CON   36445
PL3CON   36446
PRCON    36447
RGGSAV   36454        'NONE'     36454        00133        00091
RGGSTR   36536
IOCS     36610        CLOCK      36607        04335        02269
DEFINE   36611
JOIN     36614
ATTACH   36517
CLOSE    36622
OPEN     36625
READ     36630
WRITE    36533
COPY     36636
REW      36641
WEF      36644
BSR      36647
BSF      36652
STASH    36655
CLOCK    43147        'NONE'     43144        00106        00070
MINUTE   43144
XMIN     43144
'ODPX  ' JUST LOADED.

UNUSED CORE LIES FROM   43252   THROUGH   47777,  LEAVING   04526  OCTAL OR   02390   DECIMAL LOCATIONS.
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ODP COMMON MAP, JANUARY 4,1965.

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77461      T COMMON  2                    RUNNING TIME
77457  EPOCH COMMON  2                    EPOCH
77455   TFIN COMMON  2                    FINAL TRAJECTORY TIME
77453    TOB COMMON  2                    OBSERVATION TIME
77451   DELT COMMON  2                    LIGHT TIME CORRECTION
77447  TGINT COMMON  2                  . LOWER LIMIT OF GINT INTEGRATION
77445  DELT2 COMMON  2                    SECOND LIGHT TIME CORRECTION
     *               FORTRAN CARD 02
77443    GHA COMMON  1                    GREENWICH HOUR ANGLE
77442  GHAVJ COMMON  1                    INJECTION GHA
77441  ROTMX COMMON  3*3                  PROD. OF PRECESSION AND NUTATION MX.
77430   DXOR COMMON  36
77430        EQU     DXOR
77427        EQU     DXOR-1               NOT ZERO FOR GEOCENTRIC INTEGRATION
77426        EQU     DXOR-2               NOT ZERO TO UPDATE COMENT
77425        EQU     DXOR-3               BCD TARGET NAME
77424        EQU     DXOR-4               TRANSPONDER DRIFT
77423        EQU     DXOR-5
77422        EQU     DXOR-6               TARGET (1=MARS 2=MOON 3=VENUS)
77421        EQU     DXOR-7               PHYSICAL CONSTANTS STEP MULTIPLIER
77420        EQU     DXOR-8               NOT ZERO FOR FLOATING RESIDUALS
77417        EQU     DXOR-9               NOT ZERO INDICATES OPTICAL DATA
77416        EQU     DXOR-10              NOT ZERO TO PUNCH J MATRIX
77415        EQU     DXOR-11
77414        EQU     DXOR-12              INITIAL TRAJ STEP SIZE
77413        EQU     DXOR-13              NOT ZERO FOR MMP OUTPUT
77412        EQU     DXOR-14              UP LEG SLANT RANGE
77411        EQU     DXOR-15              DOWN LEG SLANT RANGE
77410        EQU     DXOR-16              UP LEG REFRACTION CORRECTION
77407        EQU     DXOR-17              DOWN LEG REFRACTION CORRECTION
77406        EQU.    DXOR-18              TFIN-EPOCH
77405        EQU     DXOR-19              DP
77404        EQU     DXOR-20              B.T FROM SPACE
77403        EQU     DXOR-21              B.R FROM SPACE
77402        EQU     DXOR-22
77401        EQU     DXOR-23
77400        EQU     DXOR-24
77377        EQU     DXOR-25
77376        EQU     DXOR-26
77375        EQU     DXOR-27              NOT ZERO, OCCULTATION-IMPACT DATA
77374        EQU     DXOR-28
77373        EQU     DXOR-29
77372        EQU     DXOR-30              RANDOM NUMBER STARTER
77371        EQU     DXOR-31              SUBR. ERROR 1,4
77370        EQU     DXOR-32              SUBR. ERROR 2,4
77367        EQU     DXOR-33              SUBR. ERROR 3,4
77366        EQU     DXOR-34              EPOCH YYMMDDHH
77365        EQU     DXOR-35              EPOCH MMSSFFF
     *               FORTRAN CARD 03
77364   RVEC COMMON  1                    SLANT RANGE
77363   RDOT COMMON  1                    SLANT RANGE RATE
77362     EL COMMON  1                    ELEVATION ANGLE
77361    AZI COMMON  1                    AZIMUTH ANGLE
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77360      DEC COMMON  1                    LOCAL DECLINATION ANGLE
77357       HA COMMON  1                    LOCAL HOUR ANGLE
77356       C1 COMMON  1                    1 WAY DOPPLER
77355      CC3 COMMON  1                    COHERENT 3 WAY DOPPLER
77354       C3 COMMON  1                    3 WAY DOPPLER
77353      CD1 COMMON  1                    DIFFERENCED 1 WAY DOPPLER
77352      CD3 COMMON  1                    DSIF RANGING
77351      XXX COMMON  1                    EXTRA DATA TYPE
        *              FORTRAN CARD 04
77350    DRVEC COMMON  1                    CORRECTIONS
77347    DRDOT COMMON  1
77346      DEL COMMON  1
77345      DAZ COMMON  1
77344     DDEC COMMON  1
77343      DHA COMMON  1
77342      DC1 COMMON  1
77341     DCC3 COMMON  1
77340      DC3 COMMON  1
77337     DCD1 COMMON  1
77336     DCD3 COMMON  1
77335     DXXX COMMON  1
        *              FORTRAN CARD 05
77334    RVECO COMMON  1                    OBSERVED VALUES
77333    RDOTO COMMON  1
77332      ELO COMMON  1
77331     AZIO COMMON  1
77330     DECO COMMON  1
77327      HAO COMMON  1
77326      C1O COMMON  1
77325 *   CC3O COMMON  1
77324      C3O COMMON  1
77323     CD1O COMMON  1
77322     CD3O COMMON  1
77321     XXXO COMMON  1
        *              FORTRAN CARD 06
77320    RVECD COMMON  1                    RESIDUALS (OBSERVED-CALCULATED)
77317    RDOTD COMMON  1
77316      ELD COMMON  1
77315     AZID COMMON  1
77314     DECD COMMON  1
77313      HAD COMMON  1
77312      C1D COMMON  1
77311     CC3D COMMON  1
77310      C3D COMMON  1
77307     CD1D COMMON  1
77306     CD3D COMMON  1
77305     XXXD COMMON  1
        *              FORTRAN CARD 07
77304    RVECW COMMON  1                    WEIGHTS
77303    RDOTW COMMON  1
77302      ELW COMMON  1
77301     AZIW COMMON  1
77300     DECW COMMON  1
77277      HAW COMMON  1
77276      C1W COMMON  1
77275     CC3W COMMON  1
77274      C3W COMMON  1
77273     CD1W COMMON  1
77272     CD3W COMMON  1
77271     XXXW COMMON  1
        *              FORTRAN CARD 08
77270       IR COMMON  1                    RECEIVER I.D.
77267       IX COMMON  1                    XMITTER I.D.
77266       ID COMMON  1                    CURRENT DATA TYPE
77265     PASS COMMON  15                   PASS IDENTIFICATION
77246     XJUP COMMON  6                    JUPITER VECTOR
77240     XERM COMMON  6                    SATURN VECTOR
77232     XMAR COMMON  6                    MARS VECTOR
77224     XVEN COMMON  6                    VENUS VECTOR
77216     XSUN COMMON  6                    SUN VECTOR
77210     XMOO COMMON  6                    MOON VECTOR
        *              FORTRAN CARD 09
77202        X COMMON  1                    PROBE VECTOR
77201        Y COMMON  1
77200        Z COMMON  1
77177     XDOT COMMON  1
77176     YDOT COMMON  1
77175     ZDOT COMMON  1
77174        U COMMON  36                   VARIATIONAL EQUATIONS
77130      DLO COMMON  1                    NUTATION IN LONGITUDE
77127      DOB COMMON  1                    NUTATION IN OBLIQUITY
        *              FORTRAN CARD 10
77126      XAC COMMON  1                    PROBE ACCELERATION
77125      YAC COMMON  1
77124      ZAC COMMON  1
77123    XJERK COMMON  1                    PROBE JERK (THIRD DERIVATIVE)
77122    YJERK COMMON  1
77121    ZJERK COMMON  1
77120     UINV COMMON  36                   INVERSE OF VARIATIONAL EQUATIONS
77054     PDBX COMMON  6*12                 PARTIALS(OBSERVABLES/CARTESIAN)
76744     BMAT COMMON  6*11                 B MATRIX OF PARTIALS
        *              FORTRAN CARD 11
76642      ELX COMMON  1                    DIRECTION COSINES
76641      ELY COMMON  1
76640      ELZ COMMON  1
76637       AX COMMON  1                    DIRECTION COSINES
76636       AY COMMON  1
76635       AZ COMMON  1
76634       DX COMMON  1                    DIRECTION COSINES
76633       DY COMMON  1
76632       DZ COMMON  1
76631      TAX COMMON  1                    DIRECTION COSINES
76630      TAY COMMON  1
76627      TAZ COMMON  1
76626      TDX COMMON  1                    DIRECTION COSINES
76625      TDY COMMON  1
76624      TDZ COMMON  1
        *              FORTRAN CARD 12
76623      TAU COMMON  1                    DOPPLER AVERAGING TIME
76622    ILIST COMMON  6                    POSITION AND VELOCITY FLAGS
76614    LLIST COMMON  11                   PHYSICAL CONSTANTS PARTIALS FLAGS
76601    MLIST COMMON  1                    VELOCITY OF LIGHT FLAG
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76600   NLIST COMMON  3*15              STATION LOCATION FLAGS
76523    NEST COMMON  1                 NO. ESTIMATED PARAMETERS
76522    NCON COMMON  1                 NO. CONSIDERED PARAMETERS
76521      EP COMMON  100
76521         EQU     EP                E.T.-U.T.
76520         EQU     EP-1
76513         EQU     EP-6              BAND(-1817=LS 0=L 1817=S)
76512         EQU     EP-7              KI FREQUENCY
76511         EQU     EP-8              KS FREQUENCY
76510         EQU     EP-9              BAND DESIGNATION (15 WORDS)
76471         EQU     EP-24             START TIME, ATTITUDE CONTROL
76470         EQU     EP-25             DP
76467         EQU     EP-26             STOP TIME, ATTITUDE CONTROL
76466         EQU     EP-27             DP
76465         EQU     EP-28
76457         EQU     EP-34             MCIM COMENT BUFFER (30 WORDS)
76421         EQU     EP-64             NOT ZERO TO READ CARDS FROM A2
76420         EQU     EP-65             ID FOR PREDICTS
76417         EQU     EP-66             POWERED FLIGHT PARAMETERS (10 WORDS)
76375         EQU     EP-84             STEP MAP FLAG-U PRODUCT
76374         EQU     EP-85             START TIME, STEP MAP PRINTOUT
76373         EQU     EP-86             DP
76372         EQU     EP-87             FLAG TO REPEAT TRAJ FOR STEP MAP
76371         EQU     EP-88             SPACE COMENT BUFFER (17 WORDS)
76350         EQU     EP-105            MAPPED FORWARD EPOCH
76347         EQU     EP-106            DP
76346         EQU     EP-107            FLAG FOR PUNCHING MATRICES
76345         EQU     EP-108            NOT ZERO TO BYPASS LAIL
76344         EQU     EP-109
76235   SIGX3 COMMON  12*15             REJECTION SIGMAS
        *             FORTRAN CARD 13.
75751       A COMMON  1                 COMMON
75750       B COMMON  1                 STORAGE
75747       C COMMON  1                 AVAILABLE
75746       D COMMON  1                 FOR
75745       E COMMON  1                 FAP
75744       F COMMON  1                 OR
75743       G COMMON  1                 FORTRAN
75742       H COMMON  1                 USAGE
75741       O COMMON  1
75740       P COMMON  1
75737       Q COMMON  1
75736       R COMMON  1
75735       S COMMON  1
        *             FORTRAN CARD 14
75734     RNJ COMMON  2                 SPHERICAL INJECTION CONDITIONS
75732   PHINJ COMMON  2
75730   THINJ COMMON  2
75726     VNJ COMMON  2
75724    ELNJ COMMON  2
75722    AZNJ COMMON  2
75720     XNJ COMMON  6                 CARTESIAN INJECTION CONDITIONS
75712    XNDP COMMON  6
        *             FORTRAN CARD 15
75704   GRAVE COMMON  1                 K(EARTH)
75703      RE COMMON  1                 EARTH RADIUS
75702     GMB COMMON  1                 RADIATION PRESSURE CONSTANT
75701   GRAVM COMMON  1                 K(MOON)
75700    RVEN COMMON  1                 MASS RATIO VENUS
75677    RMAR COMMON  1                 MASS RATIO MARS
75676    RJUP COMMON  1                 MASS RATIO JUPITER
75675      UJ COMMON  1                 COEFFICIENT SECOND HARMONIC
75674      GH COMMON  1                 COEFFICIENT THIRD HARMONIC
75673      GD COMMON  1                 COEFFICIENT FOURTH HARMONIC
75672      AU COMMON  1                 ASTRONOMICAL UNIT
75671    VELC COMMON  1                 VELOCITY OF LIGHT
        *             FORTRAN CARD 16
75670      RI COMMON  15                STATION RANGE
75651    PHII COMMON  15                STATION LATITUDE (GEOCENTRIC)
75632  THETAI COMMON  15                STATION LONGITUDE
        *             FORTRAN CARD 17
75613   GRAVS COMMON  1                 K(SUN)
75612   GRAVV COMMON  1                 K(VENUS)
75611   GRAVR COMMON  1                 K(MARS)
75610   GRAVJ COMMON  1                 K(JUPITER)
75607   OMEGA COMMON  1                 ANGULAR ROTATION RATE OF EARTH
75606      XI COMMON  1                 STATION X(T)
75605      YI COMMON  1                 STATION Y(T)
75604      ZI COMMON  1                 STATION Z(T)
75603     RAI COMMON  1                 STATION RIGHT ASCENSION
        *             FORTRAN CARD 18
75602      UI COMMON  15                NORTH SOUTH DISPLACEMENT (GEOD-GEOC)
75563      VI COMMON  15                EAST WEST DISPLACEMENT
75544     FNI COMMON  15                LOCAL INDEX OF REFRACTION
75525     TAB COMMON  1000
75525         EQU     TAB               DATA FILE INPUT BUFFER (400 WORDS)
74705         EQU     TAB-400           DATA FILE OUTPUT BUFFER (400 WORDS)
74065         EQU     TAB-800           SCRATCH AREA, LAB (200 WORDS)
73555      YI COMMON  49*24             PROBE EPHEMERIS INTERPOLATION BUFFER
71325    RESR COMMON  8*15              SCALE FACTORS
71135    IRES COMMON  8*15              PLOT FLAGS
70745     NHR COMMON  1                 PLOT STEP
        *             FORTRAN CARD 19
70744    DRDC COMMON  12                VELOCITY OF LIGHT PARTIALS
70730    DIM3 COMMON  12*3*15           STATION PARTIALS BY DATA TYPE
67674   CPPH1 COMMON  20                CAP PHI MATRIX OF PARTIALS
67650   CPPH2 COMMON  20                DP
67624   CPTH1 COMMON  20                CAP THETA MATRIX OF PARTIALS
67600   CPTH2 COMMON  20                DP
67554      XJ COMMON  20*20             J MATRIX
66734     XJ2 COMMON  20*20             DP
66114      XK COMMON  400               SCRATCH 20*20 MATRIX
65274     XK2 COMMON  400               SCRATCH 20*20 MATRIX
64454   RIGHT COMMON  20                RESIDUAL*CPPHI ACCUMULATED
64430   RITE2 COMMON  20                DP
        *             FORTRAN CARD 20
64404   CPGAM COMMON  20*20             COVARIANCE MATRIX
63564   CPGM2 COMMON  20*20             DP
62744   GFLIP COMMON  400               INPUT COVARIANCE MATRIX (INVERSE)
62124   GFLP2 COMMON  400               DP
61304   GAMIN COMMON  20*20             COV MX OF UNADJUSTED PARAMETERS
60464    DINT COMMON  60                V MATRIX INTEGRAND
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60362    DIN2 COMMON  66                  DP
60260     DIG COMMON  48
60260         EQU     DIG
60231  PLOFIL EQU     DIG-23              IOCS PLOT  CONTROL (12 WORDS FORWARD)
60215  PUNFIL EQU     DIG-35              IOCS PUNCH CONTROL (12 WORDS FORWARD)
60201  PRIFIL EQU     DIG-47              IOCS PRINT CONTROL (12 WORDS FORWARD)
       *              FORTRAN CARD 21
60200    YEAR COMMON  1                   7-WORD TIME BLOCK
60177   MONTH COMMON  1                   INTEGERS IN ADDRESS PART
60176     DAY COMMON  1                   FAP USE ONLY
60175    HOUR COMMON  1
60174     MIN COMMON  1
60173     SEC COMMON  1
60172    FRAC COMMON  1
       *              FORTRAN CARD 22
60171     IF1 COMMON  1
60170     IF2 COMMON  1
60167     IF3 COMMON  1                   CONTENTS OF KEYS 10-17
60166     IF4 COMMON  1
60165     IF5 COMMON  1                   ZERO TO CLOSE DATA FILE/PREDICT OUTPUT
60164     IF6 COMMON  1                   DATA FILE READ  1817=EOF  2817=NORMAL
60163     IF7 COMMON  1
60162     IF8 COMMON  1                   NOT ZERO TO CHECK RESIDUAL REJECTION
60161     IF9 COMMON  1
60160    IF10 COMMON  1                   NOT ZERO TO PRINT PHI VECTORS
       *              FORTRAN CARD 23
60157   KLIST COMMON  4                   FLAGS FOR ATTITUDE CONTROL ESTIMATION
60153    FABC COMMON  9                   ATTITUDE CONTROL COEFFICIENTS
60142   ELMIN COMMON  1                   MINIMUM ELEVATION ANGLE
60141    RMAX COMMON  1                   MAXIMUM SLANT RANGE
60140     RUN COMMON  1                   DATA FILE OUTPUT COUNTER
60137   BEFOR COMMON  1
60136      CA COMMON  11                  PARTIALS DF/DQ
60123      QB COMMON  6                   PARTIALS DF/DXO
60115    TOBL COMMON  2                   PREVIOUS TOB
60113     XMU COMMON  20                  SCRATCH COLUMN VECTOR
60067      XX COMMON  400                 SCRATCH 20*20 MATRIX
57247      XC COMMON  400                 SCRATCH 20*20 MATRIX
       *              FORTRAN CARD 24
56427   IGNAZ COMMON  12*15               NOT ZERO TO IGNORE DATA POINT
56143    SOUR COMMON  2                   SUM OF SQUARED RESIDUALS
56141   BU225 COMMON  15*15               INPUT BUFFER
55600    BU12 COMMON  12                  DP INPUT BUFFER
       *              FORTRAN CARD 25
55564      XN COMMON  3                   CORRECTED PROBE COORDINATES
55561     DXN COMMON  3
55556    DDXN COMMON  3
55553   DDDXN COMMON  3
55550      TS COMMON  1                   DATA SAMPLE INTERVAL
55547     SSQ COMMON  12*6*4              S**2 WEIGHTING TABLE
55107      TL COMMON  12*6*4              T WEIGHTING TABLE
54447     GSQ COMMON  6                   G WEIGHTING TABLE
54441   OHBAD COMMON  12                  NOT ZERO IF DATA TYPE REJECTED LAST
       *              FORTRAN CARD 26
54425   QTILD COMMON  20                  A PRIORI ESTIMATE
54401     QTP COMMON  20                  DP
54355      QP COMMON  20                  ESTIMATED CONDITIONS AND CONSTANTS
54331    QPDP COMMON  20
54305     CZ1 COMMON  1                   DOPPLER COEFFICIENTS
54304     CZ2 COMMON  1
54303     CZ3 COMMON  1
54302     CZ4 COMMON  1
54301     CZ5 COMMON  1
54300     CZ6 COMMON  1
54277      PI COMMON  45                  INITIAL POINTING TIMES
54222     PTD COMMON  45                  POINTING COUNT INTERVALS
54145     PTF COMMON  45                  FINAL POINTING TIMES
54070    PTFD COMMON  45
54070         EQU     PTFD                OCCULTATION-IMPACT TIMES (30 WORDS)
54032         EQU     PTFD-30             START-STOP TIMES (12 WORDS)
54016         EQU     PTFD-42
54013    PINT COMMON  45                  POINTING SAMPLE INTERVAL
53736   PINTD COMMON  45                  CURRENT POINTING TIME
53661   BALNC COMMON  12*15               INPUT WEIGHTS
       *              FORTRAN CARD 27
53375  COSRAI COMMON  1                   COS(RAI)
53374  SINRAI COMMON  1                   SIN(RAI)
53373  COSPHI COMMON  1                   COS(PHII)
53372  SINPHI COMMON  1                   SIN(PHII)
53371   SINEL COMMON  1                   SIN(EL)
53370    C137 COMMON  1                   NOT ZERO TO BYPASS LA13
53367    GADT COMMON  1                   PHYSICAL CONSTANTS INTEGRATION STEP
53366    CAPQ COMMON  1                   Q SUM OF SQUARES
53365   CAPQL COMMON  1
53364     DCQ COMMON  1
       *              FORTRAN CARD 28
53363    NTOT COMMON  1                   NUMBER OF POINTS IN SOUR
53362     QNU COMMON  20                  NEW Q-S (QP+RIGHT)
53336    QNUD COMMON  20                  DP
53312    ITNO COMMON  1                   ITERATION NUMBER
53311   COSEL COMMON  1                   COS(EL)
53310   SINAZ COMMON  1                   SIN(AZ)
53307   COSAZ COMMON  1                   COS(AZ)
       *              FORTRAN CARD 29
53306    CORM COMMON  400                 SCRATCH 20*20 MATRIX
52466    GIPP COMMON  400                 SCRATCH 20*20 MATRIX
51646    GMAT COMMON  66                  V MATRIX OF PARTIALS
51544     IFA COMMON  10
51544         EQU     IFA                 ZERO TO INTEGRATE TO ENCOUNTER
51543         EQU     IFA-1
51542         EQU     IFA-2
51541         EQU     IFA-3               NOT ZERO FOR DATA SIGMA OUTPUT
51540         EQU     IFA-4               RADIUS OF TARGET
51537         EQU     IFA-5
51536         EQU     IFA-6
51535         EQU     IFA-7               NOT ZERO TO TURN OFF SOLAR PRESSURE
51534         EQU     IFA-8               NOT ZERO TO TURN OFF LIGHT TIME
51533         EQU     IFA-9               NOT ZERO TO TURN OFF REFRACTION
51532   XFREQ COMMON  1                   XMITTER FREQUENCY
51531   TFREQ COMMON  1                   XPONDER FREQUENCY
51530    KEYS COMMON  1                   CONTENTS OF KEYS
51527   XPDBX COMMON  6                   XMITTER ROOT PARTIALS
51521   TXCON COMMON  6*15                FREQUENCY COEFFICIENTS
51367   TXCN2 COMMON  6*15                DP
       *              FORTRAN CARD 30
51235   COMTS COMMON  11                  PAGE HEADING
51222   SIGMA COMMON  12*15               DATA FILE SIGMA
50736    BIAS COMMON  12*15               DATA FILE BIAS
50452    TMAP COMMON  2                   CURRENT MAPPING TIME
50450  ITERAT COMMON  1
50447     YY1 COMMON  6*45                TRANSMITTER ID TABLE
50031   TIMAP COMMON  24                  MAPPING TIMES
50001    AREA COMMON  1                   S/C AREA
50000   FMASS COMMON  1                   S/C MASS
47777    GAMM COMMON  66                  PHYSICAL CONSTANTS INTEGRATION MATRIX
47675    CAPU COMMON  400                 MAPPING MATRIX TO ENCOUNTER
              END
```

V. OUTPUT

Primary output from the ODP is in the form of a BCD tape which may be listed on the IBM 1401. This listing contains the following items:

1. List of card input
2. *A priori* covariance matrix
3. Inverse of *a priori* covariance matrix
4. Trajectory information
5. J matrix
6. J matrix correlations
7. Parameter estimates and statistics
8. Inverse of J matrix
9. Covariance matrix
10. Covariance matrix correlations

The following items are output on option:

1. Residuals, computed observables, weights, and frequencies
2. Residual statistics
3. Pointing ephemeris
4. Mapping matrix
5. Mapped covariance matrix
6. Position and velocity of probe at mapping times
7. Encounter parameters and statistics
8. Supplementary printout at data times--vectors and partials

All items, with the exception of the supplementary partials printout, may be printed on the SC-3070 in SFOF Mode II operation.

Any matrix which is printed by the ODP may also be punched on option. In this case the card images are written on the same BCD output tape for punching by the 1401.

The ODP also writes a plotting tape for the SC-4020 plotter, containing plots of residuals versus time, and angle residuals versus angles.

A binary tape for the Matrix Manipulation Program, containing data partials and mapping matrices, is generated on option. This capability does not exist in Mode II operation.

Error comments and status-of-program messages are printed on the administrative printer in Mode II and the on-line printer in Mode IV. Refer to Subroutine 28, ERROR, for a listing of these comments.

A. DISK AND TAPE FORMATS

The Planetary Ephemeris format is presented in Ref. 4, and the Matrix Manipulation Program tape format in Ref. 11 (Section IX). The other formats are covered in Section VI; the Prediction File is presented in Subroutine 30, FILL; the Data File in Subroutine 43, KINE; the Probe Ephemeris in Subroutine 45, LOOKUP; and the Combined Ephemeris in Subroutine 86, RITEM.

B. OUTPUT SYMBOLS AND DEFINITIONS

The following symbols appear on the output listings. The corresponding symbols used in this report and the definitions are given:

Output symbol	Report symbol	Definition
X	x	position of probe, geocentric equatorial true of date, km
Y	y	
Z	z	
DX	$\dot{x}$	velocity of probe, geocentric equatorial true of date, km/sec
DY	$\dot{y}$	
DZ	$\dot{z}$	
KE	GM_e	gravitational constant of Earth, km^3/sec^2
RE	R_e	equatorial radius of Earth, km
G	γB	solar pressure constant
KM	GM_m	gravitational constant of Moon, km^3/sec^2
MV	M_v	mass of Venus, solar masses
MM	M_r	mass of Mars, solar masses

Output symbol	Report symbol	Definition
MJ	M_j	mass of Jupiter, solar masses
J	J	second harmonic coefficient
H	H	third harmonic coefficient
D	D	fourth harmonic coefficient
AU	a_e	astronomical unit, km
FA	F_{ao}	attitude control coefficients
FB	F_{bo}	
FC	F_{co}	
C	c	speed of light, km/sec
RI(I)	R_i	radius of Earth at station i, km
LA(I)	ϕ_i	geocentric latitude of station i, deg
LO(I)	λ_i	longitude of station i, deg
R	ρ	slant range, km
DR	$\dot{\rho}$	slant range rate, km/sec
EL	γ	elevation angle, deg
AZ	σ	azimuth angle, deg
DEC	δ	declination, deg
HA	α	hour angle, deg
C1	f_1	one-way integrated doppler frequency, cps
CC3	f_{c3}	coherent three-way integrated doppler frequency, cps
C3	f_3	three-way integrated doppler frequency, cps
D1	f_{d1}	differenced one-way integrated doppler frequency, cps

Output symbol	Report symbol	Definition
RU	ρDSIF	DSIF ranging
B	$\lvert B \rvert$	vector from target center of mass perpendicular to probe asymptote, km
B·RO	$\underline{B}\cdot\underline{R}_0$	dot products, target orbital plane, km
B·TO	$B\cdot T_0$	
B·RT	$\underline{B}\cdot\underline{R}_T$	dot products, target equatorial plane, km
B·TT	$B\cdot\underline{T}_T$	
TL	t_L	linearized time of flight, hours (lunar missions) or days
TF	t_f	true time of flight, hours (lunar missions) or days
SMAA	a	semi-major axis of dispersion ellipse at target, km
SMIA	b	semi-minor axis, km
THETA	θ	inclination of dispersion ellipse to target orbital plane, deg
DEL T	σ_t	standard deviation of linearized time of flight, sec
DEL B	σ_B	standard deviation of $\underline{B}$ vector, km
DEL S	σ_S	standard deviation of asymptote unit vector, km
DEL BR	$\sigma_{\underline{B}\cdot\underline{R}}$	standard deviation of $\underline{B}\cdot\underline{R}$, km
DEL BT	$\sigma_{\underline{B}\cdot\underline{T}}$	standard deviation of $\underline{B}\cdot\underline{T}$, km
C3	c_3	vis viva energy, km^2/sec^2
TC	τ	doppler count time, sec
Q	q	transmitter index
FRQ	f_q	if $q \neq 0$, station frequency less 29.66×10^6 cps
	f_T	if $q = 0$, probe frequency less 960×10^6 cps

VI. SUBROUTINES

Section VI contains the documentation for the 104 Subroutines which were written primarily for use by the SPODP. Documentation is not included for JPL general-purpose routines and SFOF routines.

IDENTIFICATION 1

AAT
Melba Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

This subroutine forms the matrix product of two vectors.

RESTRICTIONS

Standard Fortran II arrays.

USE

CALL	AAT (X, Y, PRO)
X (1, 6)	P
Y (6, 1)	P^T
PRO (6, 6)	Product matrix

CODING INFORMATION

Length of subroutine is 77 (10) or 115 (8) words.

IDENTIFICATION 2

ABDD
Charles Coltharp, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

ABDD computes the function.

$$S = \frac{Z_i(ax + by) - cz}{d},$$

the form of which has frequent application in ODP station location partial expressions.

RESTRICTIONS

COMMON break: 47675

USE

CALL	ABDD	
PZE	D	d
PZE	R	x, y, z (1 x 3)

COMMON input:

O	a
B	b
C	c
Z_i	Z - component of geocentric station vector, km.

COMMON output:

S	s

CODING INFORMATION

Length of subroutine is 24 (10) or 30 (8) words.

IDENTIFICATION 3

ACE
Melba Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

To compute the unit vector as needed in calculation of the attitude control effects partials in BMATRX.

RESTRICTIONS

a. COMMON from ODP
b. Subroutines used:
SQRT

USE

CALL ACE (DDX)
Computes R, X/R etc, and stores the result in DDX(I).

CODING INFORMATION

Length of subroutine is 57 (10) or 71 (8) words.

IDENTIFICATION 4

ANGPLT
Alfred Schoepke, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

ANGPLT plots hour angle residuals versus hour angle, and declination residuals versus declination. A tape containing the plotting information is written for the SC-4020.

RESTRICTIONS

a. COMMON break: 47675

b. Subroutine used:

    PKINE
    FIXT
    BIBCD
    CXPLOT

USE

CALL ANGPLT

COMMON input:

IR	station identification
RVECD	residual array
RVEC	data type array

CODING INFORMATION

Length of subroutine is 383 (10) or 577 (8) words.

IDENTIFICATION 5

AQUI/ALLI/BAQUI/BALLI
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

To format, list, and send, via TELTYP, predictions needed by the tracking stations.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   - PROUT
   - FGDOUT
   - PKINE
   - FIXT
   - TELTYP
   - ENDOUT
   - BIBCD

In MODE 2, the predictions are transmitted in real time by TELTYP. In MODE 4, a magnetic tape (A9) is written by TELTYP. This tape is then processed to punch paper tape acceptable to the teleprinters.

USE

CALL	AQUI	to list predictions
CALL	BAQUI	to prepare for transmission
CALL	ALLI	to list drive tape for Goldstone
CALL	BALLI	to prepare drive tape for transmission

CODING INFORMATION

Length of subroutine is 460 (10) or 714 (8) words.

REFERENCE

Heller, J., IOM to F. Curl, Nominal Predict Format, June 10, 1963.

IDENTIFICATION 6

BEER
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

BEER stores zeroes in certain ODP common locations prior to the data fit. It also executes the reset entry of REJEC.

RESTRICTIONS

a. COMMON break: 46711
b. Subroutine called:
   REJEC

USE

CALL BEER

COMMON output: zeroes in DINT, DIN2, QA, QB, TOBL, TOBL-1, TGINT, TGINT-1, XMU, RIGHT, RITE2, XX, XC, XJ, XJ2, XK, XK2, IF2, IF4. BIGNO in IF1 and IF5.

CODING INFORMATION

Length of subroutines is 57 (10) or 71 (8) words.

IDENTIFICATION 7

BIBCD
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

To convert the binary equivalent of 2 digit decimal numbers to BCD for print-out.

RESTRICTION

Range of numbers: $1 \leq n \leq 99$

USE

With argument in the accumulator
CALL BIBCD
The BCD equivalent is in the accumulator on return.

CODING INFORMATION

Length of subroutine is 45 (10) or 55 (8) words.

IDENTIFICATION

BMATRX
Melba Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

BMATRX is written to compute the analytic partials of the physical constants when these parameters are being estimated or considered in the ODP.

RESTRICTIONS

a. COMMON break: 47675
b. When computing partials of the attitude control effects, partials of MJ, H, and D are inhibited, thus a maximum of 11 of the possible 14 can be computed at one time.
c. Subroutines used:
   - ACE
   - GIG2
   - RCAL
   - RCOM
   - RSIG
   - SQRT

METHOD

Formulas for the partial derivatives of acceleration with respect to physical constants, $\partial \ddot{r}/\partial q$, are derived from the equations of motion. These are integrated to obtain $\partial r/\partial q$.

The equations for these partials follow:

$$\frac{\partial \ddot{x}}{\partial GM_e} = \frac{-xg_1}{r^3}$$

$$\frac{\partial \ddot{y}}{\partial GM_e} = \frac{-yg_1}{r^3}$$

$$\frac{\partial \ddot{z}}{\partial GM_e} = \frac{-zg_2}{r^3}$$

$$\frac{\partial \ddot{x}}{\partial R_e} = \frac{-GM_m}{R_e}\left\{2x_m\left[\frac{1}{\left|\underline{r}_m - \underline{r}\right|^3} - \frac{1}{r_m^3}\right] - 3\frac{\left(\underline{r}\cdot\underline{r}_m - r^2\right)\left(x - x_m\right)}{\left|\underline{r}_m - \underline{r}\right|^5} - \frac{3x}{\left|\underline{r}_m - \underline{r}\right|^3}\right\} \qquad x \rightarrow y, z$$

8-2 of 4

$$\frac{\partial \ddot{x}}{\partial \gamma B} = \frac{c_1 A_p (x - x_s)}{M_p \left|\underline{r} - \underline{r}_s\right|^3} \qquad x \rightarrow y, z$$

where

$c_1 = 1.031 \times 10^8$

A_p = surface area of probe, m^2

M_p = mass of probe, kg

$$\frac{\partial \ddot{x}}{\partial GM_m} = -\left[\frac{x_m}{r_m^3} + \frac{(x - x_m)}{\left|\underline{r}_m - \underline{r}\right|^3}\right] \qquad x \rightarrow y, z$$

$$\frac{\partial \ddot{x}}{\partial M_v} = -GM_s\left[\frac{x_v}{r_v^3} + \frac{(x - x_v)}{\left|\underline{r}_v - \underline{r}\right|^3}\right] \qquad x \rightarrow y, z$$

$$\frac{\partial \ddot{x}}{\partial M_r} = -GM_s\left[\frac{x_r}{r_r^3} + \frac{(x - x_r)}{\left|\underline{r}_r - \underline{r}\right|^3}\right] \qquad x \rightarrow y, z$$

$$\frac{\partial \ddot{x}}{\partial M_j} = -GM_s\left[\frac{x_j}{r_j^3} + \frac{(x - x_j)}{\left|\underline{r}_j - \underline{r}\right|^3}\right] \qquad x \rightarrow y, z$$

$$\frac{\partial \ddot{x}}{\partial J} = -x\left[1 - 5\left(\frac{z}{r}\right)^2\right]\frac{GM_e}{r^2}\frac{R_e^2}{r^3} \qquad x \rightarrow y$$

$$\frac{\partial \ddot{z}}{\partial J} = -z\left[3 - 5\left(\frac{z}{r}\right)^2\right]\frac{GM_e}{r^2}\frac{R_e^2}{r^3}$$

$$\frac{\partial \ddot{x}}{\partial H} = x\left[7\left(\frac{z}{r}\right)^2 - 3\right]\frac{z}{r}\frac{GM_e}{r^3}\frac{R_e^3}{r^3} \qquad x \rightarrow y$$

$$\frac{\partial \ddot{z}}{\partial H} = \left[1 - 10\left(\frac{z}{r}\right)^2 + \frac{35}{3}\left(\frac{z}{r}\right)^4\right]\frac{3r}{5}\frac{GM_e}{r^3}\frac{R_e^3}{r^3}$$

$$\frac{\partial \ddot{x}}{\partial D} = -x\left[3 - 42\left(\frac{z}{r}\right)^2 + 63\left(\frac{z}{r}\right)^4\right]\frac{GM_e}{7r^3}\frac{R_e^4}{r^4} \qquad x \rightarrow y$$

$$\frac{\partial \ddot{z}}{\partial D} = -z\left[15 - 70\left(\frac{z}{r}\right)^2 + 63\left(\frac{z}{r}\right)^4\right]\frac{GM_e}{7r^3}\frac{R_e^4}{r^4}$$

$$\frac{\partial \ddot{x}}{\partial a_e} = \frac{1}{a_e}\sum_{k=1}^{4} GM_k\left[x_k\left(\frac{1}{\left|\underline{r}_k - \underline{r}\right|^3} - \frac{1}{r_k^3}\right) - \frac{3\left(r^2 - \underline{r}\cdot\underline{r}_k\right)\left(x - x_k\right)}{\left|\underline{r}_k - \underline{r}\right|^5}\right] \qquad x \rightarrow y, z$$

where

$k = 1$ = Sun
$k = 2$ = Venus
$k = 3$ = Mars
$k = 4$ = Jupiter

The partial derivatives of acceleration with respect to the attitude control effects are given by

$$\begin{bmatrix} \frac{\partial \ddot{x}}{\partial F_{AO}} & \frac{\partial \ddot{x}}{\partial F_{BO}} & \frac{\partial \ddot{x}}{\partial F_{CO}} \\ \frac{\partial \ddot{y}}{\partial F_{AO}} & & \vdots \\ \frac{\partial \ddot{z}}{\partial F_{AO}} & \cdots & \frac{\partial \ddot{z}}{\partial F_{CO}} \end{bmatrix} = \frac{10^{-8}}{m}\begin{bmatrix} A_x & B_x & C_x \\ A_y & B_y & C_y \\ A_z & B_z & C_z \end{bmatrix}$$

where the unit vectors along the three body fixed axes are defined by

$$\overline{A} = \frac{-\overline{H}(\overline{E}\cdot\overline{H}) + \overline{E}}{\left|\overline{H}(\overline{E}\cdot\overline{H}) - \overline{E}\right|} = A_x, A_y, A_z$$

$$\overline{B} = \frac{\overline{E} \times \overline{H}}{\left|\overline{E} \times \overline{H}\right|} = B_x, B_y, B_z$$

$$\overline{C} = -\overline{H} = C_x, C_y, C_z$$

and

$\overline{E} = E_x, E_y, E_z$ = Unit vector directed from the probe toward Canopus

$\overline{H} = H_x, H_y, H_z$ = Unit vector directed from the probe toward the Sun

USE

CALL BMATRX

The subroutine checks lists in the COMMON area to determine what is required.

CODING INFORMATION

Length of subroutine is 794(10) or 1432(8) words.

REFERENCES

a. Anderson, John D., RFP 312-37, August 29, 1961.
b. Null, George W., RFP 312-179, Addendum 3, December 11, 1963.

IDENTIFICATION

CALL

Michael R. Warner, JPL

Fortran II, Version 3

January 4, 1965

PURPOSE

CALL serves as the logical control routine for the data fitting link, LA6. All steps from reading the ODG data file through computation of partials and residuals to writing the residual file are initiated by this routine.

RESTRICTIONS

a. COMMON break: 46711

b. Subroutines called:

BEER
KINE
COEF
STARP
(DFSB)
REAP
CHADP
DOPLR
COROP
CORR
DICOS
OBTOX
CATS
OFFSYS
WAIT
QUIZ
REJEC
PM360
FORM
GERTA/GREOF
FILL

USE

CALL CALL

COMMON input:

IGNAZ	data type delete flags (12 × 15)
PTFD-30	data start and stop times
LLIST	physical constants solve flags (11)
EPOCH	ODP epoch, d.p. sec past 1950.0
THETAI	station longitude, deg
SIGX3	rejection sigmas (12 × 15)
DXDR-27	occultation-impact data flag

COMMON output:

HAO	observed hour angle from observed optical right ascension
RVECD	residual array
TOBL	previous observation time

CODING INFORMATION

Length of subroutine is 339 (10) or 528 (8) words.

IDENTIFICATION

CATS

Michael R. Warner, JPL

Fortran II, Version 3

January 4, 1965

PURPOSE

CATS computes the partials of the ODP data types with respect to the station locations. Such a partial may be non-zero only if the tracking datum is from the same station as the specified station location.

RESTRICTIONS

a. COMMON break: 47675

b. Subroutines called:

VEC
ABDD
COS

METHOD

$$\left.\begin{aligned} X_i &= R_i \cos(\alpha_G + \lambda_i)\cos\phi_i \\ Y_i &= R_i \sin(\alpha_G + \lambda_i)\cos\phi_i \\ Z_i &= R_i \sin\phi_i \end{aligned}\right\} \text{(station coordinates)}$$

$$\left.\begin{aligned} \frac{\partial\rho_i}{\partial R_i} &= \frac{1}{R_i}(\underline{R}_i \cdot \underline{L}) \\ \frac{\partial\rho_i}{\partial\phi_i} &= Z_i\left\{\left[L_x \cos(\alpha_G + \lambda_i) + L_y \sin(\alpha_G + \lambda_i)\right] - L_z R_i \cos\phi_i\right\} \\ \frac{\partial\rho_i}{\partial\lambda_i} &= Y_i L_x - X_i L_y \end{aligned}\right\} \text{(slant range partials)}$$

where

$$\underline{L} = \frac{\underline{\rho} + \underline{r}_s}{\rho}$$

λ_i = station longitude

ϕ_i = station geocentric latitude

R_i = station Earth radius

$$\left.\begin{aligned}
\frac{\partial \dot{\rho}_i}{\partial R_i} &= \frac{1}{R_i} (\underline{R}_i \cdot \underline{L}') \\
\frac{\partial \dot{\rho}_i}{\partial \phi_i} &= -Z_i \left\{ \left[L'_x \cos(\alpha_G + \lambda_i) + L'_y \sin(\alpha_G + \lambda_i) \right] + L'_z R_i \cos \phi_i \right\} \\
\frac{\partial \dot{\rho}_i}{\partial \lambda_i} &= -Y_i L'_x + X_i L'_y
\end{aligned}\right\} \text{(range rate partials)}$$

where

$$L'_x = \frac{1}{\rho_i} (-\dot{x} - 2\omega Y_i + \dot{\rho}_i L_x + \omega y)$$

$$L'_y = \frac{1}{\rho_i} (-\dot{y} + 2\omega X_i + \dot{\rho}_i L_y - \omega x)$$

$$L'_z = \frac{1}{\rho_i} (-\dot{z} + \rho_i L_z)$$

$$\left.\begin{aligned}
\frac{\partial \gamma_i}{\partial R_i} &= \frac{-1}{R_i \rho_i} (\underline{R}_i \cdot \underline{\tilde{D}}) \\
\frac{\partial \gamma_i}{\partial \phi_i} &= \frac{1}{\rho_i} \left\{ Z_i \left[\tilde{D}_x \cos(\alpha_G + \lambda_i) + \tilde{D}_y \sin(\alpha_G + \lambda_i) \right] - \tilde{D}_z R_i \cos \phi_i \right\} \\
\frac{\partial \gamma_i}{\partial \lambda_i} &= \frac{1}{\rho_i} (Y_i \tilde{D}_x - X_i \tilde{D}_y)
\end{aligned}\right\} \text{(elevation angle partials)}$$

$$\left.\begin{aligned}
\frac{\partial\sigma_i}{\partial R_i} &= \frac{-1}{R_i\rho_i}(\underline{R}_i \cdot \underline{\widetilde{A}}) \\
\frac{\partial\sigma_i}{\partial\phi_i} &= \frac{1}{\rho_i}\left\{Z_i[\widetilde{A}_x \cos(\alpha_G + \lambda_i) + \widetilde{A}_y \sin(\alpha_G + \lambda_i)] - \widetilde{A}_z R_i \cos\phi_i\right\} \\
\frac{\partial\sigma_i}{\partial\lambda_i} &= \frac{1}{\rho_i}(Y_i\widetilde{A}_x - X_i\widetilde{A}_y)
\end{aligned}\right\} \quad \text{10-3 of 5 (azimuth angle partials)}$$

$$\frac{\partial\gamma_i}{\partial S_i}(\underline{\widetilde{D}}) \rightarrow \frac{\partial\delta_i}{\partial S_i}(\underline{D}) \qquad \text{(declination partials)}$$

$$\frac{\partial\sigma_i}{\partial S_i}(\underline{\widetilde{A}}) \rightarrow \frac{\partial\alpha_i}{\partial S_i}(\underline{A}) \qquad \text{(hour angle partials)}$$

where

$$D_x = -\sin\delta_i \cos(\alpha_G + \lambda_i)$$

$$D_y = -\sin\delta_i \sin(\alpha_G + \lambda_i)$$

$$D_z = \cos\delta_i$$

$$A_x = -\sin(\alpha_G + \lambda_i)$$

$$A_y = \cos(\alpha_G + \lambda_i)$$

$$A_z = 0$$

$$\widetilde{D}_x = \sin\gamma_i\left[\sin\sigma_i \sin(\alpha_G + \lambda_i) + \cos\sigma_i \sin\phi_i \cos(\alpha_G + \lambda_i)\right] + \cos\phi_i \cos(\alpha_G + \lambda_i)\cos\gamma_i$$

$$\widetilde{D}_y = -\sin\gamma_i\left[\sin\sigma_i \cos(\alpha_G + \lambda_i) - \cos\sigma_i \sin\phi_i \sin(\alpha_G + \lambda_i)\right] + \cos\phi_i \sin(\alpha_G + \lambda_i)\cos\gamma_i$$

$$\tilde{D}_z = -\cos\sigma_i \cos\phi_i \sin\gamma_i + \sin\phi_i \cos\gamma_i$$

$$\tilde{A}_x = -\cos\sigma_i \sin(\alpha_G + \lambda_i) + \sin\sigma_i \sin\phi_i \cos(\alpha_G + \lambda_i)$$

$$\tilde{A}_y = \cos\sigma_i \cos(\alpha_G + \lambda_i) + \sin\sigma_i \sin\phi_i \sin(\alpha_G + \lambda_i)$$

$$\tilde{A}_z = -\sin\sigma_i \cos\phi_i$$

The vectors $\underline{A}$, $\underline{D}$, $\underline{\tilde{A}}$, and $\underline{\tilde{D}}$, defined above, are computed by subroutine DICOS.

$$\frac{\partial f_{1i}}{\partial S_i} = \frac{\Omega_2}{c}\frac{\partial \dot{\rho}_i}{\partial S_i} \quad \text{(one-way doppler partials)}$$

$$\frac{\partial f_{c3i,q}}{\partial S_i} = \frac{\Omega_4}{c}\frac{\partial \dot{\rho}_i}{\partial S_i} \quad \text{(two-way doppler receiver partials)}$$

$$\frac{\partial f_{3i,q}}{\partial S_i} = \frac{\Omega_6}{c}\frac{\partial \dot{\rho}_i}{\partial S_i} \quad \text{(three-way doppler receiver partials)}$$

$$\frac{\partial f_{d1i,j}}{\partial S_i} = \frac{\Omega_2}{c}\frac{\partial \dot{\rho}_i}{\partial S_i} \quad \text{(differenced one-way doppler receiver i partials)}$$

$$\frac{\partial f_{c3i,q}}{\partial S_q} = \frac{\Omega_4}{c}\frac{\partial \rho_q}{\partial S_q} \quad \text{(two-way doppler transmitter partials)}$$

$$\frac{\partial f_{3i,q}}{\partial S_q} = \frac{\Omega_6}{c}\frac{\partial \dot{\rho}_q}{\partial S_q} \quad \text{(three-way doppler transmitter partials}$$

$$\frac{\partial f_{d1i,j}}{\partial S_j} = \frac{\Omega_2}{c}\frac{\partial \dot{\rho}_j}{\partial S_j} \quad \text{(differenced one-way doppler receiver j partials)}$$

where

Ω_2 = one-way multiplier

Ω_4 = two-way multiplier

Ω_6 = three-way multiplier

USE

CALL CATS

COMMON inputs:

RI	R_i, km
PHII	ϕ_i, deg
THETAI	λ_i, deg
GHA	α_G, deg
ELX	$\underline{L}$
AX	$\underline{A}$
DX	$\underline{D}$
TAX	$\underline{\tilde{A}}$
TDX	$\underline{\tilde{D}}$
RVEC	ρ_i, km
OMEGA	ω, deg/sec
X	$\underline{r}$, km
XDOT	$\underline{\dot{r}}$, km/sec
CZ2	Ω_2
CZ4	Ω_4
CZ6	Ω_6

COMMON output:

DIM3 partials $\frac{\partial F}{\partial S_i}$ $(12 \times 3 \times 15)$

CODING INFORMATION

Length of subroutine is 421 (10) or 645 (8) words.

REFERENCES

a. Warner, M. R., Nead, M. W., Hudson, R. H., TM33-168, March 18, 1964.

b. Anderson, John D., RFP 312-37, August 29, 1961.

IDENTIFICATION

COEF
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

COEF calculates the coefficients used by the ODP in doppler calculations. The subroutine is cognizant of band differences. All intermediate calculations are in double precision.

RESTRICTIONS

COMMON break: 47675
Subroutines used:
(DFAD)
(DFMP)
(DFSB)
QUIZ

METHOD

$$f_T = f_{T\ base} + \Delta f_T \quad \text{(transponder frequency)}$$

$$f_q = f_{q\ base} + \Delta f_q \quad \text{(transmitter frequency)}$$

$$\Omega_2 = \omega_2 [f_T + D(t_{ob} - t_0)]$$

$$\Omega_1 = \omega_1 + \Delta\omega_1 - \Omega_2$$

$$\Omega_4 = \omega_4 f_q$$

$$\Omega_3 = \omega_3 + \Delta\omega_3 \text{ for predicts} \quad \Omega_3 = 0 \text{ for data fitting}$$

$$\Omega_6 = \omega_6 f_q$$

$$\Omega_5 = \omega_5 + \Delta\omega_5 - \Omega_6 \text{ for predicts} \quad \Omega_5 = 0 \text{ for data fitting}$$

where for L to S band,

$$f_{T\ base} = 2290.0 \times 10^6 \text{ cps}$$

$$f_{q\ base} = 20.00 \times 10^6 \text{ cps}$$

$$k_1 = f_{q\ base} + \Delta k_1$$

$$\omega_2 = 0.3125$$

$$\omega_1 = 9.375 \times 10^6 \text{ cps}$$

$$\omega_4 = 32.579185520$$

$$\omega_3 = 9.375 \times 10^6 \text{ cps}$$

$$\omega_6 = 32.579185520$$

$$\omega_5 = 9.375 \times 10^6 \text{ cps}$$

$$\Delta\omega_1 = 30\ k_1$$

$$\Delta\omega_3 = 30\ k_1$$

$$\Delta\omega_5 = 30\ k_1$$

for L band,

$$f_{T\ base} = 960.0 \times 10^6 \text{ cps}$$

$$f_{q\ base} = 29.66 \times 10^6 \text{ cps}$$

$$\omega_2 = 0.96875$$

$$\omega_1 = 930.15 \times 10^6 \text{ cps}$$

$$\omega_4 = 32.359550561$$ 11-3 of 5

$$\omega_3 = 100000. \text{ cps}$$

$$\omega_6 = 31.348314605$$

$$\omega_5 = 930.15 \times 10^6 \text{ cps}$$

$$\Delta\omega_1 = \Delta\omega_3 = \Delta\omega_5 = 0$$

for S band,

$$f_{T\ base} = 2290.0 \times 10^6 \text{ cps}$$

$$f_{q\ base} = 20.00 \times 10^6 \text{ cps}$$

$$k_s = f_{q\ base} + \Delta k_s$$

$$\omega_2 = 1.0$$

$$\omega_1 = 1000000.$$

$$\omega_4 = 104.25339367$$

$$\omega_3 = 1000000.$$

$$\omega_6 = 104.25339367$$

$$\omega_5 = 1000000.$$

$$\Delta\omega_1 = \omega_6 k_s$$

$$\Delta\omega_3 = 0$$

$$\Delta\omega_5 =$$

also

D = transponder (beacon) drift

t_{ob} = observation time

t_0 = ODP epoch

USE

CALL COEF

COMMON input:

EP-6	band indication
EP-7	Δk_1, cps
EP-8	Δk_s, cps
TXCON	6 × 15 array of $\omega_1, \omega_2, \ldots, \omega_6$ coefficients for each station, d. p.
TFREQ	Δf_T, cps
XFREQ	Δf_q, cps
DXDR-4	D, cps/sec
TOB	observation time, d. p. sec past 1950.0
EPOCH	ODP epoch, d. p. sec past 1950.0
C1O	observed one-way doppler (flag)
CD1O	observed differenced one-way doppler (flag)
CC3O	observed two-way doppler (flag)
C3O	observed three-way doppler (flag)
CD3O	observed DSIF ranging (flag)

COMMON output:

CZ1	Ω_1
CZ2	Ω_2
CZ3	Ω_3
CZ4	Ω_4
CZ5	Ω_5
CZ6	Ω_6
RNJ	Ω_5, d. p.
PHINJ	Ω_6, d. p.

CODING INFORMATION

Length of subroutine is 503 (10) or 767 (8) words.

REFERENCES

a. Warner, M. R., Nead, M. W., Hudson, R. H., TM 33-168, March 18, 1964.
b. Wollenhaupt, Wilber R., RFP 312-268, April 16, 1964.
c. Wollenhaupt, Wilber R., RFP 312-319, September 3, 1964.

IDENTIFICATION

COL
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

COL calculates the G^2 terms in the weighting function

$$\sigma_j^2 = \sum_{p=1}^{6} S_{pjk}^2 \, G_{pj}^2 \max\left(\frac{t_{pjk}}{\tau}, 1\right)$$

RESTRICTIONS

a. COMMON break: 47675

b. Subroutines used:

COS
SQRT

METHOD

The computation of the g value depends on the value of the weight code group (p) and the data type (j). The following table indicates the g term for each of the p, j combinations:

12-2 of 3

Group index p		1	2	3	4	5	6
Data type index	j						
ρ_i	1	1	1	$\dot{\rho}_i$	ρ_i	$\Delta_r \rho_i$	1
$\dot{\rho}_i$	2	1	ρ_i	ρ_i	$\Delta_r \dot{\rho}_i$	1	
γ_i	3	1	1	1	$\Delta_r \gamma_i$		
σ_i	4	$\frac{1}{\cos \gamma_i}$	1	1			
δ_i	5	1	1	1	$\Delta_r \delta_i$		
a_i	6	$\frac{1}{\cos \delta_i}$	1	1	$\Delta_r a_i$		
f_{1i}	7	Ω_2	Ω_2	$\frac{1}{\tau}$	$\frac{\Omega_2}{c}$		
f_{c3i}	8	$\frac{\Omega_4}{c}$	$\frac{1}{\tau}$	$\frac{\Omega_4}{c} \frac{(\rho_i + \rho_q)}{2}$	$\frac{1}{\sqrt{3}\tau}$	$\frac{\Omega_4}{\tau c}(\lvert\Delta_r \dot{\rho}_i\rvert + \lvert\Delta_r \dot{\rho}_q\rvert)$	$\frac{\Omega_4}{c}$
f_{3i}	9	$\frac{\Omega_6}{c}$	$\frac{1}{\tau}$	Ω_6	$\frac{\Omega_6}{c}(\lvert\Delta_r \dot{\rho}_i\rvert + \lvert\Delta_r \dot{\rho}_q\rvert)$	$\frac{\Omega_6}{c}$	
f_{d1i}	10	$\frac{\Omega_2}{c} \rho_i \rho_j$	$\frac{\Omega_2}{c}(\rho_i - \rho_j)$	$\frac{1}{\tau}$	$\frac{\Omega_2}{c}(\lvert\Delta_r \dot{\rho}_i\rvert + \lvert\Delta_r \dot{\rho}_j\rvert)$	$\frac{\Omega_2}{c}$	
ρ_{DSIF}	11	1	1	$\dot{\rho}$	ρ	$\Delta_r \rho$	1

where

ρ = slant range
$\dot{\rho}$ = range rate
γ = elevation angle
δ = declination
$\Delta_r \rho$ = refraction correction to slant range
$\Delta_r \dot{\rho}$ = refraction correction to range rate
$\Delta_r \delta$ = refraction correction to declination
$\Delta_r a$ = refraction correction to hour angle
Ω_2 = one-way doppler multiplier
Ω_4 = two-way doppler multiplier
Ω_6 = three-way doppler multiplier
τ = doppler averaging time
c = velocity of light

USE

CALL COL

COMMON input:

RVEC	ρ, km
RDOT	$\dot{\rho}$, km/sec
EL	γ, deg
DEC	δ, deg
DRVEC	$\Delta_r \rho$, km
DRDOT	$\Delta_r \dot{\rho}$, km/sec
DRDEC	$\Delta_r \delta$, deg
DRHA	$\Delta_r a$, deg
CZ2	Ω_2
CZ4	Ω_4
CZ6	Ω_6
TAU	τ, sec
VELC	c, km/sec

COMMON output:

GSQ	g^2 (1×6)

CODING INFORMATION

Length of subroutine is 262 (10) or 406 (8) words

IDENTIFICATION 13

COMAP
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

COMAP checks the mapping requests which are made of the ODP. When step-mapping the product of the U matrices for mapping is computed, thus the U matrix which is used in the calculation of the closest approach parameters is:

$$U = U_{IMP} * U_{T_N} * \ldots * U_{T2} * U_{TI}$$

where U_{TN} are the matrices computed for each step-map time and U_{IMP} is evaluated at time of closest approach. Results of the mapping matrix calculations are stored on disk to be printed in a subsequent link.

RESTRICTIONS

a. ERROR condition: disk error indicated by DCr
b. COMMON break: 47055
c. Subroutines used:
   - TAMP
   - PROM
   - REAM
   - COMIMP
   - FLAK
   - FLOT
   - DCP
   - OFFSYS
   - TYPRYT

USE

This link is called under control of the JPTRAJ Source Deck.

CODING INFORMATION

Length of subroutine is 186(10) or 272(8) words.

IDENTIFICATION

COMIMP
Melba W. Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

To project the statistical information contained in the covariance matrix $\Gamma(t_0)$ to any later time.

RESTRICTIONS

a. COMMON break: 47055
b. Subroutines used:
   MAMUL
   PRAMS
   (DFAD)
   (DFSB)
   (DFMP)

METHOD

The procedure employs a mapping matrix

$$U t_0, t = \frac{\partial Q_t}{\partial Q_{t_0}}$$

which is an extended matrix of variational partials representing all estimated parameters Q_{t_0}. If the parameter set Q_{t_0} consists only of the six initial conditions, then this matrix is identical to the familiar U matrix. A similar mapping matrix is employed for including the effect of the considered parameter set $\widetilde{Q}_{t_0}$:

$$V t_0, t = \frac{\partial Q_t}{\partial \widetilde{Q}_{t_0}}$$

The mapping operation is then accomplished by

$$\Gamma_t = U \Gamma_{t_0} U^T - V \Gamma_{\widetilde{Q}} \nu^T J^{-1} U^T - U J^{-1} \nu \Gamma_{\widetilde{Q}} V^T + V \Gamma_{\widetilde{Q}} V^T$$

If no parameters are being considered, this reduces to

$$\Gamma_t = U\Gamma_{t_0}U^T$$

The covariance matrix of estimated parameters is defined as

$$\Gamma = J^{-1} + J^{-1}KJ^{-1}$$

where

$$J^{-1} = (J^* + \tilde{\Gamma}^{-1})^{-1}$$

and

$$K = \upsilon\Gamma_{\tilde{Q}}\upsilon^T$$

where

$\Gamma_{\tilde{Q}}$ = a priori covariance matrix of the m considered parameters

$$\upsilon = \sum_{i=1}^{N} \phi_i w^{-1} \theta_i^T$$

(θ_i is the analogous vector of partials of considered parameters)

USE

CALL COMIMP

The matrix thus generated is used in the calculation of the target centered covariance matrix (TACCOM) and the closest approach parameters.

CODING INFORMATION

Length of subroutine is 750(10) or 1356(8) words.

REFERENCE

Anderson, John D., RFP 312-37, August 29, 1961.

IDENTIFICATION 15

COMOUT
Michael R. Warner, JPL
IMB 7094 Fap
January 4, 1965

PURPOSE

COMOUT writes the midcourse and trajectory information on the COMENT region of disk.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   COMENT

USE

CALL COMOUT

COMMON input:

EP-63	midcourse COMENT buffer (29 words forward)
EP-104	trajectory COMENT buffer (17 words forward)

CODING INFORMATION

Length of subroutine is 14(10) or 16(8) words.

IDENTIFICATION

COROP
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

COROP computes the refraction corrections to optically obtained hour angle and declination.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   SQRT
   EXP(3)
   ARTAN
   SIN

METHOD

$$\Delta_r\gamma = \tan^{-1}\left(\frac{A}{\rho - B}\right) \quad \text{(correction to elevation angle)}$$

where

$$A = \frac{0.00211}{(\gamma/57.2957795 + 0.0598)^{2.42}}$$

$$B = \sqrt{C^2 - R_e^2 + R_e^2 \sin^2\gamma} - R_e \sin\gamma$$

$$C = R_e + 51.2064$$

ρ = slant range

R_e = earth equatorial radius

The program then uses $\Delta_r\gamma$ to obtain $\Delta_r\alpha$ and $\Delta_r\delta$ in the same manner as subroutine CORR (q.v.).

USE

CALL COROP

COMMON input:

RVEC	ρ, km
EL	γ, deg
RE	R_e, km

COMMON output:

DHA	$\Delta_r \alpha$, deg
DDEC	$\Delta_r \delta$, deg

CODING INFORMATION

Length of subroutine is 120(10) or 170(8) words.

REFERENCES

a. Warner, M. R., Nead, M. W., Hudson, R. H., TM 33-168, March 18, 1964.

b. Cain, Dan L., TM 312-275, February 14, 1963.

IDENTIFICATION

CORR

Michael R. Warner, JPL

Fortran II, Version 3

January 4, 1965

PURPOSE

CORR calculates the refraction corrections and the vertical displacements for angular tracking data.

RESTRICTIONS

a. COMMON break: 47675

b. Subroutines called:

SIN

SQRT

METHOD

$$\Delta_r\gamma = 57.2957795 \frac{n}{340.0} b_1 b_2 \qquad \gamma < 0.3 \text{ radians}$$

$$\Delta_r\gamma = 57.2957795\, n \times 10^{-6} \frac{\cos\gamma}{\sin\gamma} \qquad \gamma \geq 0.3 \text{ radians}$$

$$\Delta_r\alpha = \frac{\Delta_r\gamma \cos\phi \sin^2\alpha}{\cos^2\gamma \sin\sigma} \qquad \delta < 87°$$

$$\Delta_r\delta = \frac{(\sin\phi\cos\gamma - \sin\gamma\cos\phi\cos\sigma)\Delta_r\gamma}{\cos\delta} \qquad \delta < 87°$$

$$\Delta_r\alpha = \Delta_r\delta = 0 \qquad \delta \geqq 87°$$

$$b_1 = 1.0 - (1.216 \times 10^5 b_3 \gamma_{rad}) - (51.0 - 300.0\,\gamma_{rad})\sqrt{b_3}$$

$$b_2 = \left[7.0 \times 10^{-4}/(0.0589 + \gamma_{rad})\right] - 1.26 \times 10^{-3}$$

$$b_3 = \frac{1}{10^3(r - R_i)}$$

$$\Delta_v \alpha = \frac{v}{\cos \phi}$$

$$\Delta_v \gamma = u \cos \sigma$$

$$\Delta_v \sigma = u \sin \sigma \frac{\sin \gamma}{\cos \gamma}$$

$$\Delta_v \delta = 0$$

where

γ = elevation angle (γ_{rad} = γ in radians)
σ = azimuth angle
α = hour angle
δ = declination
Δ_r = refraction correction
Δ_v = vertical correction
n = index of refraction (nominally 340.0)
ϕ = geocentric latitude of station
r = geocentric probe distance
R_i = Earth radius at station i
u = north-south displacement of vertical
v = east-west displacement of vertical

USE

CALL CORR

COMMON input:

SINEL	sin γ
IFA-9	$\neq 0$ to bypass Δ_r and Δ_v calculation
EL	γ
ELZ	sin δ
X, Y, Z	geocentric probe vector
RI(i)	Earth radius at station i
FNI(i)	index of refraction at station i
COSEL	cos γ
HA	α
COSPHI	cos ϕ
SINAZ	sin σ

COSAZ	cos σ
UI(i)	north-south displacement, station i
VI(i)	east-west displacement, station i

COMMON output:

DEL	$\Delta_r\gamma + \Delta_v\gamma$
DHA	$\Delta_r a + \Delta_v a$
DAZ	$\Delta_v\sigma$
DDEC	$\Delta_r\delta$

CODING INFORMATION

Length of subroutine is 188(10) or 274(8) words.

REFERENCES

a. Warner, M. R., Nead, M. W., Hudson, R. H., TM 33-168, March 18, 1964.

b. Cain, Dan L., IOM to W. Hoover, July 6, 1960.

c. Cain, Dan L., IOM to W. Hoover, October 4, 1960.

IDENTIFICATION

CXPLOT/XXXFSR/CDC
John R. Schoeni, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

To generate on the computer plotting tapes to be displayed on the SC-4020 microfilm recorder. Controlled by a set of pseudo-operations, the routine will scale data, generate and label grid lines, and annotate the plotted information.

RESTRICTIONS

a. ERROR return when incorrect calling sequence is given.
b. Subroutine used:
   IOCS

USE

CXPLOT uses IOCS to control I/O buffering and the user before calling CXPLOT must open a reserve file for the subroutine's use. In defining the buffer pool to be attached to the plotting file, it is recommended that at least two buffers of up to 200 words in length be assigned. The entry into CXPLOT is from a FAP calling sequence and consists of a call CXPLOT followed by pseudo-operations which specify the operations to be performed. The calling sequence is terminated by an error exit of the form, PZE A, where A is the location of the users error routine. Normal return is to the location following the error return. The following pseudo-operations are recognized.

FVE N, T, D FVE O, O, O	Selection of tape unit and indication of film advance
SIX SX, L, SY SIX F, SIZE, D	Printing horizontal titles
SVN SX, L, Sy SVN F, SIZE, D	Printing vertical titles
PON Rx_0,, Rx_n PON Ry_0,, Ry_n PON n, e, p PON m, e, q PON Fx,, Fy PON X_0,, X_n PON Y_0,, Y_n	Generation and labelling of grid

PTW Lx_0, EX, Ly_0 PTW N, A, CHAR	Generation of graph
PTH X, t, Y	Generation of special grid line or form flash
MZE O, t, N	Termination of plot
PZE A,	Error return

CONTROL PSEUDO-OPERATIONS

<u>FVE N, T, D</u>

An FVE pseudo-operation must be the first pseudo-operation encountered in the first calling sequence to CXPLOT in a program because it causes various addresses throughout the subroutine to be initialized.

<u>N</u> In the FVE pseudo-operation, N indicates that every Nth point will be plotted. N = 0 = 1

<u>T</u> T = 1 will cause a film advance command to be generated. T = 0 indicates no frame advance.

<u>D</u> is the symbolic location of the File Control Block that has been opened for this file.

<u>FVE O, O, O</u>

A second FVE pseudo-operation is used when the output is to be written on the IBM 7094 using a packed format and high density tape mode. The plot tape generated by the use of this option requires processing on the 1401 before being plotted on the SC-4020. The Standard SFOF mode of operation is high density and packed.

<u>MZE O, T, N</u>

The MZE pseudo-operation gives information required to terminate a particular plot or set of plots.

If <u>N</u> is zero, the instruction is treated as a skip, and control will pass to the next pseudo-operation.

If <u>N</u> is non-zero, STOP PRINT and ADVANCE FRAME commands will be generated and written on the tape previously specified.

<u>T</u> not used.

<u>PZE A</u>

The PZE pseudo-operation indicates the end of the calling sequence. Normal exit is to the instruction following this pseudo-operation. "A" is the address of a user supplied error routine.

SIX SX, L, SY
SIX F, SIZE, D

The SIX pseudo-operations give information required for printing horizontal titles. The first operation in the pair describes where the title is to be located. The second operation tells the location of the format statement and the letter size. Six pseudo-operations must always occur in pairs.

L = 1 SX and SY designate the X and Y coordinates locating the center of the title.

L = 0 SX and SY designate the X and Y coordinates locating the position at which the first character of the title is to be centered.

F designates the location of the format statement to be used for the title. The format statement starting at location F must be of the form

(xHyz -----------).

x an integer indicating the number of hollerith characters which follow the H.

y if blank the current frame will be used. This is the normal case.

y if equal to 1, a film advance command is generated before printing this title.

z is always a blank character.

SIZE designates the letter size and may have the values 0, 1, 2, 3 specifying that letters of 1, 2, 4, or 8 times normal size are to be used. (Caution: a character 8 times normal size is 64 by 128 units in size.)

D When printing normal size letters, SIZE is zero, D indicates whether the letters will be generated by the vector generator or by the plotting matrix.

D = 0: plotting matrix.
D = 1: vector generator.

VERTICAL TITLES

SVN SX, L, SY
SVN F, SIZE, D

The SVN pseudo-operations give information required for printing titles vertically. They are analogous to the SIX pseudo-operations in format.

GRIDS & LABELS

PON

The PON pseudo-operations specify the grid lines to be drawn, the exposure to be used in drawing them, the formats to control their labelling and the scaling to be used in the plot.

The first five PON pseudo-operations must be used as a group. 18-4 of 6

PON Rx_0, , Rx_n
PON Ry_0, , Ry_n
PON n, e, p
PON m, e, q
PON FX, , Fy

PON Rx_0, , Rx_n

Rx_0 is the location of the lower end of the range of x values.
Rx_n is the location of the upper end of the range of x values.

The limits for the range will be in floating point form.

PON Ry_0, , Ry_n

is analogous to the PON Rx_0, , Rx_n for the range of y.

PON n, e, p

contains an integer n specifying the number of uniform intervals in the x-direction (vertical grids) to be bounded by grid lines, and an integer p indicating that the first grid line and every p^{th} grid line following will be labelled. If e = 1, the labelled grid lines will be drawn heavy; otherwise they will be light (vertical grids).

PON m, e, q

This is analogous to the third PON but refers to the y-direction (horizontal grids).

PON Fx, , Fy

contains the locations of format statements to be used in labelling the horizontal and vertical grid lines, respectively. These should be of the form:

FX BCI , (F c.d),

where

F indicates that a conversion from a floating point number to fixed point number should be performed, and that the fixed point number should be printed.

c designates the "column width." ($c \leq 9$)

d designates the number of digits to be retained to the right of the decimal point. $d < (c-1)$

PON X_0, , X_n
PON Y_0, , Y_n

The sixth and seventh PON pseudo-operations specify the area of the character on surface (1023 × 1023) to be used for plotting. These two PON pseudo-operations may be omitted, and if so the standard case of

PON 96,,992

PON 0,,896

will be assumed by the subroutine.

PON X_0,,X_n

is the range of the horizontal positions to be used

$$(0 \leqslant X_0 < X_n \leqslant 1023).$$

PON Y_0,,Y_n

contains the range of vertical positions to be used for the graph

$$(0 \leqslant Y_0 < Y_n \leqslant 1023).$$

GENERATION OF GRAPH

PTW Lx_0, EX, Ly_0

PTW N, A, CHAR

The PTW pseudo-operations specify the character and the exposure to be used in plotting, the memory area containing the sets of (x, y) values to be plotted, and the scaling factors to be used.

Lx_0 designates the starting memory location for the sequence of values of x to be plotted.

Ly_0 designates the starting location for the corresponding values of y.

N designates the number of pairs of values of x and y to be plotted.

Thus, locations Lx_0 to Lx_o+N - 1 contain the values of x corresponding to the values of y found in locations Ly_0 to Ly_0+N - 1.

Note the special case where the data are in x, y pairs. N is the number of c and y values, and the address of the FVE pseudo-operation is set to 2. The same type of logic applies to triplets, etc.

EX designates the exposure to be used in plotting. If EX = 0, the exposure will be heavy; otherwise, the light mode will be used.

A=0 The scaling factors computed from the previous set of PON pseudo-operations will be used.

A≠0 The four locations following the pair of PTW instructions should contain the location of floating point values of a, b, c, and d in that order.

For each pair of values, x, y, a corresponding pair of coordinates (X, Y) is computed by the subroutine as follows:

$$X = ax + b$$

$$Y = cy + d$$

where

a, b, c and d are the scaling parameters. They depend upon the range of coordinates to be used when plotting the range of values specified.

If, in scaling, a point is either $0 > X > 1024$ or $0 > Y > 1024$, the point is discarded.

CHAR The Hollerith character to be used for the plot is given in the six bit positions 30 to 35 of location CHAR.

JOINING POINTS BY VECTORS

If the character specified is the space the vector generator will be used for the plot, and successive points will be connected using straight line segments.

PTH X, t, Y

The PTH pseudo-operation allows the programmer two options: one to draw grid lines directly in either the x or y direction, and one to control usage of the form flash.

t = 0 A horizontal grid line will be drawn beginning at X, Y and extending to the right edge of the frame.

t = 1 A vertical grid line will be drawn from X, Y to the upper edge of the frame.

t = 4 A form flash command will be generated. Care must be taken not to generate more than one form flash on the same plot.

CODING INFORMATION

Length of subroutine is 1744(10) or 3320(8) words.

IDENTIFICATION

DATAPE
Melba W. Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

To generate a simulated data file for checking and for study programs.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   - IXTAB
   - OFFSYS
   - (DFAD)
   - TIMER
   - LOOKUP
   - INTR1
   - GHADP
   - COEF
   - DOPLR
   - CORR
   - ND2F
   - FILT

Types of doppler are limited as follows:

If IX (transmitter) = 0, C3 and CC3 are zero.
If IX $\neq$ 0, IR (receiver) $\neq$ IX, C1 and CC3 are zero.
If IX $\neq$ 0, IR = IX, C1 and C3 are zero.

METHOD

Data identified under the control card DATA TAPE SIGMA will be included on the file. Weights for each data type must be included under WEIGHTS BY DATA TYPE AND STATION. The equation for the computation of the data value in the file is:

$$R(I) = Rc(I) + \Delta R(I) + F(I, IR) * A + B(I, IR)$$

where

R(I) = the array of data where I references the data type
Rc(I) = calculated value of the data point

$\Delta R(I)$ = correction on calculated value

F(I, IR) = noise factor on data by type and station. This provided by setting the data type under DATA TAPE SIGMA to a floating point number.

A = random number

B(I, IR) = bias. Obtained by value under DATA TAPE BIAS according type.

Data is calculated by the same routines employed in the fitting of data.

USE

CALL DATAPE

CODING INFORMATION

Length of subroutine is 301(10) or 455(8) words.

IDENTIFICATION 20

DECOD
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

DECOD determines the group value for the given group number of the weight code word. This word consists of six 3-bit groups from bit S through bit 17. Each group may have a value from 0 through 7. DECOD also floats the data sample rate, which occupies the address portion of the weight code word.

RESTRICTION

COMMON break: 47675

USE

CALL	DECOD	
PZE	J	group number
PZE	K	group value
COMMON input:		
RVECW		weight code array (1 × 11)
ID		data type identification
COMMON output:		
TS		sample rate, sec.

CODING INFORMATION

Length of subroutine is 32 (10) or 40 (8) words.

IDENTIFICATION 21

DIAG/DIAGO
Melba W. Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

To compute standard deviation of the mapped forward covariance matrix or standard deviation of input covariance matrix.

RESTRICTIONS

a. COMMON break: 47675
b. Each subroutine computes the square root of the diagonal of a specific matrix.
c. Subroutines used:
   SQRT

USE

CALL	DIAG	Standard deviation of input covariance matrix
CALL	DIAGO	Standard deviation of mapped forward covariance matrix

CODING INFORMATION

Length of each subroutine is 105 (10) or 151 (8) words.

IDENTIFICATION 22

DICOS
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

DICOS computes the direction cosine vectors $\underline{A}$, $\underline{D}$, $\tilde{\underline{A}}$, and $\tilde{\underline{D}}$, which are defined in the documentation of subroutine CATS.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   SIN/COS

USE

CALL DICOS

COMMON input:

DEC	δ, deg
GHA	α_G, deg
THETAI	λ_i, deg
EL	γ, deg
AZI	σ, deg
PHII	ϕ_i, deg

COMMON output:

AX	$\underline{A}$
DX	$\underline{D}$
TAX	$\tilde{\underline{A}}$
TDX	$\tilde{\underline{D}}$

CODING INFORMATION

Length of subroutine is 123 (10) or 173 (8) words.

IDENTIFICATION

(DISCBU) REDE/RITE/PISA
Charles Coltharp, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

DISCBU provides elementary buffering for reading and writing scratch information on disk.

RESTRICTIONS

Subroutines used:

DCP

METHOD

DISCBU uses DCP for reading and writing the disk. All physical records are 200 words in length. Each logical record is preceded on the disk by a control word,

```
PZE O,,L
```

where L is the number of words in the logical record. L may be zero, but L will never be greater than 200.

A control word of

```
MZE O,,O
```

denotes a logical end of file.

USE

```
To write   CALL   RITE
           PZE    FILE,,   ERREOF
           IOXY   A,,      N
```

```
To read  CALL   REDE
         PZE    FILE,,   ERREOF
         IOXY   A,,      N
         .
         .
         .
```

A is the location into which information is read, or from which it is written.

TCH, transfer in channel, will be recognized by both read and write operations.

The tag portion of all IO commands is ignored.

The address and decrement portions of IOCD commands are ignored.

Closed or unopened files are opened automatically by the first read or write operation requested.

Read Operation

IOCD	Rewind file; close file. When IOCD is used it must be the only command in the command list.
IOCP	Read N words, ignoring logical record marks, and proceed to next command. If this command precisely finishes a record, the logical end of record may be recognized by the next command.
IOCT	Read N words, ignoring logical record marks, and terminate IO. Unread words in a partially read record will be lost.
IORP	Read to logical record mark (read one whole record, or finish a record already started), and proceed to next command. Put number of words read into the decrement portion of the IORP command. N is not interpreted.
IORT	Same as IORP, but terminate IO.
IOSP	Same as IORP if the number of words in the record is less than or equal to N. Otherwise, transmission is stopped after N words have been read. Unread words in this record will be lost. Control proceeds to the next command.
IOST	Same as IOSP, but terminate IO.

Write Operation

IOCD	Write logical EOF, rewind file; close file. When IOCD is used it must be the only command in the command list.
IOCP	Write N words, and proceed to next command.
IOCT	Write N words followed by a logical record mark, and terminate IO
IORP	Write N words followed by a logical record mark, and proceed to next command.

IORT Same as IOCT.

IOSP Same as IORP.

IOST Same as IORT.

If at any time in writing, a record reaches a length of 200 words before a logical record mark is indicated by the user, DISCBU will insert a logical record mark before continuing the transmission.

File Block

```
FILE   BCI   1,   XXXXXX
   +1  PZE   J    (decrement = P)
   +2  PZE   K    (decrement = Q)
   +3  PZE   BUFFER   (decrement = R)
   +4  PZE   200
```

XXXXXX an entry in the disk directory, defined as scratch

J that record in XXXXXX with which this file begins

K that record in XXXXXX with which this file ends

BUFFER the location of a 400 word block of core storage

The decrements of FILE +1 through FILE +3 (the items in parentheses, above) will be used by DISCBU for bookkeeping. These items will be zero when the file is not open, and they should be set zero initially by the user.

P last disk record transmitted

Q buffer designation

0 = next disk transmission will be from (or into) BUFFER + 0

1 = next disk transmission will be from (or into) BUFFER + 200

R location of next word in BUFFER to be read or written.

FILE +4 is the location given to DCP for the flag word. Initially this must be a positive, non-zero number.

Error - End of File Return

Control is returned to ERREOF under the conditions described below.

If an error is indicated by DCP, that indication will be in the AC on return. The error codes are described in the design specifications for DCP.

If the user tries to exceed the self-imposed file bounds (K is the largest usable disk record in XXXXXX), the AC on return will be MZE 0,0,-1.

No provision is made for continuing if the condition occurs on a read operation. Before the file may be used again, the user must issue the sequence

```
CALL   REDE
PZE    FILE,,   ERREOF
IOCD
```

to close and rewind the file.

If the condition occurs on a write operation, the user may continue, provided all seven index registers are preserved, by executing

TRA $PISA.

However, K should be increased if the user wishes to read the material back at a later time.

If a logical EOF is encountered by a read operation, the AC will be plus zero.

CODING INFORMATION

Length of subroutine is 273 (10) or 421 (8) words.

IDENTIFICATION 24

DNAME
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

DNAME contains a list of the BCD names of the eleven ODP data types.

USE

The BCD names, one per word, are stored backward. The entry point, DNAME, is assigned to the first logical location (last physical location).

CODING INFORMATION

Length of subroutine is 12 (10) or 14 (8) words.

IDENTIFICATION

DOPLR
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

DOPLR obtains the calculated values of the ODP data types.

RESTRICTIONS

COMMON break: 47675

Subroutines called:

- ABDD
- ARSIN
- ARTAN
- DMOD
- RATES
- SQRT
- VEC
- (DFAD)
- (DFMP)

METHOD

DOPLR first obtains the fine light-time correction in a two-iteration procedure:

$$\epsilon = 0$$

$$\underline{r}_t = \underline{r}'_t + \epsilon \dot{\underline{r}}'_t$$

$$\dot{\underline{r}}_t = \dot{\underline{r}}'_t + \epsilon \ddot{\underline{r}}'_t$$

$$\ddot{\underline{r}}_t = \ddot{\underline{r}}'_t + \epsilon \dddot{\underline{r}}'_t$$

$$\dddot{\underline{r}}_t = \dddot{\underline{r}}'_t$$

$$\Delta t = \frac{\rho + \Delta t' \dot{\rho}}{C + \dot{\rho}}$$

$\epsilon = \Delta t' - \Delta t$; the procedure is then repeated.

where

$\Delta t' =$ coarse correction from subroutine TIMER

$t' = t_{ob} - \Delta t'$

$\rho =$ slant range at t'

$\dot{\rho} =$ range rate at t'

$c =$ speed of light

The eleven ODP data types are then obtained. DOPLR calls subroutine RATES to obtain slant range and its derivatives and all other leg-dependent quantities:

$$\rho = \left| \underline{r}_t - \underline{R}_{it_{ob}} \right| \qquad \text{(slant range)}$$

where

$\underline{r} =$ geocentric position vector of probe

$\underline{R}_i =$ geocentric position vector of station i

$$\dot{\rho} = \frac{\underline{\rho} \cdot \underline{\dot{\rho}}}{\rho} \qquad \text{(range rate)}$$

where

$\underline{\rho} =$ topocentric position vector of probe

$\underline{\dot{\rho}} =$ topocentric velocity vector of probe

$$\gamma = \sin^{-1} \frac{\underline{R}_i \cdot \underline{L}}{R_i} \qquad \text{(elevation angle)}$$

where

$$\underline{L} = \frac{\underline{\rho} + \underline{r}_s}{\rho}$$

$R_i =$ Earth radius at station i

$\underline{r}_s =$ geocentric position vector of Sun

$$\sigma = \tan^{-1} \frac{\sin \sigma}{\cos \sigma} \qquad \text{(azimuth angle).}$$

where

$$\sin \sigma = \frac{L_y \cos(\alpha_G + \lambda_i) - L_x \sin(\alpha_G + \lambda_i)}{\cos \lambda_i}$$

$$\cos \sigma = \frac{-L_x \sin \phi_i \cos(\alpha_G + \lambda_i) - L_y \sin(\alpha_G + \lambda_i)\sin \phi_i + L_z \cos \phi_i}{\cos \gamma_i}$$

α_G = Greenwich hour angle

λ_i = longitude of station i

ϕ_i = geocentric latitude of station i

$$\alpha = \alpha_G + \lambda_i - \tan^{-1}\left(\frac{\rho_y}{\rho_x}\right) \quad \text{(hour angle)}$$

$$\delta = \sin^{-1} L_z \quad \text{(declination)}$$

$$f_1 = \Omega_1 + \Omega_2\phi_1 \quad \text{(one-way integrated doppler frequency)}$$

$$f_{c3} = \Omega_3 + \Omega_4\phi_3 \quad \text{(coherent three-way integrated doppler frequency)}$$

$$f_3 = \Omega_5 + \Omega_6\phi_3 \quad \text{(three-way integrated doppler frequency)}$$

where

$\Omega_1, \Omega_2, \cdots \Omega_6$ are defined in COEF writeup.

$$\phi_1 = \frac{\dot{\rho}_i}{c} - \frac{1}{c^2} h_1 - \frac{\dddot{\rho}_i}{c} \frac{\tau^2}{24}$$

$$\phi_3 = \frac{1}{c}(\dot{\rho}_i + \dot{\rho}_q) - \frac{1}{c^2} h_3 - \frac{1}{c}(\dddot{\rho}_i + \dddot{\rho}_q) \frac{\tau^2}{24}$$

τ = doppler counting interval

q = transmitter index

i = receiver index

$$h_1 = \frac{\dot{\rho}}{\rho}\, \underline{\rho} \cdot (\underline{r} - \underline{r}_s) + \frac{1}{2}\left(\dot{R}_{it_{ob}} - \dot{r}_t^2\right)$$

$$h_3 = \dot{\rho}_i^2 + \dot{\rho}_q \dot{\rho}_i + \frac{\dot{\rho}_i}{\rho_i}\, \underline{\rho}_i \cdot \left(\dot{\underline{R}}_{it_{ob}} - \dot{\underline{r}}_{st}\right)$$

$$- \frac{\dot{\rho}_q}{\rho_q}\, \underline{\rho}_q \cdot \left(\dot{\underline{R}}_{qt_{tr}} - \dot{\underline{r}}_{st}\right) + \frac{1}{2}\left(\dot{R}_{it_{ob}}^2 - \dot{R}_{qt_{tr}}^2\right)$$

$$f_{d1} = f_{1i} - f_{1j} \qquad \text{(differenced one-way doppler from stations i and j)}$$

where f_{1i} and f_{1j} are one-way doppler values which must be taken simultaneously at stations i and j

$$\rho_{DSIF} = \frac{\Omega_6(\rho_q + \rho_i)}{16\,c} + \epsilon \qquad \text{(DSIF ranging)}$$

where

ϵ = ranging system bias

USE

CALL DOPLR

COMMON input:

DELT	$\Delta t'$, d.p. sec past 1950.0
X	$\underline{r}(1 \times 3)$, km
XDOT	$\dot{\underline{r}}(1 \times 3)$, km/sec
XAC	$\ddot{\underline{r}}(1 \times 3)$, km/sec^2
XJERK	$\dddot{\underline{r}}(1 \times 3)$, km/sec^3
VELC	c, km/sec
CZ1, · · · CZ6	$\Omega_1, \cdots \Omega_6$
RVECO	observed values of ODP data types (1×11)
OMEGA	Earth rotation rate, deg/sec

COMMON output:

RVEC	calculated values of ODP data types (1×11)
DELT2	Δt, d.p. sec past 1950.0

CODING INFORMATION

Length of subroutine is 715 (10) or 1313 (8) words.

REFERENCE

Warner, M. R., Nead, M. W., Hudson, R. H., TM 33-168, March 18, 1964.

IDENTIFICATION

ENDIT
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

ENDIT sets up and solves the normal equations. The covariance matrix

$$\Gamma = J^{-1} + J^{-1} KJ^{-1}$$

is obtained from the matrices accumulated by subroutine FORM. The ΔQ vector is retained for subsequent output.

RESTRICTIONS

COMMON break: 47675
Subroutines used:
- (DFSB)/(DFMP)/(DFAD)
- PRIM
- SQRT
- STPREG
- REVRT
- NOUT

METHOD

The matrix inversion is accomplished by subroutine STPREG (q.v.).

USE

CALL ENDIT
COMMON input:

KLIST	attitude control estimate flags
FABC	attitude control coefficients

ILIST	initial conditions estimate flags
XNJ	initial conditions
LLIST	physical constants estimate flags
GRAVE	physical constants
MLIST	velocity of light estimate flag
VELC	velocity of light
NLIST	station locations estimate flags
RI	station locations
GFLIP	a priori Γ^{-1}
QTILD	nominal values corresponding to QTILD
NEST	number of estimated parameters
NCON	number of considered parameters
RIGHT	accumulated right-hand side
XJ	accumulated normal matrix
SOUR	sum of squares
NTOT	number of data points
XX	accumulated consider matrix
XMU	accumulated consider vector

COMMON output:

QNU	updated parameter list
RIGHT	ΔQ vector
XJ	J inverse
CPGAM	covariance matrix
XNJ, GRAVE, RI, FABC	updated parameters
CAPQ	Q sum of squares

CODING INFORMATION

Length of subroutine is 828 (10) or 1474 (8) words.

IDENTIFICATION 27

EPPHEM
Melba W. Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

To prepare an ephemeris tape with complete information required from the planetary ephemeris and the probe ephemeris for each time point of the ODP. This program checks the requirements of each iteration and interpolates and if necessary integrates the partials of the physical constants. The information is written on tape A-4.

RESTRICTIONS

a. COMMON break: 47055
b. Subroutines used:
    GAMAT
    LOOKUP
    RITEM
    TOCIM
    INTR1
    PONT
    STARP
    WREOF
    KINE
    QUIZ
    TIMER
    (DFSB)

METHOD

EPPHEM is primarily a logical decision box, which accomplishes its task through the use of subroutines. A flow chart is given to supply further clarification.

USE

CALL EPPHEM

CODING INFORMATION

Length of subroutine is 361 (10) or 551 (8) words.

IDENTIFICATION

ERROR
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

ERROR prints ODP error condition messages. There are three versions of this subroutine in the ODP; the version in link LA9 prints recoverable error condition messages, the version in link LA12 prints unrecoverable error messages, and the version in the other links stores the calling sequence for subsequent action by LA12.

RESTRICTIONS

COMMON break: 47675

Subroutines used: (LA9)
- TYPRYT
- ONLIN

Subroutines used: (LA12)
- TYPRYT
- PROUT
- ENDSYS
- RECOV

USE

```
CALL  ERROR
PZE   I  )
PZE   J  }   Decrement integers
PZE   K  )
```

I	Error message	Version
1	INCORRECT RECORD NUMBER IN DISK CALLING SEQUENCE	LA12
2	WEIGHT (J = ID) FOR STATION (K = IR) = 0	LA12
3	DISK STORAGE NOT ALLOCATED FOR THIS JOB	LA9

4	ESTIMATE OR CONSIDER LIST EXCEEDS 20 PARAMETERS	LA9
5	NO INPUT RECEIVED WITHIN TIME LIMIT	LA9
6	PROGRAM UNABLE TO READ/WRITE PROBE EPHEMERIS	LA12
7	FIRST PROBE EPHEMERIS TIME GREATER THAN LOOKUP ARGUMENT	LA12
8	LAST PROBE EPHEMERIS TIME LESS THAN LOOKUP ARGUMENT	LA12
9	INJECTION CONDITION = 0	LA9
10	INPUT J MATRIX NOT N*N	LA9
11	INADMISSIBLE SYMBOL OR DATA FIELD	LA9
12	INPUT CONSIDER MATRIX NOT M*M	LA9
13	POINTING TIME LESS THAN EPOCH + R/C	LA9
14	MAPPING TIME LESS THAN EPOCH	LA9
15	DISK TRANSMISSION ERROR	LA12, LA9
16	DISK BUFFER ALLOCATION INSUFFICIENT	LA12
17	PLANETARY EPHEMERIS ERROR	LA12
18	DATA POINT OUT OF TIME SORT	LA12
19	ERROR IN CXPLOT CALLING SEQUENCE	LA12
20	ERROR IN DP SQRT SUBROUTINE	LA12, LA9
21	LOOKUP TIME FAILS TO MATCH TIME ON EPHEMERIS TAPE	LA12

The second line of messages 1, 2, 3, 6, 7, 8, 15, 16, 17, 18, 19, 20, 21, is

RECOVERY IMPOSSIBLE. JOB ABORTED.

The second line of messages 4, 5, 9, 11, 13, 14, is

USER MUST CORRECT AND RELOAD INPUT DECK WITHIN 3 MINUTES.

The second line of messages 10, 12, is

CONDITION IGNORED. JOB WILL CONTINUE.

CODING INFORMATION

Length of the LA9 version is 286 (10) or 436 (8) words.

Length of the LA12 version is 326 (10) or 506 (8) words.

Length of the dummy version is 9 (10) or 11 (8) words.

IDENTIFICATION 29

FDATA
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

FDATA stores the nominal values of the S and T weighting tables in COMMON arrays SSQ and TL, respectively. The S values are squared prior to their storage in SSQ.

RESTRICTIONS

COMMON break: 47675

USE

CALL FDATA

CODING INFORMATION

Length of subroutine is 591 (10) or 1117 (8) words.

REFERENCE

Hamilton, Thomas W., Inter-Office Memorandum to M. Warner, June 1962.

IDENTIFICATION

FILL/FILT
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

FILL writes the ODP residual file on disk in the same physical format as the ODG-generated data file. It is also used to write the tracking predictions on disk for subsequent output. FILT writes a simulated ODG data file on disk. Both entries use the RITE entry of the buffered disk routine DISCBU.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   RITE
   PISA

USE

```
CALL    FILL
PZE

CALL    FILT
PZE
```

COMMON input:

TOB	time of observation, d.p. sec past 1950.0
RVEC	array of computed data types (1 × 11)
RVECD	array of residuals (1 × 11)
RVECW	array of weights (1 × 11)
IF5	≠ 0 normal entry, = 0 end-of-file entry
EP-6	band designation
XFREQ	transmitter frequency
TFREQ	transponder frequency
IR	receiver ID, B17
IX	transmitter ID, B17
TAU	doppler averaging time, sec

COMMON output:

TAB-799 400 word output buffer for DISCBU

The disk logical record format is as follows:

Word	0	word count (2N + 5, B17) or - 0 for EOF	
	1	TOB	
	2	TOB-1	
	3	XFREQ if IX ≠ 0	
		TFREQ if IX = 0	
	4	0	
	5	bit S	1 if L - S band
			0 if L or S band
		1	1 if RVEC ≠ 0
		2	1 if RVEC - 1 ≠ 0
		3	1 if RVEC - 2 ≠ 0
		.	.
		.	.
		.	.
		11	1 if RVEC - 10 ≠ 0
		12-15	not used
		16	1 if L - S or S band
			0 if L band
		17	not used
		18-21	IX
		22-25	IR
		26-35	TAU
	6	first member of RVEC which is non-zero	
	7	bits S-17 RVECD corresponding to word 6	
		18-35 RVECW corresponding to word 6	
	8	second member of RVEC which is non-zero	
	9	second RVECD - RVECW word	
	.		
	.		
	.		
	2N + 4	Nth member of RVEC which is non-zero	
	2N + 5	Nth RVECD - RVECW word	

CODING INFORMATION

Length of subroutine is 191 (10) or 277 (8) words.

IDENTIFICATION 31

FIRST
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

Main program for link 1 of SFOF-JPTRAJ version of the JPL Orbit Determination Program. FIRST clears COMMON and formats the rejection table on the disk.

RESTRICTIONS

a. ERROR condition: disk error indicated by DCP
b. COMMON break: 46711
c. Subroutines used:
    FDATA
    NOMNL
    FLAK
    DISCBU

USE

Initiates ODP by clearing COMMON and calling subroutines to store the permanent or semi-permanent information. This link is called only once per "run" of the ODP.

CODING INFORMATION

Length of subroutine is 427 (10) or 653 (8) words.

IDENTIFICATION 32

FIT

Melba W. Nead, JPL

IBM 7094 Fap

January 4, 1965

PURPOSE

Main program for link 6. The purpose of the routine is to control calculation of the observables and the linkage.

RESTRICTIONS

a. ERROR condition: disk error indicated by DCP

b. COMMON break: 46711

c. Subroutines used:

CALL

OCIM

FLAK

DISCBU

TAPIO

USE

When fitting data, this link is called by the JPTRAJ monitor.

CODING INFORMATION

Length of subroutine is 476 (10) or 734 (8) words.

IDENTIFICATION 33

FLAT/FLAPR/FLAK

Melba W. Nead, JPL

IBM 7094 Fap

January 4, 1965

PURPOSE

Subroutine to check the I/O activity flags.

RESTRICTIONS

a. ERROR exit to indicate disk I/O error

b. Subroutines used:

ERROR

TYPRYT

USE

CALL	FLAT	To check TAPIO flag
CALL	FLAPR	To check PROUT flag
CALL	FLAK	To identify disk error return

CODING INFORMATION

Length of subroutine is 64 (10) or 100 (8) words.

REFERENCE

EPD - 125, Rev. 1, April 1, 1964

IDENTIFICATION

FORM
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

FORM sets up the column matrix of partials $\partial F/\partial Q$ and accumulates the normal matrix J.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   PARLEY
   (DFMP)/(DFAD)/(DFSB)
   SQRT

METHOD

The partials $\partial F/\partial Q$ are obtained by the chain rule when Q is an initial condition or physical constant:

$$\frac{\partial F}{\partial Q} = \frac{\partial F}{\partial \underline{r}} \frac{\partial \underline{r}}{\partial Q}$$

If Q is the velocity of light or a station parameter, $\partial F/\partial Q$ are computed analytically and input to FORM.

USE

A = 1.0	to execute entire routine
CALL FORM	
A = -1.0	to bypass chain rule section (occultation or impact time partials)
CALL FORM	

COMMON input:

RVECW	weight for data type ID
ID	data type identification
POBX	partials $\partial F/\partial \underline{r}$ (6 × 12)
GMAT	partials $\partial \underline{r}/\partial q$ (6 × 11)
U	partials $\partial \underline{r}/\partial r_0$ (6 × 6)
ILIST	initial conditions flags (6)
LLIST	physical constants flags (11)

MLIST	velocity of light flag (1)
NLIST	station locations flags (3 × 15)
QA	partials $\partial F/\partial q$ from occultation-impact
QB	partials $\partial F/\partial r_0$ from occultation-impact
DRDC	partials $\partial F/\partial \overline{c}$
DIM3	partials $\partial F/\partial S_i$
NEST	number of estimated parameters
NCON	number of considered parameters
RVECD	residual, data type ID
IF10	phi vector output flag
DXDR-13	MMP output flag

COMMON output:

CPPHI	ordered partials $\partial F/\partial Q$
CPTHT	ordered partials $\partial F/\partial \widetilde{Q}$ (considered)
XJ	J matrix
RIGHT	right-hand side of normal equations
XX	J matrix for considered parameters
NTOT	number of data points
SOUR	sum of squares

CODING INFORMATION

Length of subroutine is 566 (10) or 1066 (8) words.

IDENTIFICATION 35

G1G2
Melba W. Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

G1G2 computes the gravity equations g_1 and g_2.

RESTRICTION

COMMON break: 47675

METHOD

$$g_1 = 1 + \left[3 - 42\left(\frac{z}{r}\right)^2 + 63\left(\frac{z}{r}\right)^4\right]\left[\frac{D}{7}\left(\frac{R_e}{r}\right)^4\right] + \left[H\left(\frac{R_e}{r}\right)^3\right]\left[3 - 7\left(\frac{z}{r}\right)^2\right]\frac{z}{r}$$
$$+ \left[J\left(\frac{R_e}{r}\right)^2\right]\left[1 - 5\left(\frac{z}{r}\right)^2\right]$$

$$g_2 = 1 + \left[15 - 70\left(\frac{z}{r}\right)^2 + 63\left(\frac{z}{r}\right)^4\right]\left[\frac{D}{7}\left(\frac{R_e}{r}\right)^4\right] - \left[H\left(\frac{R_e^3}{r}\right)\right]\left[1 - 10\left(\frac{z}{r}\right)^2\right.$$
$$\left. + \frac{35}{3}\left(\frac{z}{r}\right)^4\right]\frac{3}{5}\frac{r}{z} + \left[J\left(\frac{R_e}{r}\right)^2\right]\left[3 - 5\left(\frac{z}{r}\right)^2\right]$$

USE

CALL G1G2 (G1, G2) Results are stored in G1 and G2.

CODING INFORMATION

Length of subroutine is 182 (10) or 266 (8) words.

REFERENCE

Anderson, John D., TM 312-131, August 23, 1961.

IDENTIFICATION

GAMAT
Melba W. Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

To obtain the partials $\partial r/\partial q$ from the following integral using Simpson's rule:

$$\Upsilon(t) = U(t) \int_{t_0}^{t} U^{-1}(t^*) B(t^*)\, dt^*$$

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   - BMATRX
   - INSPC
   - INTR1
   - LOOKUP
   - (DFAD)
   - (DFDP)
   - (DFMP)
   - (DFSB)

METHOD

The partials of acceleration with respect to physical constants $\partial \ddot{r}/\partial q$ are evaluated in BMATRX. These partials are then numerically integrated to obtain $\partial r/\partial q$.

Using the acceleration partials as evaluated in BMATRX, if

$$
B = \begin{bmatrix}
0 & 0 & \cdots & 0 \\
0 & 0 & \cdots & 0 \\
0 & 0 & \cdots & 0 \\
\frac{\partial \ddot{x}}{\partial q_1} & \frac{\partial \ddot{x}}{\partial q_2} & \cdots & \frac{\partial \ddot{x}}{\partial q_n} \\
\frac{\partial \ddot{y}}{\partial q_1} & \frac{\partial \ddot{y}}{\partial q_2} & \cdots & \frac{\partial \ddot{y}}{\partial q_n} \\
\frac{\partial \ddot{z}}{\partial q_1} & \frac{\partial \ddot{z}}{\partial q_2} & \cdots & \frac{\partial \dot{z}}{\partial q_n}
\end{bmatrix}
$$

$$
U = \begin{bmatrix}
\frac{\partial x}{\partial x_0} & \cdots & \frac{\partial x}{\partial \dot{z}_0} \\
\frac{\partial y}{\partial x_0} & \cdots & \frac{\partial y}{\partial \dot{z}_0} \\
\frac{\partial z}{\partial x_0} & \cdots & \frac{\partial z}{\partial \dot{z}_0} \\
\frac{\partial \dot{x}}{\partial x_0} & \cdots & \frac{\partial \dot{x}}{\partial \dot{z}_0} \\
\frac{\partial \dot{y}}{\partial x_0} & \cdots & \frac{\partial \dot{y}}{\partial \dot{z}_0} \\
\frac{\partial \dot{z}}{\partial x_0} & \cdots & \frac{\partial \dot{z}}{\partial \dot{z}_0}
\end{bmatrix}
$$

and

$$\Upsilon = \begin{Bmatrix} \frac{\partial x}{\partial q_1} & \cdots & \frac{\partial x}{\partial q_n} \\ \frac{\partial y}{\partial q_1} & \cdots & \frac{\partial y}{\partial q_n} \\ \frac{\partial z}{\partial q_1} & \cdots & \frac{\partial z}{\partial q_n} \\ \frac{\partial \dot{x}}{\partial q_1} & \cdots & \frac{\partial \dot{x}}{\partial q_n} \\ \frac{\partial \dot{y}}{\partial q_1} & \cdots & \frac{\partial \dot{y}}{\partial q_n} \\ \frac{\partial \dot{z}}{\partial q_1} & \cdots & \frac{\partial \dot{z}}{\partial q_n} \end{Bmatrix}$$

then the partials $\partial r/\partial q$ are obtained from the following integral using Simpson's method:

$$\Upsilon(t) = U(t) \int_{t_0}^{t} U^{-1} (t^*)B(t^*)\, dt^*$$

The Simpson procedure uses an integration step based on the data times; if no data times exist in the interval, the time steps employed in the trajectory integration are used. The inverse of the U matrix is obtained not by the usual numerical methods but by an inspection method as defined in the subroutine INSPC.

USE

CALL GAMAT Result of the integration is placed on the combined ephemeris tape for use as needed.

CODING INFORMATION

Length of subroutine is 369 (10) or 561 (8) words.

REFERENCE

Anderson, John D., RFP 312-37, August 29, 1961.

IDENTIFICATION 37

GERTA/GREOF
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

GERTA writes the partials $\partial F/\partial Q$ (the "phi vector") on the MMP output tape, B7-SYSUT9. Each set of partials is tagged by time, receiver, transmitter, and data type.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   WRITEB/ENDFIL
   FLAT

USE

CALL GERTA

CALL GREOF for end-of-file

COMMON input:

CPPHI	partials $\partial F/\partial Q$ (1×20)
TOB	time, d. p. sec past 1950.0
IR	receiver ID
IX	transmitter ID
ID	data type ID

CODING INFORMATION

Length of subroutine is 141 (10) or 215 (8) words.

IDENTIFICATION

GHADP
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

GHADP calculates the Greenwich hour angle for the time given in COMMON location TOB. Intermediate calculations are in double precision. Output is in COMMON location GHA.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   (DFDP)
   (DFAD)
   (DFMP)
   (DFSB)
   DMOD
   COS

METHOD

$$\alpha_G = 100°.0755426 + 0°.985647346d + 2°.9015 \times 10^{-13} d^2 + \omega s + \Delta\lambda \cos\bar{\epsilon} \pmod{360°}$$

where α_G = Greenwich hour angle
d = integer days past 1950.0
s = sec past 0^h of d th day
ω = Earth rotation rate
$\bar{\epsilon}$ = mean obliquity
$\Delta\lambda$ = nutation in longitude

The mean obliquity is given by

$$\bar{\epsilon} = 23°.445759 - 0°.1309404T - 0°.88 \times 10^{-6} T^2 + 0°.5 \times 10^{-6} T^3$$

where T = Julian centuries past 1950.0

USE

CALL GHADP

COMMON input:

TOB	observation time, d.p. sec past 1950.0
OMEGA	Earth rotation rate, deg/sec
DLO	nutation in longitude, deg

COMMON output:

GHA	Greenwich hour angle, deg

CODING INFORMATION

Length of subroutine is 208 (10) or 320 (8) words.

REFERENCE

Holdridge, D. B., TR 32-223, March 2, 1962.

IDENTIFICATION 39

IMPAR
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

IMPAR computes the partials of impact time with respect to the estimated and considered parameters.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
FORM

METHOD

$$\frac{\partial T_I}{\partial Q} = \frac{-1}{\underline{\rho} \cdot \dot{\underline{\rho}}} \left(\underline{\rho} \cdot \frac{\partial \underline{\rho}}{\partial Q}\right)$$

where

T_I = impact time
Q = parameter
$\underline{\rho}$ = target centered probe position
$\dot{\underline{\rho}}$ = target centered probe velocity

USE

CALL	IMPAR	
PZE	XTAR	geocentric target position and velocity

COMMON input:

X	geocentric probe position and velocity (1 × 6)
U	partials $\partial\underline{\rho}/\partial r_0$ (6 × 6)
GMAT	partials $\partial\underline{\rho}/\partial q$ (6 × 11)
LLIST	physical constants flags (11)

COMMON output:

QA	partials $\partial T_I/\partial q$ (1 × 11)
QB	partials $\partial T_I/\partial r_0$ (1 × 6)

CODING INFORMATION

Length of subroutine is 127 (10) or 177 (8) words.

IDENTIFICATION 40

INSPC
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

INSPC inverts the U matrix of variational partials by inspection.

RESTRICTIONS

COMMON break: 47675

METHOD

If the U matrix is partitioned

$$U = \left[\begin{array}{c|c} U_{11} & U_{12} \\ \hline U_{21} & U_{22} \end{array}\right]$$

then its inverse may be written as

$$U^{-1} = \left[\begin{array}{c|c} U_{22}^T & -U_{12}^T \\ \hline -U_{21}^T & U_{11}^T \end{array}\right]$$

USE

CALL INSPC

COMMON input:

U — U matrix of variational partials (6 x 6)

COMMON output:

UINV — U^{-1}

CODING INFORMATION

Length of subroutine is 200 (10) or 310 (8) words.

REFERENCE

Anderson, John D., TM 312-409, March 24, 1964.

IDENTIFICATION 41

INTR1/BNTR2

Alan D. Rosenberg and Melba W. Nead, JPL

IBM 7094 Fap

January 4, 1965

PURPOSE

This version of INTR1 uses the latest version of the JPL Ephemeris routines, EPHEM, to obtain the necessary planetary information. INTR1 adjusts this output so it matches output from the original INTR1 rotated to true of date for the ODP.

RESTRICTIONS

a. Portions of the ODP COMMON storage must be made available to the routine. ERROR return for planetary ephemeris tape error.

b. Subroutines used:

   EPHEM
   PNUT
   ROT
   ERROR

USE

CALL	BNTR2	Enter one time to set up blocks of storage necessary to EPHEM
CALL	INTR1	Time is used from COMMON

CODING INFORMATION

Length of subroutine is 2188 (10) or 4214 (8) words.

REFERENCES

a. Holdridge, D. B., TR 32-223, Space Trajectories Program for the IBM 7090 Computer, March 2, 1962.

b. Peabody, P. R., Scott, J. F., Orozco, E. G., TR 32-580, User's Description of JPL Ephemeris Tapes, March 2, 1964.

IDENTIFICATION 42

IXTAB
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

IXTAB does a lookup in the table of transmitter ID's and frequencies by means of a time argument.

RESTRICTION

COMMON break: 47675

USE

```
CALL  IXTAB
PZE   N
```

N is the location of a flag which is zero for the initialization entry and non-zero for the normal entry. The initialization entry returns the lookup pointer to the first point in the table.

COMMON input:

TOB	lookup time, d.p. sec past 1950.0
EPOCH	ODP epoch, d.p. sec past 1950.0
YY1	table of times, sec past epoch (1 × 90)
YY1-90	table of transmitter ID's (1 × 90)
YY1-180	table of frequencies (1 × 90)

COMMON output:

IX	transmitter ID
XFREQ	transmitter frequency if IX $\neq$ 0
TFREQ	transponder frequency if IX $\neq$ 0

CODING INFORMATION

Length of subroutine is 54 (10) or 66 (8) words.

IDENTIFICATION

KINE
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

KINE reads the ODG data file or the ODP residual file from disk. Each entry loads COMMON with the contents of the next sequential logical record. KINE uses the REDE entry of the buffered disk routine DISCBU.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   REDE
   ERROR
c. Error conditions:
   Disk parity error
   Attempted read outside of file limits

USE

```
CALL  KINE
PZE   RVECO  )                  PZE   RVEC   )
PZE   RVECW  } for ODG data     PZE   RVECD  } for ODP residual
PZE   = 1001 } reading          PZE   = 1    } reading
PZE   = 2000 )                  PZE   = 1000 )
PZE   IF6      1B17 = EOF, 2B17 = normal
```

COMMON output:

TOB	observation time, d. p. sec past 1950.0
RVEC	array of computed data types
RVECO	array of observed data types
RVECW	array of weight code-words
RVECD	array of residual-weight words
PASS	pass identification
XFREQ	transmitter frequency, cps
TFREQ	transponder frequency, cps
IR	receiver identification
IX	transmitter identification
TAU	doppler averaging time, sec

The ODG logical record format is as follows:

Word 0 word count (2N + 5, B17) or -0 for EOF

1 TOB

2 TOB - 1

3 XFREQ if IX $\neq$ 0

TFREQ if IX $\neq$ 0

4 PASS

5 bit S 1 if L - S band

0 if L or S band

1 1 if RVECO $\neq$ 0

2 1 if RVECO - 1 $\neq$ 0

3 1 if RVECO - 2 $\neq$ 0

.

.

.

11 1

12-15 not used

16 1 if L - S or S band

0 if L band

17 1 if optical data

18-21 IX

22-25 IR

26-35 TAU

6 first member of RVECO which is non-zero

7 bits S-17 weight codeword corresponding to word 6

18-35 data sample rate, sec

8 second member of RVECO which is non-zero

9 second weight-sample rate word

2N + 4 Nth member of RVECO which is non-zero

2N + 5 Nth weight-sample rate word

The corresponding residual record format is found in the documentation of subroutine FILL.

CODING INFORMATION

Length of subroutine is 142 (10) or 216 (8) words.

IDENTIFICATION 44

LOCO
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

This is the control routine for the link which restores the ODP COMMON from disk following computation of the trajectory. In addition it controls preparation of the combined ephemeris on tape A4.

RESTRICTIONS

a. ERROR condition: disk error indicated by DCP
b. COMMON break: 47675
c. Subroutines used:

KOOL
TAPIO
INTR1
EPPHEM
FLAK
TYPRYT

USE

This is one of the basic links of the ODP in that it restores COMMON and prepares the ephemeris. It is called under control of the JPTRAJ monitor.

CODING INFORMATION

Length of subroutine is 116 (10) or 164 (8) words.

IDENTIFICATION

LOOKUP/KOOL
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

To perform look-up on the probe ephemeris generated by SPACE.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   ERROR Called when time incompatible with the ephemeris which has been generated.
   REDE

METHOD

The subroutine computes the coefficients for a 5th degree Lagrangian interpolation and provides values for the position, velocity, acceleration and jerk (3rd derivative) of the probe, variational equations, nutation in longitude and nutation in obliquity. (Flow chart is included)

$$y(x) = \sum_{k=0}^{w} l_k(x) f(x_k)$$

where

$$l_i(x) = \frac{\pi(x)}{(x - x_i)\pi'(x_i)}$$

$$= \frac{(x - x_0) \cdots (x - x_{i-1})(x - x_{i+1}) \cdots (x - x_n)}{(x_i - x_0) \cdots (x_i - x_{i-1})(x_i - x_{i+1}) \cdots (x_i - x_n)}$$

For each time that LOOKUP is called the following information is stored in COMMON

X, Y, Z, XDOT, YDOT, ZDOT		Probe vector
U	(36)	Variational equations
		$\partial x/\partial x_0$, $\partial x/\partial y_0$, $\partial x/\partial z_0$, $\partial x/\partial \dot{x}_0$ . . . $\partial \dot{z}/\partial x_0$ . . . $\partial \dot{z}/\partial \dot{z}_0$
DLO		Nutation in longitude
DOB		Nutation in obliquity
XAC, YAC, ZAC		Probe acceleration
XJERK, YJERK, ZJERK		Probe jerk (3rd derivative)

USE

CALL	LOOKUP (n)	n = number of items to be interpolated, 6 or 49. When 6, the probe vector only is given.
CALL	KOOL	to provide a logical reset on the probe ephemeris file and to set flag for LOOKUP to read 3 physical records needed on first entry to the subroutine.

CODING INFORMATION

Length of subroutine is 314 (10) or 472 (8) words.

REFERENCE

Hildebrand, F. B., Introduction to Numerical Analysis, McGraw-Hill, New York, 1956.

IDENTIFICATION 46

MAMUL

Melba W. Nead, JPL

Fortran II, Version 3

January 4, 1965

PURPOSE

To multiply two matrices and store in a third array.

RESTRICTION

Maximum array: 20 x 20

USE

```
CALL    MAMUL   (A, B, C, M, N, L)
               A(M, L)  *  B(L, N)  =  C (M, N)
```

CODING INFORMATION

Length of subroutine is 87 (10) or 127 (8) words.

IDENTIFICATION 47

MAPOUT
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

MAPOUT reads all matrices which were computed and stored on disk in Link 2. Here they are printed and in some cases punched. Also, the mapping information is saved for the MMP (MATRIX MANIPULATOR PROGRAM) input tape.

RESTRICTIONS

a. ERROR condition: disk error indicated by DCP

b. COMMON break: 47055

c. Subroutines used:

PRIM
FLAK
REFORM
PUMA
PRAM
DCP
IOCS
TYPRYT
OFFSYS
TACCOM

USE

This link is called under control of the JPTRAJ Source Deck.

CODING INFORMATION

Length of subroutine is 866 (10) or 1542 (8) words.

IDENTIFICATION 48

MAXIM
Melba Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

Checks data tape, mapping times, predictions, pointing times, etc. so that the trajectory can be run a minimum length of time and still satisfy all demands on the probe ephemeris.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:

    KINE
    MOCT
    QUIZ
    (DFAD)
    (DFSB)

METHOD

Flow chart is included.

USE

CALL MAXIM

CODING INFORMATION

Length of subroutine is 315 (10) or 473 (8) words.

IDENTIFICATION 49

MOCT
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

MOCT obtains the latest occultation or impact time for determining the trajectory link time stop.

RESTRICTION

COMMON break: 47675

USE

CALL	MOCT	
PZE	LAST	latest occultation/impact time, d.p. sec past 1950.0

COMMON input:

PTFD	occultation/impact input area
DXDR-27	occultation/impact flag

CODING INFORMATION

Length of subroutine is 71 (10) or 107 (8) words.

IDENTIFICATION 50

ND2F

Melba W. Nead, JPL

IBM 7094 Fap

January 4, 1965

PURPOSE

This is a SHARE routine which has been modified so that it is possible to start at a predetermined portion of the random number generator.

RESTRICTION

COMMON break: 47675

METHOD

RANO, an octal number, can be input into the ODP data.

This number is chosen from a pre-calculated set.

USE

To provide noise on a simulated data tape.

CODING INFORMATION

Length of subroutine is 39 (10) or 47 (8) words.

IDENTIFICATION

51

NOMNL
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

NOMNL stores the nominal values of all constants, other than the weighting tables and the target-dependent solar pressure constants.

RESTRICTION

COMMON break: 47675

USE

CALL NOMNL

This subroutine outputs into approximately 150 COMMON locations.

CODING INFORMATION

Length of subroutine is 499 (10) or 1051 (8) words.

REFERENCES

a. Clarke, Victor C., TR 32-604, March 6, 1964.
b. Scott, James F., IOM 317.21/318, September 1, 1964.

IDENTIFICATION 52

NORMAY
Melba Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

To normalize a matrix on its diagonal terms.

RESTRICTIONS

a. Maximum matrix: 20 × 20
b. Subroutines used:

SQRT

USE

CALL NORMAY (XMAT, YMAT, N)
XMAT = matrix A be normalized
YMAT = location to store normalized matrix
N = order of matrix

CODING INFORMATION

Length of subroutine is 169 (10) or 251 (8) words.

IDENTIFICATION 53

NOUT

Michael R. Warner, JPL

IBM 7094 Fap

January 4, 1965

PURPOSE

NOUT prints comments indicating the rows and columns of the normal matrix which were deleted by subroutine STPREG during inversion:

VARIABLE NO. XX REJECTED BY DIAGONAL TEST.

RESTRICTION

Subroutines used:

PROUT

USE

CALL NOUT
PZE INOUT

INOUT is a 1 × 20 array in which STPREG has indicated the status of each variable.

COMMON input:

PRIFIL PROUT file control block for printing.

CODING INFORMATION

Length of subroutine is 64 (10) or 100 (8) words.

IDENTIFICATION

OBTOX

Michael R. Warner, JPL

Fortran II, Version 3

January 4, 1965

PURPOSE

OBTOX computes the partials of the ODP data types with respect to the probe position and velocity at the observation time.

RESTRICTION

COMMON break: 47675

METHOD

(slant range partials)

$$\frac{\partial \rho_i}{\partial \underline{r}} = \underline{L}$$

$$\frac{\partial \rho_i}{\partial \underline{\dot{r}}} = 0$$

(range rate partials)

$$\frac{\partial \dot{\rho}_i}{\partial x} = \frac{1}{\rho_i}\left(\dot{x} + \omega y_i - \dot{\rho}_i L_x\right)$$

$$\frac{\partial \dot{\rho}_i}{\partial y} = \frac{1}{\rho_i}\left(\dot{y} - \omega x_i - \dot{\rho}_i L_y\right)$$

$$\frac{\partial \dot{\rho}_i}{\partial z} = \frac{1}{\rho_i}\left(\dot{z} - \dot{\rho}_i L_z\right)$$

$$\frac{\partial \dot{\rho}_i}{\partial \underline{\dot{r}}} = \underline{L}$$

(elevation angle partials)

$$\frac{\partial \gamma_i}{\partial \underline{r}} = \frac{\underline{\tilde{D}}}{\rho_i}$$

$$\frac{\partial \gamma_i}{\partial \underline{\dot{r}}} = 0$$

$$\frac{\partial \sigma_i}{\partial \underline{r}} = \frac{\tilde{\underline{A}}}{\rho_i}$$

$$\frac{\partial \sigma_i}{\partial \dot{\underline{r}}} = 0$$

(azimuth angle partials)

$$\frac{\partial \delta_i}{\partial x} = \frac{-\cos \alpha_{ri} \sin \delta_i}{\rho_i}$$

$$\frac{\partial \delta_i}{\partial y} = \frac{-\sin \alpha_{ri} \sin \delta_i}{\rho_i}$$

$$\frac{\partial \delta_i}{\partial z} = \frac{\cos \delta_i}{\rho_i}$$

$$\frac{\partial \delta_i}{\partial \dot{r}} = 0$$

(declination partials)

$$\frac{\partial \alpha_i}{\partial x} = \frac{\sin \alpha_{ri}}{\rho_i \cos \delta_i}$$

$$\frac{\partial \alpha_i}{\partial y} = \frac{-\cos \alpha_{ri}}{\rho_i \cos \delta_i}$$

$$\frac{\partial \alpha_i}{\partial z} = 0$$

$$\frac{\partial \alpha_i}{\partial \dot{\underline{r}}} = 0$$

(hour angle partials)

$$\frac{\partial f_{1i}}{\partial \underline{r}} = \frac{\Omega_2}{c} \frac{\partial \dot{\rho}_i}{\partial \underline{r}} \qquad \underline{r} \rightarrow \dot{\underline{r}}$$

(one-way doppler partials)

$$\frac{\partial f_{c3i,q}}{\partial \underline{r}} = \frac{\Omega_4}{c}\left(\frac{\partial \dot{\rho}_i}{\partial \underline{r}} + \frac{\partial \dot{\rho}_q}{\partial \underline{r}}\right) \qquad \underline{r} \rightarrow \dot{\underline{r}}$$

(two-way doppler partials)

$$\frac{\partial f_{3i,q}}{\partial \underline{r}} = \frac{\Omega_6}{c}\left(\frac{\partial \dot{\rho}_i}{\partial \underline{r}} + \frac{\partial \dot{\rho}_q}{\partial \underline{r}}\right) \quad \underline{r} \rightarrow \underline{\dot{r}}$$ (three-way doppler partials)

$$\frac{\partial f_{d1i,j}}{\partial \underline{r}} = \frac{\Omega_2}{c}\left(\frac{\partial \dot{\rho}_i}{\partial \underline{r}} - \frac{\partial \dot{\rho}_j}{\partial \underline{r}}\right) \quad \underline{r} \rightarrow \underline{\dot{r}}$$ (differenced one-way partials)

(all symbols used here are defined in the subroutine CATS documentation)

USE

CALL OBTOX

COMMON input:

ELX	$\underline{L}$
TAX	$\underline{\tilde{A}}$
TDX	$\underline{\tilde{D}}$
RVEC	ODP computed data type array
X	$\underline{r}$, $\underline{\dot{r}}$
OMEGA	ω, deg/sec
RAI	α_{ri}, deg
CZ2	Ω_2
CZ4	Ω_4
CZ6	Ω_6
VELC	c, km/sec

COMMON output:

POBX	$\partial F/\partial \underline{r}$, $\partial F/\partial \underline{\dot{r}}$

CODING INFORMATION

Length of subroutine is 189 (10) or 275 (8) words.

REFERENCES

a. Warner, M. R., Nead, M. W., Hudson, R. H., TM 33-168, March 18, 1964.

b. Anderson, John D., TM 312-409, March 24, 1964.

IDENTIFICATION 55

OCIM

Michael R. Warner, JPL

IBM 7094 Fap

January 4, 1965

PURPOSE

OCIM reads the ODP combined ephemeris tape, extracting occultation and impact time parameters necessary for partials calculation.

RESTRICTIONS

a. COMMON break: 47675

b. Subroutines called:

IMPAR
OCPAR
READB
FLAT
ERROR

c. Error conditions:

Ephemeris tape permanent redundancy

USE

CALL OCIM

COMMON input:

DXDR-6	target (1 = Mars 2 = Moon 3 = Venus)
DXDR-27	1B17 = occultation time 2B17 = impact time
XMOO	geocentric Moon vector
XVEN	geocentric Venus vector
XMAR	geocentric Mars vector
PTFD	occultation-impact times input array
X	geocentric probe vector
XAC	geocentric probe accelerations
XJERK	geocentric probe jerks
RVECD	residual
RVECW	weight
DINT	physical constants partials
T	corrected occultation/impact time

IDENTIFICATION

OCPAR
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

OCPAR computes the partials of occultation time with respect to the estimated and considered parameters.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   FORM

METHOD

$$\frac{\partial T_0}{\partial Q} = \frac{\underline{\rho} \cdot \underline{\rho}_m \left(\frac{\underline{\rho}_m \cdot \frac{\partial \underline{\rho}_m}{\partial Q}}{\rho_m^2} + \frac{\underline{\rho} \cdot \frac{\partial \underline{\rho}}{\partial Q}}{\rho^2} \right) - \underline{\rho} \cdot \frac{\partial \underline{\rho}_m}{\partial Q} - \underline{\rho}_m \cdot \frac{\partial \underline{\rho}}{\partial Q} + \frac{|\underline{\rho}|\,|\underline{\rho}_m| \sin \phi_p R_m}{\rho_m^2 \sqrt{\rho_m^2 - R_m^2}} \underline{\rho}_m \cdot \frac{\partial \underline{\rho}_m}{\partial Q}}{\underline{\rho} \cdot \underline{\rho}_m \left(\frac{\underline{\rho}_m \cdot \dot{\underline{\rho}}_m}{\rho_m^2} + \frac{\underline{\rho} \cdot \dot{\underline{\rho}}}{\rho^2} \right) - \underline{\rho} \cdot \underline{\rho}_m - \underline{\rho}_m \cdot \underline{\rho} + \frac{|\underline{\rho}|\,|\underline{\rho}_m| \sin \phi_p R_m}{\rho_m^2 \sqrt{\rho_m^2 - R_m^2}} (\underline{\rho}_m \cdot \underline{\rho}_m)}$$

where

$\underline{\rho}_m = \underline{r}_m - \underline{R}_i$

R_m = radius of target

$\underline{r}_m$ = geocentric target vector

$$\phi_p = \cos^{-1} \frac{\underline{\rho} \cdot \underline{\rho}_m}{|\underline{\rho}| \, |\underline{\rho}_m|}$$

$\underline{\rho}$ = topocentric probe vector

$\underline{R}_i$ = geocentric station vector

USE

CALL	OCPAR	
PZE	XTAR	$\underline{r}_m$, km
PZE	AA	$A = \underline{\Gamma} \cdot \dot{\underline{\Gamma}}$
PZE	AB	$B = \underline{\beta} \cdot \dot{\underline{\beta}}$
PZE	AC	$C = \sqrt{\Gamma^2\beta^2 - (\underline{\Gamma} \cdot \underline{\beta})^2}$
PZE	AK	$K = \underline{\Gamma} \cdot \dot{\underline{\beta}} + \underline{\beta} \cdot \dot{\underline{\Gamma}}$
PZE	AM	$M = R_m C / \beta^2 \sqrt{\beta^2 - R_m^2}$
PZE	GDB	$\underline{\Gamma} \cdot \underline{\beta}$
PZE	BETA	$\lvert\underline{\beta}\rvert$ $(\underline{\beta} = \underline{\rho}_m)$
PZE	GAMMA	$\lvert\underline{\Gamma}\rvert$ $(\underline{\Gamma} = \underline{r} - \underline{R}_i)$
PZE	XMX	$\underline{\rho}_m \cdot \underline{r}$
PZE	XXI	$\underline{r} \cdot \underline{R}_i$
PZE	SI	$\underline{R}_i$

COMMON input:

U	partials $\partial \rho / \partial \underline{r}_0$ (6 × 6)
GMAT	partials $\partial \underline{\rho} / \partial q$ (6 × 11)
LLIST	physical constants flags (11)
RI	$\lvert\underline{R}_i\rvert$, km
NLIST	station locations flags (3 × 15)
COSRAI	cos α_{ri}
SINRAI	sin. α_{ri}
COSPHI	sin ϕ_i

COMMON output:

QA	partials $\partial T_0/\partial q$
QB	partials $\partial T_0/\partial \underline{r}_0$
DIM3	partials $\partial T_0/\partial s_i$

CODING INFORMATION

Length of subroutine is 333 (10) or 515 (8) words.

REFERENCES

a. Warner, M. R., Nead, M. W., Hudson, R. H., TM 33-168, March 18, 1964.
b. Liu, Anthony, RFP 312-136, May 20, 1963.

IDENTIFICATION

ODATA/ONLIN/......
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

ODATA performs the following functions:

a. In conjunction with the conversion subroutine CARDS, reads ODP control cards and the symbolic and/or numeric data cards. The cards may be read from the on-line reader or input tape A2 (mode 4) or the user area reader (mode 2).
b. Manipulates the symbolic and numeric data and stores them in the appropriate COMMON locations for subsequent ODP use.
c. Under sense switch (or console key) control, terminates ODP execution.
d. Prints the trajectory target on the administrative (or on-line) printer.
e. Stores the target-dependent solar pressure constants.
f. On option, reads the previously computed injection conditions, constants, and covariance matrix from disk.
g. Applies Gauss' constraint to the planetary masses:

$$GM_s = 3.9640160 \times 10^{-14} a_e^3$$

$$GM_v = \frac{M_v}{M_s} GM_s$$

$$GM_r = \frac{M_r}{M_s} GM_s$$

$$GM_j = \frac{M_j}{M_s} GM_s$$

where

a_e = astronomical unit

s, v, r, j = subscripts denoting the Sun, Venus, Mars, Jupiter.

h. On option, applies the scaling constraint to the Earth radius:

$$R_{em} = 86.315745 (GM_e + GM_m)^{1/3}$$

where

R_{em} = earth radius for scaling the lunar ephemeris.

RESTRICTIONS

a. If any of the following error conditions are detected, ODATA calls subroutine ERROR for the appropriate comment printout and subsequent action:

1. Error in symbolic or numeric input.
2. Checksum or redundancy error.
3. Cards not received within time limit (mode 2).
4. Illegal card in deck (mode 2)
5. End-of-file indication (mode 4)
6. Data on input card inconsistent with ODP requirements.
7. Error in reading disk.

b. COMMON break: 47675

c. Subroutines called:

TYPRYT
IOCS - DEFINE/ATTACH/OPEN/CLOSE
CARDS
OFFSYS
ERROR
FINSYS
READS/MOOPH1/ODOFF
FLOT
SPHX
STPREG
DIAG
DISCBU - REDE
EXP(3

USE

CALL ODATA

ODATA uses most of the ODP COMMON map. Section IVB has the COMMON listing.

The input descriptions are in Section IVA.

ONLIN is used for returning to ODATA after a corrected card input error (TTR $ONLIN).

...... represents the entry point for the JPTRAJ program control block of LA9.

CODING INFORMATION

Length of subroutine is 1723 (10) or 3273 (8) words.

IDENTIFICATION 58

ORBEQ
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

ORBEQ rotates the encounter noise moment matrix from the ODP $\underline{R}$, $\underline{T}$ plane to the midcourse program $\underline{R}$, $\underline{T}$ plane.

RESTRICTIONS

a. COMMON break: 47055
b. Subroutines used
   ARTAN
   COS
   SIN

METHOD

$$\theta = \tan^{-1} \frac{\underline{B} \cdot \underline{R}_{m/c}}{\underline{B} \cdot \underline{T}_{m/c}} - \tan^{-1} \frac{\underline{B} \cdot \underline{R}_{odp}}{\underline{B} \cdot \underline{T}_{odp}}$$

$$R = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

USE

CALL	ORBEQ	
PZE	BRO	ODP $\underline{B} \cdot \underline{R}$, km
PZE	BTO	ODP $\underline{B} \cdot \underline{T}$, km
PZE	BRM	M/C $\underline{B} \cdot \underline{T}$, km
PZE	BTM	M/C $\underline{B} \cdot \underline{T}$, km
PZE	CNO	ODP noise moment matrix (6 × 6)
PZE	CNM	M/C noise moment matrix (3 × 3)·

CODING INFORMATION

Length of subroutine is 119 (10) or 167 (8) words.

IDENTIFICATION

59

OZ
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

OZ is the control program for the calculation of the closest approach parameters.

RESTRICTIONS

a. COMMON break: 47055
b. Subroutines used:

    UMAT
    TYPRYT
    IOCS
    OFFSYS

USE

When impact or closest approach parameters are requested, this link is called under control of the JPTRAJ Source Deck.

CODING INFORMATION

Length of subroutine is 766 (10) or 1376 (8) words.

IDENTIFICATION

PARAM

Michael R. Warner, JPL

IBM 7094 Fap

January 4, 1965

PURPOSE

PARAM outputs the encounter parameters page of the ODP printout. It also loads the buffers for COMENT output.

RESTRICTIONS

a. COMMON break: 47055

b. Subroutines called:

SQRT
FIXT
PROUT
TNORM
ORBEQ

USE

CALL	PARAM	
PZE	CNO	noise moment matrix of encounter parameters (6 × 6)
PZE	BRO	$\underline{B} \cdot \underline{R}$, km (ODP plane)
PZE	BTO	$\underline{B} \cdot \underline{T}$, km (ODP plane)
PZE	ELPS	miss ellipse configuration (1 × 3 - semi-major axis, semi-minor axis, orientation angle)
PZE	A	semi-major axis of encounter conic
PZE	UNJ	$\partial M/\partial Q_0$ matrix of encounter partials
PZE	TL	linearized time of flight, days
PZE	UT	$\partial M/\partial Q$ matrix of encounter partials

COMMON input:

DXDR-6	target identification
DXDR-21	$\underline{B} \cdot \underline{R}$ (midcourse plane)
DXDR-20	$\underline{B} \cdot \underline{T}$ (midcourse plane)
DXDR-2	COMENT update flag
GRAVE	GM_{Earth}, km^3/sec^2
GRAVR	GM_{Mars}
GRAVV	GM_{Venus}

GRAVM	GM_{Moon}
GRAVS	GM_{Sun}
TFIN	time of impact/closest approach, d.p. seconds past 1950.0
COMTS	ODP page heading, BCD
PRIFIL	PROUT file control block
XNJ	ODP initial conditions (1 × 6), d.p.
EPOCH	ODP epoch, d.p. sec past 1950.0
XDOT	probe velocity at encounter, km/sec (1 × 3)

COMMON output:

COMBU	midcourse program COMENT parameters
COMBW	trajectory program COMENT parameters

CODING INFORMATION

Length of subroutine is 720 (10) or 1320 (8) words.

IDENTIFICATION

PARLEY
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

To write time, partials, position and velocity of probe and planets, etc., on tape for each data point while the data is being processed.

RESTRICTIONS

a. COMMON break: 47675
b. Cannot be used in SFOF MODE 2 (real-time mode).
c. Subroutines used:

FLAT
TAPIO

USE

CALL PARLEY

The following items are written on a scratch tape to be read and printed in a subsequent link:

TOB		Observation time
GHA		Greenwich Hour Angle
X		Probe vector
Y		
Z		
XDOT		
YDOT		
ZDOT		
U	(36)	Variational equations
DLO		Nutation in longitude
DOB		Nutation in obliquity
XAC		Probe Acceleration
YAC		
ZAC		
XJERK		Probe jerk (3rd derivative)
YJERK		
ZJERK		
XSUN	(6)	Sun vector

XVEN	(6)	Venus vector	XTARG vector only
XMOO	(6)	Moon vector	XTARG vector only
XMAR	(6)	Mars vector	XTARG vector only
CPPHI	(20)	CAP PHI matrix of partials	
CPTHT	(20)	CAP THETA matrix of partials	
DELT		Light time correction	
DELT2		Second light time correction	
DHA		Refraction corrections	
DDEC		Refraction corrections	
DAZ		Refraction corrections	
DEL		Refraction corrections	
DRDOT		Refraction corrections	
DRVEC		Refraction corrections	

CODING INFORMATION

Length of subroutine is 30 (10) or 36 (8) words.

REFERENCE

Null, George, W., RFP 312-179, August 15, 1963.

IDENTIFICATION 62

PARSH
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

This link is called only when the COMENT region is to be updated, or when in MODE 4, the printing of the partials is requested. The program is called under control of the JPTRAJ monitor.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutine used:

COMOUT
WASH
FGDOUT
DISCBU

USE

Control program for writing COMENT on disk or printing partials.

CODING INFORMATION

Length of subroutine is 662 (10) or 1226 (8) words.

IDENTIFICATION 63

PERNOD/WOLF

Charles Coltharp/Michael R. Warner, JPL

IBM 7094 Fap

January 4, 1965

PURPOSE

PERNOD accumulates statistics on data residuals. It is called during the processing of each residual. WOLF is called at the end-of-file for each station's residuals. It obtains the standard deviation, root-mean-square, mean, and second moment for each data type and each pass identification.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:

FIXT
PROUT/FGDOUT
SQRT
COLA

USE

CALL	PERNOD	after each residual is read
CALL	WOLF	after each station is completed

COMMON input:

TOB	observation time, d.p. seconds past 1950.0
RVECD	residual array (1 × 11)
ITNO	iteration number
PASS	pass identification
IR	receives identification
PRIFIL	IOCS printing file control block

CODING INFORMATION

Length of subroutine is 323 (10) or 503 (8) words.

IDENTIFICATION

64

PM360
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

PM360 adjusts angle residuals by 360 deg if they are greater than 180 deg or less than -180 deg.

RESTRICTIONS

COMMON break: 47675

USE

CALL PM360

COMMON input:

DECD	declination residual
HAD	hour angle residual
AZID	azimuth residual

COMMON output:

DECD, HAD, AZID	residuals adjusted by 360 deg if necessary

CODING INFORMATION

Length of subroutine is 40 (10) or 50 (8) words.

IDENTIFICATION

PNUT
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

PNUT calculates the rotation matrix for nutation-precession.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   SIN
   COS

METHOD

$$N = \begin{bmatrix} 1 & -\Delta\lambda \cos\bar{\epsilon} & -\Delta\lambda \sin\bar{\epsilon} \\ \Delta\lambda \cos\bar{\epsilon} & 1 & -\Delta\epsilon \\ \Delta\lambda \sin\bar{\epsilon} & \Delta\epsilon & 1 \end{bmatrix}$$

$$a_{11} = 1 - 0.29697 \times 10^{-3}\, T^2 - 0.13 \times 10^{-6}\, T^3$$

$$a_{12} = -0.02234988T - 0.676 \times 10^{-5}\, T^2 + 0.221 \times 10^{-5}\, T^3$$

$$a_{13} = -0.00971711T + 0.207 \times 10^{-5}\, T^2 + 0.96 \times 10^{-6}\, T^3$$

$$a_{21} = -a_{12}$$

$$a_{22} = 1 - 0.24976 \times 10^{-3}\, T^2 - 0.15 \times 10^{-6}\, T^3$$

$$a_{23} = -0.10859 \times 10^{-3}\, T^2 - 0.3 \times 10^{-7}\, T^3$$

$$a_{31} = -a_{13}$$

$$a_{32} = a_{23}$$

$$a_{33} = 1 - 0.4721 \times 10^{-4}\, T^2 + 0.2 \times 10^{-7}\, T^3$$

where

$\Delta\lambda$ = nutation in longitude
$\Delta\epsilon$ = nutation in obliquity
$\bar{\epsilon}$ = mean obliquity (see writeup for GHADP)
T = Julian centuries past 1950.0

USE

CALL PNUT

COMMON input:

T	time, d.p. sec past 1950.0
DOB	nutation in obliquity, deg
DLO	nutation in longitude, deg

COMMON output:

ROTMX	nutation-precession matrix (NA)

CODING INFORMATION

Length of subroutine is 222 (10) or 336 (9) words.

REFERENCE

Holdridge, D. B., TR 32-223, March 2, 1962.

IDENTIFICATION 66

POINT
Melba W. Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

To generate the pointing predictions for the tracking stations.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:

COEF
FILL
OFFSYS
CORR
GHADP
REAP
DOPLR
IXTAB
(DFAD)

USE

CALL POINT

CODING INFORMATION

Length of subroutine is 196 (10) or 304 (8) words.

REFERENCE

Trask, D. W., RFP 312-37, Addendum 6, April 4, 1962.

IDENTIFICATION 67

PONT

Melba W. Nead, JPL

Fortran II, Version 3

January 4, 1965

PURPOSE

To compute the times at which the combined ephemeris shall be written for a simulated data tape or predictions.

RESTRICTIONS

a. COMMON break: 47675

b. Subroutines used:

GAMAT
INTR1
LOOKUP
OFFSYS
RITEM
TIMER
(DFAD)

Flow chart included

USE

CALL PONT

CODING INFORMATION

Length of subroutine is 201 (10) or 311 (8) words.

IDENTIFICATION 68

PRAMS
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

To save the U matrix when it is calculated by COMIMP. Core space forces the calculation and the print-out of these matrices to be done in separate links.

RESTRICTIONS

a. ERROR condition: disk error indicated by DCP
b. Subroutines used:

FLAK
DCP

USE

CALL PRAMS

CODING INFORMATION

Length of subroutine is 18 (10) or 22 (8) words.

IDENTIFICATION 69

PREDA
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

This is the main program of the link which computes predictions for the DSIF stations or prepares a simulated data tape.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:

POINT
DATAPE
TYPRYT
TAPIO

USE

This link is called under control of the JPTRAJ Source Deck when predictions or a data tape are requested.

CODING INFORMATION

Length of subroutine is 39 (10) or 47 (8) words.

IDENTIFICATION

PRIM/PRAM
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

To print any matrix up to 20×20 from a possible list of 63. Included is the capability of punching the array in a format acceptable as input back into the ODP. When step-mapping, probe position and velocity and the mapping matrix are automatically punched.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:

    BIBCD
    FLAPR
    PRIME
    NORMAY
    PRIT
    DIAGO
    FGDOUT
    PROUT

USE

```
CALL   PRIM
PZE    ,,N
```

where N is as follows:

1. Input J matrix of estimated parameters
2. Input covariance matrix of considered parameters
3. J inverse
4. Covariance matrix of estimated parameters
5. Correlation matrix of estimated parameters
6. Covariance matrix at impact
7. Covariance matrix mapped forward
8. J matrix
9. Input covariance matrix of estimated parameters
10. Correlations based on J matrix
11. U product matrix in step-mapping

CALL PRAM

TSX CAPU

Prints U matrix for mapping forward

To punch a matrix PUNCH=n under OTHER PARAMETER VALUES in the data input. This will punch the matrix only one time.

CODING INFORMATION

Length of subroutine is 787 (10) or 1423 (8) words.

REFERENCE

Trask, D. W., REP 312-37, Addendum 6, April 4, 1962.

IDENTIFICATION

71

PRIME/REFORM
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

To write impact times, probe and target vectors and the mapping matrices on the MATRIX MANIPULATOR PROGRAM input tape.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:

TAPIO
FLAT

USE

CALL	REFORM	To read mapping times from preliminary storage tape. TFIN is added to those originally saved and all are written on the final MMP tape.
CALL	PRIME	To write the mapping matrices on the MMP tape.

CODING INFORMATION

Length of subroutine is 98 (10) or 142 (8) words.

REFERENCE

Peterson, G. E., ED 218, May 15, 1964.

IDENTIFICATION 72

PRINQ/PRIT/APRIOR
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

To print DQ's, new Q's, old Q's, standard deviation of covariance matrix of estimated parameters, etc.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:

FGDOUT
DIAG
CLOCK
PROUT
FLAPR
FIXT
BIBCD

USE

CALL	PRINQ	Prints DQ's etc. of estimated parameter.
CALL	PRIT	Entered with double precision time in seconds in ACC and MQ. These are converted to year, month, day, hour, minute, second, and stored in COMMON.
APRIOR		Buffer in which the standard deviation of the aprior covariance matrix is stored through the "WANT" capability of the JPTRAJ monitor.

CODING INFORMATION

Length of subroutine is 259 (10) or 403 (8) words.

REFERENCE

Trask, D.W., RFP 312-37, Addendum 6, April 4, 1962.

IDENTIFICATION 73

PRINT
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

PRINT controls the printing of the DQ's and the matrices which have been computed in the preceding link. Also, when occultation calculations are requested it reads this information from disk and prepares it for printing.

RESTRICTIONS

a. ERROR condition: disk error indicated by DCP
b. COMMON break: 47675
c. Subroutines used:

PRINQ
PRIM
FIXT
PROUT
FGDOUT
FLAK
DISCBU
IOCS
ENDIT
OFFSYS

USE

Upon completion of the calculation of the data fitting link, the print link is called under control of the JPTRAJ MONITOR.

CODING INFORMATION

Length of subroutine is 1352 (10) or 2510 (8) words.

IDENTIFICATION 74

PROM

Melba W. Nead, JPL

Fortran II, Version 3

January 4, 1965

PURPOSE

To multiply two square matrices and store in a third array.

RESTRICTION

Maximum array: 20 × 20

USE

```
CALL   PROM (A, B, C, N)
       A (N, N) * B(N, N) = C (N, N)
```

CODING INFORMATION

Length of subroutine is 110 (10) or 156 (8) words.

IDENTIFICATION

QUEST
Melba W. Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

Checks to ascertain that the times specified are greater than EPOCH plus light time correction. Exits with an error return if time is not compatible.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
    - ERROR
    - SQRT
    - EXIT

USE

CALL QUEST

CODING INFORMATION

Length of subroutine is 117 (10) or 165 (8) words.

IDENTIFICATION 76

QUIZ
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

QUIZ allows a Fortran program to interrogate the COMMON location KEYS, which contains the "key settings" specified by the input deck.

RESTRICTION

COMMON break: 47675

USE

In Fortran,

```
B    A = (octal representation of desired key setting)
     IF (QUIZF (A) ) S1, S2, S1
```

where

S_1 is the normal return indicating that the key is set
S_2 is the normal return indicating that the key is not set

COMMON input:

KEYS key setting word

CODING INFORMATION

Length of subroutine is 2 (10) or 2 (8) words.

IDENTIFICATION

RATES
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

RATES obtains the topocentric slant range and its first three derivatives. Both the up-leg and down-leg are calculated using the light-time correction supplied by subroutine DOPLR. Four other range-dependent quantities are also obtained.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines called:
   COS
   SIN
   SQRT
   ARSIN
   EXP(3

METHOD

$$\alpha_{r_i} = \lambda_i + \alpha_G - 2\omega\Delta t \qquad \text{(station right ascension)}$$

$$\left.\begin{aligned}
X_i &= R_i \cos\phi_i \cos\alpha_{ri} \\
Y_i &= R_i \cos\phi_i \sin\alpha_{ri} \\
Z_i &= R_i \sin\phi_i \\
\dot{X}_i &= -\omega Y_i \\
\dot{Y}_i &= \omega X_i \\
\ddot{X}_i &= -\omega Y_i \\
\ddot{Y}_i &= \omega X_i
\end{aligned}\right\} \quad \text{(station coordinates and derivatives)}$$

$$\ddot{X}_i = -\omega \dot{Y}_i$$

$$\ddot{Y}_i = \omega \dot{X}_i$$

(station coordinates and derivatives)

$$\underline{\rho}_i = \underline{r} - \underline{R}_i$$

$$\dot{\underline{\rho}}_i = \dot{\underline{r}} - \dot{\underline{R}}_i$$

$$\ddot{\underline{\rho}}_i = \ddot{\underline{r}} - \ddot{\underline{R}}_i$$

$$\dddot{\underline{\rho}}_i = \dddot{\underline{r}} - \dddot{\underline{R}}_i$$

(topocentric coordinates)

$$A = \underline{\rho}_i \cdot \dot{\underline{r}}$$

$$B = \dot{\underline{R}}_i \cdot \dot{\underline{r}}_s$$

$$C = \dot{X}_i^2 + \dot{Y}_i^2$$

$$D = \underline{\rho}_i \cdot (\dot{\underline{R}}_i - \dot{\underline{r}}_s)$$

$$a = |\underline{\rho}|$$

$$b = \underline{\rho} \cdot \dot{\underline{\rho}}$$

$$c = \underline{\rho} \cdot \ddot{\underline{\rho}} + \dot{\underline{\rho}} \cdot \dot{\underline{\rho}}$$

$$d = \underline{\rho} \cdot \dddot{\underline{\rho}} + 3\dot{\underline{\rho}} \cdot \ddot{\underline{\rho}}$$

(four output quantities)

$$\rho = a$$

$$\dot{\rho} = \frac{b}{a}$$

$$\ddot{\rho} = \frac{c - \dot{\rho}^2}{a}$$

$$\dddot{\rho} = \frac{d - 3\dot{\rho}\ddot{\rho}}{a}$$

(slant range)

$$\left.\begin{aligned}\Delta_r\rho &= \frac{0.0018958}{(\sin\gamma + 0.06483)^{1.4}}\,\frac{n_i}{340.0}\\ \Delta_r\rho &= \frac{0.0018958}{\tau}\left[\frac{1}{(\sin F + 0.06483)^{1.4}} - \frac{1}{(\sin G + 0.06483)^{1.4}}\right]\frac{n}{340.0}\end{aligned}\right\}\text{(slant range)}$$

where

λ_i = longitude station i

α_G = Greenwich hour angle

ω = Earth rotation rate

Δt = light time correction

ϕ_i = geocentric latitude, station i

R_i = Earth radius at station i

$\underline{r}$ = geocentric probe coordinates

$\underline{r}_s$ = geocentric sun coordinates

γ = elevation angle

n_i = index of refraction, station i

τ = doppler averaging time

$F = \gamma + \frac{\tau\dot{\gamma}}{2}$

$G = \gamma - \frac{\tau\dot{\gamma}}{2}$

USE

CALL	RATES	
PZE	RHO	ρ, km
PZE	DRHO	$\dot{\rho}$, km/sec
PZE	DDRHO	$\ddot{\rho}$, km/sec^2
PZE	DDDRHO	$\dddot{\rho}$, km/sec^3
PZE	A	A
PZE	B	B
PZE	C	C
PZE	D	D
PZE	DT	Δt, sec
PZE	I	station index (IX for up-leg, IR for down-leg)

COMMON input:

THETAI	θ_i, deg	
GHA	$\dot{\alpha}_G$, deg	
OMEGA	ω, deg/sec	
PHII	ϕ_i, deg	
RI	R_i, km	
XN	$\underline{r}$, km	light time corrected
DXN	$\dot{\underline{r}}$, km/sec	light time corrected
DDXN	$\ddot{\underline{r}}$, km/sec^2	light time corrected
DDDXN	$\dddot{\underline{r}}$, km/sec^3	light time corrected
XSUN	$\underline{r}_s$, $\dot{\underline{r}}_s$	
EL	γ, deg	
FNI	n_i	
TAU	τ, sec	

COMMON output:

RVEC	ρ, km
RDOT	$\dot{\rho}$, km/sec
DRVEC	$\Delta_T \rho$, km
DRDOT	$\Delta_T \dot{\rho}$, km/sec

CODING INFORMATION

Length of subroutine is 435 (10) or 663 (8) words.

REFERENCES

a. Warner, M. R., Nead, M. W., Hudson, R. H., TM 33-168, March 18, 1964.

b. Anderson, John D., TM 312-409, March 24, 1964.

IDENTIFICATION 78

RCAL
Melba W. Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

RCAL is to be used to compute the coefficients as required in BMATRX:

$$A = \left(\frac{1}{||\overrightarrow{RV} - \vec{R}||^3} - \frac{1}{RV^3} \right)$$

$$B = \left(\frac{3(\overrightarrow{RV} \cdot \vec{R} - R^2)}{||\overrightarrow{RV} - \vec{R}||^5} \right)$$

$$C = \left(\frac{3}{||\overrightarrow{RV} - \vec{R}||^3} \right)$$

RESTRICTIONS

a. COMMON break: 47675
b. Subroutine used:
   SQRT

USE

CALL RCAL(RV) RV, location of the body vector. Results are stored in COMMON locations A, B, and C.

CODING INFORMATION

Length of subroutine is 159 (10) or 237 (8) words.

IDENTIFICATION 79

RCOM

Melba W. Nead, JPL

Fortran II, Version 3

January 4, 1965

PURPOSE

RCOM computes the coefficients as defined in BMATRX:

$$A = \left(\frac{1}{\left| \left| \overrightarrow{RV} - \vec{R} \right| \right|^3} \right)$$

$$B = \left(\frac{1}{RV^3} \right)$$

RESTRICTIONS

a. COMMON break: 47675

b. Subroutines used:

SQRT

USE

CALL RCOM(RV) RV, location of the body vector. Results are stored in COMMON locations A and B.

CODING INFORMATION

Length of subroutine is 91 (10) or 133 (8) words.

IDENTIFICATION 80

READS/ODOFF/MOOPH1
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

READS is the main program of the link of the ODP which reads data. The routine also includes phasing for all three possible targets, Moon, Mars, and Venus. The target is checked and the phasing is moved so as to be available to the trajectory through the WANT capability of the JPTRAJ monitor.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   ODATA
   TAPIO
   OFFSYS
   ERROR

USE

Upon the completion of each iteration, the logic of the program causes it to cycle back through READS, all under control of the Source Deck and the JPTRAJ monitor.

CALL ODOFF	To end ODP and return to system as called from ODATA.
MOOPH1	Entry to allow JPTRAJ "WANT" feature to save information from this area of READS, namely, the phasing for SPACE.

CODING INFORMATION

Length of subroutine is 704 (10) or 1300 (8) words.

IDENTIFICATION 81

REAP/REAM
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

To read the combined ephemeris tape as it is written by the subroutine RITEM.

RESTRICTIONS

a. ERROR indication received by encountering EOF on tape

b. Subroutines used:

   TAPIO
   FLAT
   ERROR

METHOD

REAP-REAM read the combined ephemeris tape which has been written by RITEM. The subroutine uses two buffers for efficiency of operation.

USE

CALL	REAP	Compares TOB with that saved on tape
CALL	REAM	Compares T with that saved on tape

CODING INFORMATION

Length of subroutine is 1375(10) or 2537(8) words.

IDENTIFICATION 82

REJEC
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

REJEC keeps a record of those residuals which were rejected by the 3-sigma test. Each bit in the rejection table represents a residual. The table is ordered sequentially.

RESTRICTION

COMMON break: 46711

USE

```
CALL   REJEC
PZE    I
PZE    J
PZE    K
```

where

I = 0	to initialize (set pointer at first bit)	
= 1	for normal entry	
J = 0	to determine rejection status of current point	
= 1	to update rejection status of current point	
K = 0	point not rejected	input if J = 1, output if J = 0
= 1	point rejected	

COMMON input and output:

CAPU 500 word rejection table, with recording capability for 18,000 residuals

CODING INFORMATION

Length of subroutine is 46 (10) or 56 (8) words.

IDENTIFICATION 83

RESID
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

Control program for the link which prints and plots residuals and prints statistics.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   THARP
   TYPRYT
   IOCS

USE

Upon request for residuals and statistics, this link is called by the JPTRAJ monitor.

CODING INFORMATION

Length of subroutine is 704 (10) or 1300 (8) words.

IDENTIFICATION 84

RESP/COLA
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

This subroutine is designed to provide both listings and plots of information from the receiving stations. The plots are the residuals, observed minus calculated values, for one, two, or three types versus time. Date, station number, time at start of frame, and pass number are included on each frame. In addition to the above, the listings contain count time, sample time, computed values for the data, and weights. Rejected data points are starred. It is possible to list the residual in fixed (nominal) or floating point (FLRES = 1.0).

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   FGDOUT
   CXPLOT
   PKINE
   PERNOD
   STATID
   FIXT
   PROUT
   FLAPR
   BIBCD
   ERROR
   CDC

A maximum of 8 data residuals can be plotted or listed on one iteration.

USE

CALL RESP With each call to RESP a maximum of 3 residuals is plotted or listed. The routine must be called again for more; the maximum number is 8.

CODING INFORMATION

Length of subroutine is 883 (10) or 1563 (8) words.

REFERENCE

Trask, D.W., RFP 312-37, Addendum 6, April 4, 1962.

IDENTIFICATION

RITEM/WREOF
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

To write the combined ephemeris tape.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   FLAT
   TAPIO

METHOD

RITEM uses TAPIO to write the combined ephemeris tape. The subroutine uses two buffers alternately to provide efficient timing. Each buffer contains four logical records of 156 words each.

USE

CALL RITEM Writes logical record on tape A4. Each record contains the following information:

T (2)	Time of data point
TOB (2)	Observation time
XJUP (6)	Jupiter vector
XERM (6)	
XMAR (6)	Mars vector
XVEN (6)	Venus vector
XSUN (6)	Sun vector
XMOO (6)	Moon vector
X	Probe vector
Y	Probe vector
Z	Probe vector
XDOT	Probe vector
YDOT	Probe vector
ZDOT	Probe vector
U (36)	Variational equations
DLO	Nutation in longitude
DOB	Nutation in obliquity

XAC YAC ZAC	Probe acceleration
XJERK YJERK ZJERK	Probe jerk (3rd derivative)
GMAT (66)	Gamma matrix

CALL WREOF To write end of file and rewind tape A4 when ephemeris is complete.

CODING INFORMATION

Length of subroutine is 1350(10) or 2506(8) words.

IDENTIFICATION 86

ROT

Michael R. Warner, JPL

Fortran II, Version 3

January 4, 1965

PURPOSE

ROT rotates the planetary ephemerides from the mean equator and equinox of 1950.0 to the true equator of equinox of date.

RESTRICTION

COMMON break: 47675

METHOD

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix}_{\text{of date}} = NA \begin{pmatrix} x \\ y \\ z \end{pmatrix}_{1950.0}$$

where

NA = nutation-precession matrix obtained by subroutine PNUT

USE

CALL ROT

COMMON input:

ROTMX	NA
XSUN	geocentric position and velocity of Sun, 1950.0
XVEN	geocentric position and velocity of Venus
XMAR	geocentric position and velocity of Mars
XJUP	geocentric position and velocity of Jupiter
XMOO	geocentric position and velocity of Moon

COMMON output:

XSUN, XVEN, XMAR, XJUP, XMOO rotated to true-of-date

CODING INFORMATION

Length of subroutine is 182 (10) or 266 (8) words.

IDENTIFICATION 87

RSIG
Melba W. Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

The partial of AU is expressed as a sum of terms evaluated for SUN, VENUS, MARS, and JUPITER. RSIG evaluates and sums these terms as they are needed in BMATRX.

$$\sum_{k=1}^{4} GM_k \left[x_k \left(\frac{1}{\left| \underline{r}_k - \underline{r} \right|^3} - \frac{1}{r_k^3} \right) - \frac{3\left(r^2 - \underline{r} \cdot \underline{r}_k \right)(x - x_k)}{\left| \underline{r}_k - \underline{r} \right|^5} \right]$$

where

k = 1 = Sun
k = 2 = Venus
k = 3 = Mars
k = 4 = Jupiter

RESTRICTION

COMMON break: 47675

USE

CALL RSIG(GRA, XPL, SIGX) where GRA is gravity of the body, XPL position of body, and SIGX is the sum. The routine is called for the four bodies and SIGX is accumulated.

CODING INFORMATION

Length of subroutine is 51 (10) or 63 (8) words.

IDENTIFICATION

88

SAVCOM
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

Control for the program to save COMMON. This routine also prints the input matrices when the ODP is initiated and checks the times supplied so the trajectory can be run only for the required period.

RESTRICTIONS

a. ERROR condition; disk error indicated by DCP
b. COMMON break: 47675
c. Subroutines used:
   - PRIM
   - TYPRYT
   - QUEST
   - MAXIM
   - ERROR
   - FLAK
   - DISCBU
   - OFFSYS

USE

To save COMMON during the trajectory link, this routine is under control of the JPTRAJ monitor.

CODING INFORMATION

Length of subroutine is 1118 (10) or 2136 (8) words.

IDENTIFICATION 89

SCALE
Melba W. Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

When the target is Mars or Venus, the target vector is divided by AU as required in calculation of the target centered covariance matrix.

USE

CALL SCALE (XPOS, P) XPOS is the target vector, the quotient is stored in P.

CODING INFORMATION

Length of subroutine is 34 (10) or 42 (8) words.

IDENTIFICATION 90

SORT
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

Time sorted predictions are prepared in Link 4. This is the main program in which these predicts are station sorted and prepared for transmission to the tracking stations.

RESTRICTIONS

a. COMMON break: 47675

b. Subroutines used:

THARP
FLAK
TYPRYT
IOCS

USE

Link 5 is called under control of the JPTRAJ Source Deck.

CODING INFORMATION

Length of subroutine is 1069 (10) or 2055 (8) words.

IDENTIFICATION

SPHX
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

SPHX converts Earth-fixed spherical coordinates to geocentric equatorial cartesian coordinates. No provision is made for nutations; thus, the output is in the mean equator and equinox of date.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   SIN
   COS
   GHADP

METHOD

$$x_0 = r_0 \cos \phi_0 \cos(\alpha_G + \lambda_0)$$

$$y_0 = r_0 \cos \phi_0 \sin(\alpha_G + \lambda_0)$$

$$z_0 = W$$

$$\dot{x}_0 = (\dot{U} - \omega V)\cos \alpha_G - (\dot{V} + \omega U)\sin \alpha_G$$

$$\dot{y}_0 = (\dot{U} - \omega V)\sin \alpha_G + (\dot{V} + \omega U)\cos \alpha_G$$

$$\dot{z}_0 = \dot{W}$$

$$U = r_0 \cos \phi_0 \cos \lambda_0$$

$$V = r_0 \cos \phi_0 \sin \lambda_0$$

$$W = r_0 \sin \phi_0$$

$$\dot{U} = v_0(\sin\gamma_0 \cos\phi_0 \cos\lambda_0 - \cos\gamma_0 \sin\gamma_0 \sin\sigma_0 - \cos\gamma_0 \sin\phi_0 \cos\lambda_0 \cos\sigma_0)$$

$$\dot{V} = v_0(\sin\gamma_0 \cos\phi_0 \sin\lambda_0 + \cos\gamma_0 \cos\gamma_0 \sin\sigma_0 - \cos\gamma_0 \sin\phi_0 \sin\lambda_0 \cos\sigma_0)$$

$$\dot{W} = v_0(\sin\gamma_0 \sin\phi_0 + \cos\gamma_0 \cos\phi_0 \cos\sigma_0)$$

where

$x_0, y_0, z_0, \dot{x}_0, \dot{y}_0, \dot{z}_0$ = geocentric equatorial position and velocity

$r_0, \phi_0, \lambda_0, v_0, \gamma_0, \sigma_0$ = Earth-fixed spherical coordinates

α_G = Greenwich hour angle

ω = Earth rotation rate

USE

CALL SPHX

COMMON input:

RNJ	r_0, km
PHINJ	ϕ_0, deg
THTNJ	λ_0, deg
VNJ	v_0, km/sec
ELNJ	γ_0, deg
AZNJ	σ_0, deg
EPOCH	epoch of state vector, d.p. sec past 1950.0
OMEGA	ω, deg/sec

COMMON output:

XNJ	$x_0, y_0, z_0, \dot{x}_0, \dot{y}_0, \dot{z}_0$ (1×6)

CODING INFORMATION

Length of subroutine is 211 (10) or 323 (8) words.

IDENTIFICATION 92

STARP
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

STARP determines whether an observed time point should be deleted or retained on the basis of input data start and stop times.

RESTRICTION

COMMON break: 47675

USE

CALL	STARP	
PZE	I	I = 0 for point outside allowed range
		= 1 for point within allowed range

COMMON input:

TOB	observation time, d.p. sec past 1950.0
PTFD-30	start-stop times

CODING INFORMATION

Length of subroutine is 24 (10) or 30 (8) words.

IDENTIFICATION

STPREG

Charles L. Lawson/Terry Kinney, JPL

Fortran II, Version 3

January 4, 1965

PURPOSE

Double precision solution of the normal equations of a linear least squares regression problem using the stepwise procedure of M. A. Efroymson.

This subroutine is particularly intended for use in least-squares problems in which the user is aware of a large number of basic functions which might bear a linear relationship to the object function but expects that only some of these basic functions make a significant contribution to the determination of the object function.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   (DFAD)/(DFMP)/(DFDP)
   DSQRT

METHOD

In an n-parameter problem this subroutine provides successively a 1-parameter fit, a 2-parameter fit, . . . , a k-parameter fit, where the new parameter introduced at each step is the one which will make the greatest reduction in the sum of squares of residuals. This criterion is equivalent to the requirement that the new parameter be selected as the one which will have the highest statistical significance in the sense that the ratio of its magnitude to its standard deviation will be largest or equivalently its "F" value will be largest (see Ref. c). The termination level k, which will be $\leq n$, is determined by the subroutine on the basis of tolerance parameters SDIN, SDOUT, and CD provided by the user.

For an exposition of this procedure, see Ref. a of this subroutine. For a complete single precision regression package which incorporates this procedure in its system solving subroutine, see Ref. b. For a discussion of this procedure including details of its implementation in this program see Ref. c.

USE

Let the overdetermined system of linear equations which expresses the linear regression problem be denoted by

$$Gc = f$$

where G is an m by n matrix (m > n), c is an n-vector, f is an m-vector. The elements of G and f are known and the coefficient vector c is to be computed as a weighted least squares solution.

The normal equations Ac = b are formed from the overdetermined system by pre-multiplication by G*W, (*denotes transposition) where W is an m by m non-negative definite weighting matrix (W may be the identity matrix).

This computation, as well as the computation of the scalar quantity s = f*Wf, is to be done by the user's program. STPREG may then be called as follows:

```
D    DIMENSION A (20, 20), B (20), S (1)
     DIMENSION INOUT (20)
     CALL STPREG (A, B, S, N, M, SDIN, SDOUT,
     CD, NIN, INOUT)
```

The parameters are defined as follows:

A(I, J), I = 1, N; J = 1, N

On entry: The matrix A, computed by the user as A = G*WG.
A is normalized by STPREG before inversion.
On return: A^{-1} if NIN = N. If NIN < N then only an NIN by NIN submatrix of A will have been inverted and the elements of this inverse will be in the locations A (I, J) corresponding to those values of I and J for which both INOUT (I) = + 1 and INOUT (J) = + 1. The other A (I, J) locations for I ≤ N, J ≤ N will contain zero.
A^{-1} is unnormalized before the return.

B(I), I = 1, N

On entry: The vector b, computed by the user as b = G*Wf.
On return: The solution vector c if NIN = N. If NIN < N then only NIN components of c will have been computed and they will be those in the locations B (I) for which INOUT (I) = + 1. The other B (I) locations for I ≤ N will contain zero.

S

On entry: The scalar s, computed by the user as s = f*Wf.
On return: The weighted sum of squares of residuals:

$$(f - Gc)^*W(f - Gc) = (f - Gc)^*Wf$$
$$= f^*Wf - (Gc)^*Wf = f^*Wf - c^*b$$

N The dimension, n, of the normal system.

M The dimension, m, of the f vector.

SDIN, SDOUT

If DSIN > 0., these two numbers will be used by the "significance" logic of the program. A coefficient will be permitted to enter the solution if the ratio of its magnitude to its standard deviation will exceed SDIN. If this ratio subsequently drops below SDOUT this coefficient will be removed from the solution. To avoid looping, SDIN should exceed SDOUT.

Typical values for SDIN and SDOUT might be SDIN = 1.96, SDOUT = 1.64, which could be interpreted as meaning that a coefficient will be permitted to enter the solution if there is a 95% probability that it is different from zero and will later be removed from the solution if this probability falls below 90%.

If SDIN ≤ 0 all significance tests will be skipped. This permits use of the program with meaningless data in B and S, as may be the case when only matrix inversion is desired.

CD — Tolerance for relative reduction in magnitude of diagonal elements. The i^{th} coefficient will not be entered into the solution if the i^{th} diagonal element becomes smaller than CD times the original i^{th} diagonal element of the matrix A. For example if CD = 10.**(-12) then a potential pivot element will not be used if it has lost more than its first 12 significant decimal places.

NIN — On return: The number of coefficients in the final solution. INOUT (I), I = 1, N On return: Flags to indicate final status of each coefficient.

- +1 Included in solution.
- -1 Rejected by diagonal test.
- -2 Rejected by significance tests.

CODING INFORMATION

Length of subroutine is 1069 (10) or 2055 (8) words.

REFERENCES

a. Efroymson, M. A., Multiple Regression Analysis, Mathematical Methods for Digital Computers, ed. Ralston and Wilf, Wiley, 1960, pp. 191-203.

b. Efroymson, M. A., Stepwise Multiple Regression with Variable Transformations, SHARE Distribution No. 1194, October, 1961.

c. Lawson, C. L., Computation of the Most Significant Coefficients in Least-Squares Estimation, JPL Section Report No. 372-5, August, 1962.

IDENTIFICATION

TACCOM
Melba W. Nead, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

To evaluate the target-centered cartesian Covariance Matrix.

RESTRICTIONS

a. COMMON break: 47055
b. Subroutines used:
   AAT
   SCALE
   (DFAD)
   (DFMP)
   (DFSB)

METHOD

In the following, A will represent the ephemeris scaling factor. Thus, A = REM when target = MOON, and A = AU when target = MARS or VENUS.

a. When A is among the estimated parameters, compute the target centered covariance matrix as

$$\Gamma_E = \Gamma_X + PP^T \sigma_A^2 - \Gamma_{XA} P^T - P \Gamma_{XA}^T$$

where

Γ_X = upper left hand 6 × 6 sub-matrix of the geocentric covariance matrix Γ

P = 6-vector giving the geocentric position and velocity of the target in units of A and A/sec, referred to the Earth equatorial system

σ_A^2 = diagonal element of Γ corresponding to A

Γ_{XA} = first 6 elements of the column of Γ corresponding to A

b. When A is not among the estimated parameters

$$\Gamma_E = \Gamma_X$$

USE

CALL TACCOM (GAME, ITAR)

GAME contains Γ_E as calculated in TACCOM

ITAR contains the target reference

ITAR = 1 MARS

ITAR = 2 MOON

ITAR = 3 VENUS

CODING INFORMATION

Length of subroutine is 938 (10) or 1652 (8) words.

REFERENCE

Carey, C., RFP 312-252, March 5, 1964.

IDENTIFICATION 95

TAMP/EPOX
Melba W. Nead, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

Writes mapping times on scratch tape A7 to be saved for matrix manipulation program input tape.

RESTRICTIONS

a. COMMON break: 47675

b. Subroutines used:

    TAPIO
    FLAT

USE

CALL TAMP

EPOX — provides space for storage of injection conditions which are saved through the WANT cards feature of JPTRAJ

CODING INFORMATION

Length of subroutine is 87 (10) or 127 (8) words.

IDENTIFICATION 96

THARP/PKINE
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

THARP serves as the logical control routine for the predictions and residuals output links, LA5 and LA8. It sets up lists of desired stations and calls the output subroutines AQUI, PERNOD, RESP, and ANGPLT. PKINE is called by these output routines in order to obtain a meaningful logical record from the disk read routine KINE.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   OFFSYS
   KINE
   AQUI/ALLI/BAQUI/BALLI
   PERNOD/WOLF
   RESP
   ANGPLT
   BIBCD
   TYPRYT

USE

CALL	THARP	
CALL	PKINE	
PZE	SUBR	= 1 if called from ANGPLT
		= 2 if called from AQUI
		= 3 if called from PERNOD
		= 4 if called from RESP

COMMON input:

IF3	ODP option flags
IRES	residual output flags (8 × 15)
RESR	plotting scale factors (8 × 15)
ITNO	iteration number
PT	pointing times (used as flags)

CODING INFORMATION

Length of subroutine is 379 (10) or 573 (8) words.

IDENTIFICATION

TIMER
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

TIMER obtains the primary light time correction which adjusts the observation time for ephemeris lookup purposes.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:
   (DFSB)
   LOOKUP
   SQRT

METHOD

$$\Delta t = 0$$

$$t = t_{ob} - \Delta t$$

$$r = \sqrt{x^2 + y^2 + z^2}$$

$$\Delta t = \frac{r - R_e}{C}$$

The procedure is then repeated with the new Δt.

USE

CALL TIMER
COMMON input:

TOB	t_{ob}, d. p. sec past 1950.0
RE	R_e, km
VELC	c, km/sec

COMMON output:

T	t, d.p. sec past 1950.0
DELT	Δt, d.p. sec

CODING INFORMATION

Length of subroutine is 98 (10) or 142 (8) words.

IDENTIFICATION 98

TNORM

Melba W. Nead/Michael R. Warner, JPL

Fortran II, Version 3

January 4, 1965

PURPOSE

TNORM normalizes an N x N matrix on its diagonal terms. N may be 2, 3, 4, 5, or 6 but the matrix must be stored in a 6 × 6 array.

RESTRICTION

Subroutine called:

SQRT

USE

CALL	TNORM	
PZE	YMAT	input matrix
PZE	XMAT	output normalized matrix
PZE	N	N

CODING INFORMATION

Length of subroutine is 170 (10) or 252 (8) words.

IDENTIFICATION

TOCIM

Michael R. Warner, JPL

IBM 7094, Fap

January 4, 1965

PURPOSE

TOCIM computes occultation time and impact time, and obtains the residual. It writes a record on the combined ephemeris tape for each observable, and outputs on disk for subsequent printing.

RESTRICTIONS

a. COMMON break: 47675

b. Subroutines used:

OFFSYS
TIMER
LOOKUP/KOOL
INTRI
SQRT
COS/SIN
GAMAT
GHADP
ARCOS/ARSIN
FLAT
RITE
WRITEB

METHOD

TOCIM uses a Newton-Raphson formula for both data types:

For occultation time,

$$\left[T_0^{(r)} - T_0^{(r-1)}\right] \frac{d(\phi_p - \phi_m)}{dt}\bigg|_{T_0^{(r-1)}} = \phi_m - \phi_p$$

where

$$\phi_m = \sin^{-1} \frac{R_m}{|\rho_m|}$$

$$\phi_p = \cos^{-1} \frac{\underline{\rho} \cdot \underline{\rho}_m}{|\underline{\rho}| |\underline{\rho}_m|}$$

$$\frac{d(\phi_p - \phi_m)}{dt} = \frac{\underline{\rho} \cdot \underline{\rho}_m}{a_1} \left[\left(\frac{a_2}{\rho^2} + \frac{a_3}{\rho_m^2} \right) - a_4 \right] + \frac{a_3 R_m}{\rho_m^2 \sqrt{\rho_m^2 - R_m^2}}$$

$$a_1 = |\underline{\rho}| |\underline{\rho}_m| \sin \phi_p$$

$$a_2 = \underline{\rho} \cdot \dot{\underline{\rho}}_m$$

$$a_3 = \underline{\rho}_m \cdot \dot{\underline{\rho}}_m$$

$$a_4 = \underline{\rho} \cdot \dot{\underline{\rho}}_m + \underline{\rho}_m \cdot \dot{\underline{\rho}}$$

For impact time,

$$\left[T_I^{(r)} - T_I^{(r-1)} \right] \left| \dot{\underline{r}} - \dot{\underline{r}}_m \right| = \left| \underline{r} - \underline{r}_m \right| - R_m$$

(all quantities are defined in the subroutine OCPAR documentation)

USE

CALL TOCIM

COMMON input:

DXDK-6	target identification
IFA-4	R_m, km
PTFD	occultation-impact data buffer
DXDR-27	occultation-impact buffer
LLIST	physical constants estimate flags
RI	station Earth radius, km
PHII	station geocentric latitude, deg
THETAI	station longitude, deg
EPOCH	ODP epoch, d. p. sec past 1950.0
OMEGA	Earth rotation rate, deg/sec

CODING INFORMATION

Length of subroutine is 998 (10) or 1746 (8) words.

REFERENCE

Warner, M. R., Nead, M. W., Hudson, R. H., TM 33-168, March 18, 1964.

IDENTIFICATION

UMAT

Kenneth Oslund/ Michael R. Warner, JPL

Fortran II, Version 3

January 4, 1965

PURPOSE

UMAT computes the encounter conic, rotating from the geocentric equatorial system to the target-centered $\underline{R}$, $\underline{T}$ system. All encounter parameters and statistics are obtained by this routine.

RESTRICTIONS

Subroutines called:

SQRT
LOG
GERPU
ARTAN
PARAM

METHOD

The following inputs are in the UMAT calling sequence:

$\underline{r}'_{tp}$, $\dot{\underline{r}}'_{tp}$	target centered probe position and velocity at time of encounter
$\underline{r}_{ct}$, $\dot{\underline{r}}_{ct}$	position and velocity of target, centered at that body's primary, at time of encounter
Γ_e	covariance matrix at encounter (7 × 7)
U_e	mapping matrix to encounter (7 × 7)
μ	GM_{target}
t_f	time of flight

First, the rotation matrix is obtained:

$$r'^2 = \underline{r}_{ct} \cdot \underline{r}_{ct}$$

$$\dot{s}'^2 = \dot{\underline{r}}_{ct} \cdot \dot{\underline{r}}_{ct}$$

$$r'\dot{r}' = \underline{r}_{ct} \cdot \underline{\dot{r}}_{ct}$$

$$\underline{u}_p = \frac{\underline{r}_{ct}}{r'}$$

$$\underline{v}_p = \frac{r'\underline{\dot{r}}_{ct} - \dot{r}'\underline{r}_{ct}}{r'\sqrt{\dot{s}'^2 - \dot{r}'^2}}$$

$$a_{33} = \sqrt{\left(u_{pr} + v_{py}\right)^2 + \left(u_{py} - v_{px}\right)^2} - 1$$

$$a_{23} = \sqrt{u_{pz}^2 + v_{pz}^2}$$

$$a_{11} = \frac{\frac{1}{1 + a_{33}}\left[v_{pz}\left(u_{px} + v_{py}\right) + u_{pz}\left(u_{py} - v_{px}\right)\right]}{a_{23}}$$

$$a_{12} = \frac{\frac{1}{1 + a_{33}}\left[v_{pz}\left(u_{py} - v_{px}\right) - u_{pz}\left(u_{px} + v_{py}\right)\right]}{a_{23}}$$

$$a_{21} = -a_{12}a_{33}$$

$$a_{22} = a_{11}a_{33}$$

$$a_{31} = a_{12}a_{23}$$

$$a_{32} = -a_{11}a_{23}$$

The target-centered probe vector is then rotated:

$$\underline{r}_{tp} = A\underline{r}'_{tp}$$

$$\underline{\dot{r}}_{tp} = A\underline{\dot{r}}'_{tp}$$

and the following column vectors are formed:

$$\underline{X}_p = \begin{pmatrix} \underline{r}_{tp} \\ 0 \end{pmatrix} \qquad \dot{\underline{X}}_p = \begin{pmatrix} \dot{\underline{r}}_{tp} \\ 0 \end{pmatrix}$$

$$\underline{X}_v = \begin{pmatrix} 0 \\ \underline{r}_{tp} \end{pmatrix} \qquad \dot{\underline{X}}_v = \begin{pmatrix} 0 \\ \dot{\underline{r}}_{tp} \end{pmatrix}$$

(the seventh member of these vectors is in each case zero)

The encounter conic is then obtained:

$$r^2 = \underline{X}_p \cdot \underline{X}_p$$

$$\underline{\dot{s}}^2 = \dot{\underline{X}}_p \cdot \dot{\underline{X}}_p$$

$$r\dot{r} = \underline{X}_p \cdot \dot{\underline{X}}_p$$

$$a = \frac{1}{\frac{2}{r} - \frac{\dot{s}^2}{\mu}} \quad \text{(semi-major axis)}$$

$$e^2 = 1 - \frac{r^2 \dot{s}^2 - (r\dot{r})^2}{\mu / a} \quad \text{(eccentricity)}^2$$

$$e \sinh F = \frac{r\dot{r}}{\sqrt{-\mu / a}}$$

$$e \cosh F = 1 - \frac{r}{a}$$

$$e \exp F = e \sinh F + e \cos F$$

$$F = \log(\exp F) \quad \text{(hyperbolic anomaly)}$$

$$e\, p_z = X_{pz} \frac{e \cosh F}{r} - \dot{X}_{pz}\, e \sinh F \sqrt{-\frac{a}{\mu}}$$

$$e \sin \Phi_s = \left(\frac{X_{pz}}{r} - X_{pz} \sqrt{-\frac{a}{\mu}} \right) \exp F + \dot{X}_p\, e \sqrt{-\frac{a}{\mu}}$$

$$\underline{B} \cdot \underline{T} \cos \Phi_s = \sqrt{-\frac{a}{\mu}} (X_{pz}\dot{X}_{py} - X_{py}\dot{X}_{px})$$

$$\underline{B} \cdot \underline{R} \cos \Phi_s = a(\sin \Phi_s - e\, p_z)$$

$$T_a = \frac{3}{2}\sqrt{-\frac{a}{\mu}} (e \sinh F - F + \log e)$$

$$T_e = \left(\frac{e \sinh F + 1}{e}\right) a \sqrt{-\frac{a}{\mu}}$$

$$T_F = -r \sqrt{-\frac{a}{\mu}}$$

$$v_\infty = \frac{1}{\sqrt{-\frac{a}{\mu}}}$$

$$n = \frac{-v_\infty}{a}$$

$$t_L = t_f + \frac{(F - e \sinh F - \log e)}{n} \qquad \text{(linearized time of flight)}$$

The next step is to obtain the encounter partials. The encounter parameter set (M) is

$\underline{B} \cdot \underline{R}$	as defined above
$\underline{B} \cdot \underline{T}$	as defined above
t_L	linearized time of flight
$\underline{S} \cdot \underline{R}_s$, $\underline{S} \cdot \underline{T}_s$	dot products of incoming asymptote unit vector $\underline{S}$ with standard $\underline{R}$ and $\underline{T}$ vectors
C_3	vis-viva energy

These parameters are related to the position and velocity of the probe at encounter and the target gravitational constant. This set is called Q.

$$F_{az} = \frac{\exp F}{r}$$

$$F_{a\dot{z}} = -\sqrt{-\frac{a}{\mu}}(\exp F - e)$$

$$F_{bz} = \frac{e \cosh F}{r}$$

$$F_{b\dot{z}} = -\sqrt{-\frac{a}{\mu}}\, e \sinh F$$

$$F_{cx} = -\dot{X}_{py}$$

$$F_{cy} = \dot{X}_{px}$$

$$F_{c\dot{x}} = X_{py}$$

$$F_{c\dot{y}} = -X_{px}$$

$$S_x = \left[\left(\frac{X_{px}}{r} - \sqrt{-\frac{a}{\mu}}\,\dot{X}_{px}\right) \exp F + e\sqrt{-\frac{a}{\mu}}\,\dot{X}_{px}\right]\frac{1}{e} \quad x \rightarrow y$$

$$S_z = \sin \Phi_s$$

$$T_{sx} = \frac{S_y}{\cos \Phi_s}$$

$$T_{sy} = -\frac{S_x}{\cos \Phi_s}$$

$$R_{sx} = T_{sy} S_z$$

$$R_{sy} = -T_{sx} S_z$$

$$R_{sz} = \cos \Phi_s$$

$$\underline{\delta a} = 2a^2\left(\frac{\underline{X}_p}{r^3} + \frac{\dot{\underline{X}}_n}{\mu}\right)$$

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$$\delta a_\mu = -\frac{a^2(1 + e\cosh F)}{r\mu}$$

$$\left[\underline{\delta e} \vdots \delta' e_\mu\right] = \frac{1}{e}\left[-\frac{\frac{e}{a}\cosh F\,\underline{X}_p}{r} - \frac{e\sinh F(\dot{\underline{X}}_\rho + \underline{X}_v)}{\sqrt{-\frac{\mu}{a}}}\right.$$

$$\left. + \delta\underline{a}\left(\frac{\frac{1}{2}e^2\sinh^2 F}{a} + \frac{r\,e\cosh F}{a^2}\right)\right]$$

$$\delta e_\mu = \delta' e_\mu + \frac{1}{e}\left[-\frac{1}{\mu}\left(\frac{1}{2}e^2\sinh^2 F + \frac{r}{a}e\cosh F\right) + \frac{r^2}{2a^2} + \frac{r^2\delta a_\mu}{2a^3}\right]$$

$$\left[\delta\underline{F} \vdots \delta' F_\mu\right] = \frac{1}{e^2}\left[\frac{\frac{e}{a}\sinh F\,X_p}{r} + \frac{e\cosh F(\dot{\underline{X}}_p + \underline{X}_v)}{\sqrt{-\frac{\mu}{a}}}\right.$$

$$\left. - \underline{\delta a}\left(\frac{\frac{1}{2}e^2\cosh^2 F}{a} + \frac{r\,e\sinh F}{a^2}\right)\right]$$

$$\delta F_\mu = \delta' F_\mu + \frac{1}{e^2}\left(-\frac{e\sinh F}{2\mu\,e\cosh F} - \frac{r^2\,e\sinh F\,\delta a_\mu}{2\,e\cosh F\,a^3}\right)$$

$$\left[\delta\Phi_s \vdots \delta'\Phi_{s\mu}\right] = \left[-\frac{X_{pz}\underline{X}_p\exp F}{r^3} - \frac{\frac{1}{2}\dot{X}_{pz}(e - \exp F)}{\sqrt{-\frac{\mu}{a}}}\underline{\partial a}\left(-\frac{\dot{X}_{pz}a}{\sqrt{-\frac{\mu}{a}}} + \sin\Phi_s\right)\delta\underline{e}\right.$$

$$\left. - \left(\dot{X}_{pz}\sqrt{-\frac{a}{\mu}} - \frac{X_{pz}}{r}\right)\delta\underline{F}\exp F + \underline{F_a}\right]\frac{1}{e\cos\Phi_s}$$

$$\left[\underline{\delta S_x} \vdots \delta' S_{x\mu}\right] = \frac{1}{e}\left[-\frac{X_{px}\exp F\,\underline{X}_p}{r^3} + \frac{\dot{X}_{px}(\exp F - e)}{2\sqrt{-\frac{\mu}{a}}}\underline{\delta a}\right.$$

$$\left. + \left(\sqrt{-\frac{a}{\mu}}\,\dot{X}_{px} - S_x\right)\delta\underline{e} - \left(\frac{\sqrt{-\frac{a}{\mu}}\,\dot{X}_{px} - X_{px}}{r}\right)\exp F\,\delta\underline{F} + \underline{F_a}\right]$$

$$\left[\underline{\delta S_y} \vdots \delta' S_{y\mu}\right] = \left[\underline{\delta S_x} \vdots \delta' S_{x\mu}\right] \quad x \rightarrow y$$

$$\left[\delta S_z \vdots \delta' S_{z\mu}\right] = \cos \Phi_s \underline{\delta \Phi_s}$$

$$\underline{E_p} = -\frac{e \sinh F \sqrt{-\frac{a}{\mu}}\, \underline{\dot{X}_p}}{2\mu}$$

$$\underline{\delta S_\mu} = \underline{\delta' S_\mu} + \left[\underline{E_p} - (e \cosh F - e^2) \frac{\underline{\dot{X}_p} \sqrt{-\frac{a}{\mu}}}{2\mu}\right] \frac{1}{e \cos \Phi_s}$$

$$\delta\Phi_{s\mu} = \delta' \Phi_{s\mu} + \delta' S_{z\mu}$$

$$\left[\underline{e\, \delta P_z} \vdots \left(e\, \delta P_{z\mu}\right)'\right] = -\frac{X_{pz}\; e \cosh F\, \underline{X_p}}{r^3} + \frac{X_{pz}\; e \sinh F\, \underline{\delta a}}{2\sqrt{-\frac{\mu}{a}}}$$

$$\left(- \dot{X}_{pz}\; e \cosh F \sqrt{-\frac{a}{\mu}} - \frac{e \sinh F}{r}\right) \underline{\delta F} + \underline{F_b}$$

$$e\, \delta P_{z\mu} = (e\, \delta P_{z\mu}) + E_{pz}$$

The program now computes the variational matrix $V = \left(\frac{\partial M}{\partial Q}\right)$:

$$\left[\underline{v_1} \vdots v'_{1\mu}\right] = \left[\left(e \sin \Phi_p - e^2 P_z\right) \underline{\delta a} - a\, e\, P_z \underline{\delta e}\right.$$

$$\left. - (\underline{B} \cdot \underline{R}\; e \sin \Phi_p a\, e \cos \Phi_p) \underline{\delta \Phi_s} - a\, e^2\, \underline{\delta P_z}\right] \frac{1}{e \cos \Phi_p}$$

$$\left[\underline{v_2} \vdots v'_{2\mu}\right] = \left(\frac{e \cos \Phi_p\, \underline{B} \cdot \underline{T}}{2a} \underline{\delta a} + \underline{B} \cdot \underline{T}\; e \sin \Phi_p \underline{\delta \Phi_s} - e \sqrt{-\frac{a}{\mu}}\, \underline{F_c}\right) \frac{1}{e \cos \Phi_p}$$

$$\left[\underline{v_3} \vdots v'_{3\mu}\right] = T_a\, \underline{\delta a} + T_e\, \underline{\delta e} + T_F\, \underline{\delta F}$$

$$\left[v_4 \vdots v'_{4\mu}\right] = \frac{\mu}{a^2}\, \underline{\delta a}$$

$$\left[v_5 \vdots v'_{5\mu}\right] = T_{sx}\, \underline{\delta S_x} + T_{sy}\, \underline{\delta S_y}$$

$$\left[v_6 \vdots v'_{6\mu}\right] = R_{sx}\,\delta \underline{S_x} + R_{sy}\,\delta \underline{S_y} + R_{sz}\,\delta \underline{S_z}$$ 100-8 of 9

$$v_{1\mu} = v'_{1\mu}$$

$$v_{2\mu} = v'_{2\mu} + \frac{\underline{B} \cdot \underline{T}}{2\mu}$$

$$v_{3\mu} = v'_{3\mu} - \frac{\sqrt{-\frac{a^3}{\mu}}\,(F - e \sinh F - \log e)}{2\mu}$$

$$v_{4\mu} = v'_{4\mu} - \frac{1}{a}$$

$$v_{5\mu} = v'_{5\mu}$$

$$v_{6\mu} = v'_{6\mu}$$

The following matrix manipulations are then performed:

$$N = V^T A \Gamma_e A^T V \qquad \text{(noise moment matrix)}$$

$$V_0 = VAU_e \qquad \left(V_0 = \frac{\partial M}{\partial Q_0} \text{ matrix}\right)$$

Finally, the configuration of the miss ellipse is obtained:

$$r = \sqrt{\left(\frac{n_{11} - n_{22}}{2}\right)^2 + n_{12}^2}$$

$$s = \frac{n_{11} + n_{22}}{2}$$

$$a_m = \sqrt{s + r} \qquad \text{(semi-major axis)}$$

$$b_m = \sqrt{s - r} \qquad \text{(semi-minor axis)}$$

$$\theta = \frac{1}{2} \tan^{-1}\left(\frac{2n_{12}}{n_{22} - n_{11}}\right) \qquad \text{(inclination)}$$

USE

CALL	UMAT		
PZE	XT	$\underline{r}'_{tp}$, $\dot{\underline{r}}'_{tp}$	(1×6)
PZE	XH	$\underline{r}_{ct}$, $\dot{\underline{r}}_{ct}$	(1×6)
PZE	G	Γ_e	(7×7)
PZE	U	U_e	(7×7) in (20×20) array
PZE	TMU	μ of target	
PZE	TF	t_f, sec	

CODING INFORMATION

Length of subroutine is 1681 (10) or 3221 (8) words.

REFERENCES

a. Warner, M. R., Nead, M. W., Hudson, R. H., TM 33-168, March 18, 1964.
b. Anderson, John D., RFP 312-83, October 1962.
c. Null, George W., RFP 312-179, Addendum 2, September 19, 1963.

IDENTIFICATION 101

VEC
Charles Coltharp, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

VEC computes the standard dot product of two 1 × 3 vectors, $A = \underline{X} \cdot \underline{Y}$.

RESTRICTION

COMMON break: 47675

USE

```
CALL  VEC
PZE   X
PZE   Y
```

COMMON output:

A	dot product

CODING INFORMATION

Length of subroutine is 15 (10) or 17 (8) words.

IDENTIFICATION

WAIT
Michael R. Warner, JPL
Fortran II, Version 3
January 4, 1965

PURPOSE

WAIT obtains the a priori weight for each data point used in the normal equations.

RESTRICTIONS

a. COMMON break: 47675

b. Subroutines used:

COL
DECOD
SQRT
WOCT
COS
ERROR

Error condition:

If the weight obtained is less than 10^{-20}, the program will abort.

METHOD

Method a1.

If a priori coefficients $\sqrt{\tilde{\omega}_j}$ are input to the program, the calculated weight is

$$\sqrt{\omega_j} = \sqrt{\tilde{\omega}_j}\ \beta_1\ \beta_2 \sqrt{\frac{60}{\tau_s}}$$

where

β_1 = 1 when not weighting azimuth or hour angle

$= \frac{1}{\cos \gamma}$ when weighting azimuth angle

$= \frac{1}{\cos \delta}$ when weighting hour angle

β_2 = 1 when weighting azimuth angle

$= 1 + \frac{18}{(\gamma + 1)^2}$ when not weighting azimuth angle

τ_s = data sample rate

δ = declination

γ = elevation angle

Method a2.

If octal weight codes are input to the ODP a priori coefficient table, the program uses Method b.

Method b.

If octal weight codes are input by the ODG data file, and if no input was made to the ODP coefficient array, the calculated sigma is

$$\omega_j = \sum_{i=1}^{6} S_{pjk}^2 \, g_{pj}^2 \; \max \left(\frac{T_{pjk}}{\tau}, \; 1 \right)$$

(see documentation for subroutines DECOD and COL).

USE

CALL WAIT

COMMON input:

BALNC	$\sqrt{\tilde{\omega}_j}$ (12 × 15)
ID	data type identification
IR	receiver identification
SSQ	S_{pjk}^2 (12 × 6 × 4)
TL	T_{pjk} (12 × 6 × 4)
GSQ	g_{pjk}^2 (6)
TAU	τ (doppler averaging time, sec)
IF10	phi vector output flag
DEC	δ, deg
EL	γ, deg
TS	τ_s, sec

COMMON output:

RVECW	array of weights

CODING INFORMATION

Length of subroutine is 230 (10) or 346 (8) words.

REFERENCE

Hamilton, Thomas W., TM 312-182, April 12, 1962.

IDENTIFICATION 103

WASH
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

WASH prints certain time-dependent quantities which are calculated by the ODP (see list below). The subroutine is operative only in Mode-IV or the JPTRAJ production mode.

RESTRICTIONS

a. COMMON break: 47675
b. Subroutines used:

   READB
   FLAT/FLAPR
   FIXT
   PROUT

USE

CALL WASH

COMMON input:

TOB	observation time, d.p. sec past 1950.0
GHA	Greenwich hour angle, deg
X	geocentric probe vector
XSUN	geocentric Sun vector
XMOO	geocentric Moon vector
XVEN	geocentric Venus vector
XMAR	geocentric Mars vector
CPPHI	partials $\partial F/\partial Q$
CPTHT	partials $\partial F/\partial \tilde{Q}$
U	partials $\partial \underline{r}/\partial \underline{r}_0$
GMAT	partials $\partial \underline{r}/\partial q$
DRVEC	refraction corrections

CODING INFORMATION

Length of subroutine is 401 (10) or 621 (8) words.

IDENTIFICATION 104

WOCT
Michael R. Warner, JPL
IBM 7094 Fap
January 4, 1965

PURPOSE

WOCT determines whether an input a priori weight represents a floating point quantity or an octal weight code.

USE

CALL	WOCT	
PZE	WT	a priori weight word
PZE	CODE	output if octal code
PZE	TEST	= 0 if floating point
		≠ 0 if octal code

CODING INFORMATION

Length of subroutine is 11 (10) or 13 (8) words.

VII. OPERATING INSTRUCTIONS

The ODP may be operated in three modes: SFOF Mode II, SFOF Mode IV, and the JPTRAJ Production Mode. Mode II requires the full SFOF hardware configuration, namely, the 7094-disk-7040, with associated user-area equipment. Mode IV requires the 7094 and disk, properly initialized for SFOF operation. The JPTRAJ Production Mode is independent of the SFOF system, requiring only the 7094 and disk.

A. MODE II OPERATION

1. After the system has been initialized and the user programs loaded on disk, ask the operator to mount the following tapes:

   A3 scratch for 1401 output
   A4 scratch for combined ephemerides
   B6 EPHEM system tape
   B9 scratch for 4020 plot output (optional)

2. Type PS1X$ at the user area 7 console.

3. Depress the TURN ON button, then the TRANSMIT MESSAGE button.

4. When requested by the administrative printer, enter the ODPX source deck via the user area card reader.

5. At the conclusion of PS1X, type ODPX$ at the user-area 5 console.

6. Depress the TURN ON button, then the TRANSMIT MESSAGE button.

7. At the beginning of ODPX execution, the message ENTER SWITCHES. 22 = TERMINATE, 23 = DELAY, NONE = PROCEED will be printed by the administrative printer. To proceed, clear the switches and type ODPX$ at the user area console.

8. Depress the OPTION SWITCH ENTRY button, then the TRANSMIT MESSAGE button.

9. When requested by the administrative printer, enter the input deck, as described in Section IV A, via the user area card reader. The program will then execute the options requested by the input deck.

10. To obtain the full SC-3070 printout, type 1$ at the console, depress the AUTO ON button, then the TRANSMIT MESSAGE button.

11. The message described in step 7 will be printed between iterations. The user has the opportunity to read a new deck for the next iteration, or terminate ODP execution.

B. MODE IV OPERATION

1. After the system has been initialized and the user programs loaded on disk, mount the following tapes:

A3	scratch for 1401 output
A4	scratch for combined ephemeris
B6	EPHEM system tape
B7	scratch for MMP output (optional)
B1	scratch for supplementary partials output (optional)
B9	scratch for 4020 plot output (optional)

2. While the system is at the idle stop, depress sense switch 1 and depress START at the 7094 console.

3. At the card reader select, enter the card TURN ON, PS1X$.

4. Raise sense switch 1.

5. At the card reader select, enter the ODPX source deck.

6. At the conclusion of PS1X (idle stop), depress sense switch 1 and depress START.

7. At the card reader select, enter the card TURN ON, ODPX$.

8. Raise sense switch 1.

9. At the card reader select, enter the input deck, as described. The program will then execute the options requested by the input deck.

10. To obtain on-line printout, depress sense switch 6.

11. The card reader will select between iterations for additional input. If console key 22 is depressed at the end of an iteration, the execution will be terminated.

C. JPTRAJ PRODUCTION MODE OPERATION

1. Mount the following tapes:

A1	JPTRAJ system tape
A2	input tape (see below)
A3	scratch for 1401 output
A4	scratch for combined ephemeris
A5	JPTRAJ program tape
B1	scratch for system operation
B6	EPHEM system tape
B7	scratch for MMP output (optional)
B9	scratch for 4020 plot output (optional)

2. The input tape should contain the following card images:

```
$JOB     MRW, 2116000, 542-70285-1-3170, FC (example of
         JPL job card)
*        JPTRAJ
$RESTORE
*        DATA
         [ODPX source deck]
         [ODPX input deck
           for iteration 1]
               .
               .
               .
               .
               .
               .
         [ODPX input deck
           for iteration n]
         EOF card
$PAUSE
```

3. To start the system, depress the LOAD TAPE button at the 7094 console.

4. Once the program has been restored on disk, the $RESTORE card and the A5 tape need not be used.

D. SOURCE DECK LISTING

```
         ANALYSIS OF THE JPTRAJ SOURCE PROGRAM FOR THE ODP PROVIDES
         THE BASIC LOGIC OF THE PROGRAM. IN THE FOLLOWING THE STARRED
         ITEMS ARE DIRECTLY FROM THE SOURCE PROGRAM WHICH IS GIVEN
         IN COMPLETE FORM IN THE APPENDIX.   NON-STANDARD EXITS FOR
         EACH LINK ARE EXPLAINED. THE STANDARD EXIT IS IN SEQUENCE.

*N1      ODPX     N9
         N9

*N9      LA9      X,N11,N1,N4
         X        TERMINATE JOB
         N11      USE SAME PROBE EPHEMERIS,SKIP TRAJ THIS PASS
         N1       RESTART FEATURE, TO RESET TO NOMINAL INPUT
         N4       USE SAME COMBINED EPHEMERIS, SKIP TO LINK 4
                  THE CARD    SW5=1    WILL CAUSE THE ODP TO READ THE INPUT
                  DECK FROM TAPE A2. NORMAL INPUT IS BY ONLINE READER.

*N12     LA12     X
         X        TERMINATE JOB

*N13     SPACE    X
         X        TERMINATE JOB

*N11     LA11     N4,N6,N12
         N4       EXIT TO PREDICT-DATA TAPE LINK
         N6       EXIT TO DATA FITTING LINK
         N12      EXIT TO LINK 12 FOR ERROR, THEN TO X

*N2      LA2      N12, X
         N12      EXIT TO LINK 12 FOR ERROR COMMENT, THEN TO X
         X        TERMINATE JOB

*N2A     LA2A     N9,N12
         N9       STEP MAP COMPLETED, CHECK FOR MORE INPUT
         N12      EXIT TO LINK 12 FOR ERROR, THEN TO X

*N3      LA3      N9,N10
                  (NO EXIT TO LINK 4)
         N9       IMPACT MAPPING COMPLETE, CHECK FOR MORE INPUT
         N10      COMMENT OUTPUT REQUESTED

*N4      LA4      N6,N12
         N6       NO SORTING NECESSARY, GO TO DATA FITTING LINK
         N12      EXIT TO LINK 12 FOR ERROR

*N5      LA5      N9,N12
                  (NO EXIT TO LINK 6)
         N9       PREDICTS SORTED CHECK FOR MORE INPUT
         N12      EXIT TO LINK 12 FOR ERROR

*N6      LA6      N12
         N12      EXIT TO LINK 12 FOR ERROR

*N7      LA7      N9,N10,N12


         N9       RETURN FOR MORE INPUT, NO RESIDUALS, STATISTICS REQUESTED
         N10      EXIT HERE TO PRINT PARTIALS
         N12      ERROR EXIT

*N8      LA8      N9,N12
                  (NO EXIT TO LINK 10)
         N9       RETURN FOR MORE INPUT
         N12      ERROR EXIT

*N10     LA10     N8,N9
                  (NO EXIT TO LINK X)
         N8       AFTER PARTIALS PRINT RETURN TO LINK 8 FOR RESIDUALS
                  AND STATISTICS
         N9       NO OTHER REQUESTS, RETURN TO INPUT LINK

*X       END
```

VIII. CHECK CASES

```
        SOURCE PROGRAM LISTING

*N1     DDPX    N9
*N9     LA9     X,N11,N1,N4
55164/=1.0E16
*N12    LA12    K
*N13    SPACE   K
                SCFORF=2
*       WANT    N9,(MODPH1),200,(MOTOR,BRHOPT),18
*       WANT    N11,(TAPEX),6
*       WANT    N12,(XNJ,INJX),1,(XNJ-1,INJY),1
*       ETC     (XNJ-2,INJZ),1,(XNJ-3,INJDX),1
*       ETC     (XNJ-4,INJDY),1,(XNJ-5,INJDZ),1
*       ETC     (EPOCH,INJT),1,(EPOCH-1,INJT+1),1
*       ETC     (OUT,GRAY-2),1,(AU,SCALE1+1),1
*       ETC     (RE,SCALE1),1,(PORE,HARMN+5),1
*       ETC     (QD,HARMN+4),1,(QH,HARMN+3),1
*       ETC     (QJ,HARMN+2),1,(GRAVE,GRAV),1
*       ETC     (GRAVM,GRAV+1),1,(GRAVS,GRAV+2),1
*       ETC     (GRAVV,GRAV+3),1,(GRAVR,GRAV+4),1
*       ETC     (GRAVJ,GRAV+6),1,(STEP,H),1
*       ETC     (TARGET,TARBCD),1,(AREA,RADOPT+3),1
*       ETC     (GHB,RADOPT+4),1,(FMASS,RADOPT+5),1
*       ETC     (FA0,GASOPT+9),1,(FB0,GASOPT+12)
*       ETC     (FC0,GASOPT+15),1,(FA1,GASOPT+8)
*       ETC     (FB1,GASOPT+11),1,(FC1,GASOPT+14)
*       ETC     (FA2,GASOPT+7),1,(FB2,GASOPT+10)
*       ETC     (FC2,GASOPT+13),1,(JETON,GASOPT),1
*       ETC     (JETON,GASOPT+2),1,(JETON-1,GASOPT+3),1
*       ETC     (JETOFF,GASOPT+5),1,(JETOFF-1,GASOPT+6),1
*       ETC     (TFIN,SECP50),1,(TFIN-1,SCCP50+1),1
*       ETC     (FMASS,GASOPT+16),1
GASOPT+1=(CANOPU)
INJBCO=(EARTH)
RADOPT=.1031E9
*N11    LA11    N4,N6,N12
*       WANT    N9,(C137),1
*       WANT    N13,(CLPT,TRADE+1),1,(CLPT+1,TRADE),1
*       ETC     (CLPBTC,TRADE+2),1,(CLPBRC,TRADE+3),1
*       ETC     (CLPBTT,TRADE+4),1,(CLPBRT,TRADE+5),1
*       ETC     (TAPEX),6
*N2     LA2     N12,X
*       WANT    N11,(EPOX),14
*N2A    LA2A    N9,N12
*N3     LA3     N9,N10
*N4     LA4     N6,N12
*N5     LA5     N9,N12
*N6     LA6     N12
*N7     LA7     N9,N10,N12
*       WANT    N9,(APRIOR-19,APRIOR-19),20
*N8     LA8     N9,N12
*N10    LA10    N8,N9
*X      END                                                  (0

                THERE WERE NO GLARING SOURCE DECK ERRORS.

                THE OBJECT STRING HAS 00516 OCTAL OR  334 DECIMAL WORDS.
```

```
0000 134501     PAGE HEADING                                            (23
0000 13450      (MARS CHECK CASE - FIT SIMULATED DATA, THEN MAP)
0000 13450      EPOCH                                                   (01
0000 13450      641102815,0757000
0000 13450      GEOCENTRIC POSITION AND VELOCITY AT EPOCH               (02
0000 13450      X=.56682222E4 Y=.21966726E4 Z=-.32403740E4
0000 13450      DX=-.18839477E1 DY=.10978654E2 DZ=-.12280548E1
0000 13450      OTHER OPTIONS AND CONSTANTS                             (03
0000 13450      TARGET=(MARS)
0000 13450      INFRQ=3624200.
0000 13450      ESTIMATE THESE PARAMETERS                               (04
0000 13450      X Y Z DX DY DZ MM AU
0000 13450      COVARIANCE MATRIX OF ESTIMATED PARAMTERS                (10
0000 13450      DIAG=10.,10.,10.,.01,.01,.01,.1E-17,25.
0000 13450      POINTING TIMES, SAMPLE RATE, COUNT TIME                 (17
0000 13450      DOHJET=641102816,0,641103016,0,3600.,60.
0000 13450      JOBJET=641102816,0,641103016,0,3600.,60.
0000 13450      DATA FILE SIGMA                                         (21
0000 13450      HA(4)=.001 DEC(4)=.002 CC3(4)=.001
0000 13450      HA(5)=.002 DEC(5)=.001 CC3(5)=.002
0000 13450      STATISTICS AND RESIDUALS FOR THESE DATA TYPES           (14
0000 13450      HA(4)=.01 DEC(4)=.01 CC3(4)=.01
0000 13450      HA(5)=.01 DEC(5)=.01 CC3(5)=.01
0000 13450      WEIGHTS BY DATA TYPE AND STATION                        (16
0000 13450      HA(4)=.5 DEC(4)=.5 CC3(4)=.1
0000 13450      HA(5)=.5 DEC(5)=.5 CC3(5)=.1
0000 13450      TRANSMITTER ID TABLE                                    (26
0000 13450      4,2038516.,641102916,0,5,2038516.
0000 13450      OFFLINE CONTROL                                         (27
0000 13450      KEY(2) KEY(14) KEY(16)
0000 13450      END DATA                                                (0
```

INPUT COVARIANCE MATRIX OF ESTIMATED PARAMETERS   ITERATION NUMBER   0

	X	Y	Z	DX	DY	DZ	MM	AU
X	.10000000 02	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00
Y	.00000000 00	.10000000 02	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00
Z	.00000000 00	.00000000 00	.10000000 02	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00
DX	.00000000 00	.00000000 00	.00000000 00	.99999998-02	.00000000 00	.00000000 00	.00000000 00	.00000000 00
DY	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.99999998-02	.00000000 00	.00000000 00	.00000000 00
DZ	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.99999998-02	.00000000 00	.00000000 00
MM	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.99999998-18	.00000000 00
AU	.00000000 00	.00000000 00	.00000000 00	.00000000 00	..00000000 00	.00000000 00	.00000000 00	.25000000 02

INPUT J MATRIX OF ESTIMATED PARAMETERS   ITERATION NUMBER   0

	X	Y	Z	DX	DY	DZ	MM	AU
X	.99999999-01	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00
Y	.00000000 00	.99999999-01	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00
Z	.00000000 00	-.00000000 00	.99999999-01	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00
DX	.00000000 00	-.00000000 00	-.00000000 00	.10000000 03	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00
DY	.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	.10000000 03	-.00000000 00	-.00000000 00	-.00000000 00
DZ	.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	.10000000 03	-.00000000 00	-.00000000 00
MM	.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	.99999998 18	-.00000000 00
AU	.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	.39999999-01

```
CASE  1                              IBSYS-JPTRAJ-SPACE 022265

DOUBLE PRECISION EPHEMERIS TAPE - EPHEM1

  GME  .39860063 06      J  .16234500-02     H -.57499999-05     D  .78749999-05    RE  .63781650 04   REM  .63783112 04
    G  .66709998-19      A  .88781796 29     B  .88800194 29     C  .88836976 29   OME  .41780741-02    AU  .14959850 09
  GMM  .49026293 04    GMS  .13271411 12   GMV  .32476627 06   GMA  .42977368 05   GMC  .37918700 08   GMJ  .12670935 09
  EGM  .39860320 06    MGM  .49027779 04    JA  .29200000-02    HA  .00000000 00    DA  .00000000 00    RA  .34170000 04
RADIATION PRESSURE INPUT
  ARA  .11120000 02     GB  .95999999-01   MAS  .25900000 03   GB1  .00000000 00   GB2  .00000000 00    SC  .10310000 09

INJECTION CONDITIONS           MARS        23570055142320220000000 J.D.= 2438728.13052083  NOV. 28,1964 15 07 57.000

GEOCENTRIC        XO .56682222 04  YO .21466726 04  ZO-.32403748 04 DXO-.18839477 01 DYO .10978654 02 DZO-.12280548 01
CARTESIAN         TO .54476999 05 GHA .29452970 03 GHO .66920765 02
DATE OF RUN 022265A  13460                  EARTH    IS THE CENTRAL BODY FOR INTEGRATION   COWELL EQUATIONS OF MOTION

       PROBE IS IN EARTH'S    SHADOW

   0 DAYS  0 HRS.  0 MIN.  0.000 SEC.      23570055142320220000000 J.D.= 2438728.13052083  NOV. 28,1964 15 07 57.000

       GEOCENTRIC                                                                                  EQUATORIAL COORDINATES

    X  .56682219 04      Y  .21466724 04     Z -.32403747 04    DX -.18839476 01    DY  .10978653 02    DZ -.12280547 01
    R  .68729157 04    DEC -.28129771 02    RA  .20742711 02     V  .11206614 02   PTH  .12650650 02    AZ  .90421379 02
    R  .68729154 04    LAT -.28129772 02   LON  .86213015 02    VE  .10775808 02   PTE  .13165318 02   AZE  .90439129 02
   XS -.58995549.08     YS -.12408705 09    ZS -.53810146 08   DXS  .27792202 02   DYS -.10840364 02   DZS -.47011071 01
   XM -.38523466 06     YM -.44736395 05    ZM  .18645579 05   DXM  .37058146-01   DYM -.92038371 00   DZM -.41497853 00
   XT -.19750066 09     YT  .58811766 08    ZT  .33854926 08   DXT  .87298950 01   DYT -.21590059 02   DZT -.91209471 01
   RS  .14755881 09     VS  .30199675 02    RM  .38827148 06    VM  .10102904 01    RT  .20883364 09    VT  .25010665 02
  GED -.28291871 02    ALT  .49950940 03   LOS  .31004216 03   RAS  .24457186 03   RAM  .18662395 03   LOM  .25209425 03
  DUT  .35000000 02     DT  .37500000 01    DR  .24543145 01   SHA  .62358861 04   DES -.21387223 02   DEM  .27525167 01
  CCL  .11901304 03    MCL  .21144471 03   TCL  .21574659 03

                                              GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE                235700551326202354642400 J.D.= 2438728.12770659  NOV. 28,1964 15 03 53.850
  SMA -.41536075 05    ECC  .11580720 01     B  .24259727 05   SLR  .14169237 05   APO  .00000000 00   RCA  .65656922 04
   VH  .30978206 01     C3  .95964924 01    C1  .75152290 05   TFP  .24314986 03    TF -.28142345-02   LTF -.25588951-01
   TA  .23551647 02    MTA  .14971233 03    EA  .64722201 01    MA  .10390285 01                       TFI  .00000000 00

                                                            ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
    X  .56682219 04      Y  .21466724 04     Z -.32403747 04    DX -.18839476 01    DY  .10978653 02    DZ -.12280547 01
  INC  .28132666 02    LAN  .11163641 03   APF  .24566020 03    MX -.35740510 00    MY  .93392694 00    MZ -.64857359-02
   WX  .43829295 00     WY  .17385475 00    WZ  .88185818 00    PX  .89883014 00    PY -.86854062-01    PZ -.42960527 00
   QX  .19040406-02     QY  .98093365 00    QZ -.19433341 00    RX -.21994247 00    RY  .16164777 00    RZ -.96202662 00
   BX  .45496172 00     BY  .80323618 00    BZ -.38447559 00    TX  .59221295 00    TY  .80578151 00    TZ  .00000000 00
  SXI  .77710383 00    SYI  .41972693 00   SZI -.46897637 00   DAI -.27967872 02   RAI  .28374231 02
  SXO -.77518326 00    SYO  .56972462 00   SZO  .27295548 00   DAO  .15840210 02   RAO  .14368579 03

  BTQ  .24222576 05    BRQ  .13420740 04     B  .24259727 05   THA  .31712828 01    T VECTOR IN  EARTH EQUATOR PLANE

                                                            ALL VECTORS REFERENCED TO ECLIPTIC PLANE
    X  .56682219 04      Y  .68027003 03     Z -.38269391 04    DX -.18839476 01    DY  .95837711 01    DZ -.54945680 01
  INC  .42277832 02    LAN  .13934388 03   APF  .21231137 03    MX -.35740509 00    MY  .85425011 00    MZ -.37751597 00
   WX  .43829294 00     WY  .51035282 00    WZ  .73989141 00    PX  .89883011 00    PY -.25060393 00    PZ -.35958584 00
   QX  .19040406-02     QY  .82264062 00    QZ -.56855842 00    RX -.18420546-01    RY  .15001224-01    RZ -.99971770 00
   BX  .45496171 00     BY  .58396360 00    BZ -.67230674 00    TX  .63146777 00    TY  .77540212 00    TZ  .00000000 00
```

```
CASE  I                                          IBSYS-JPTRAJ-SPACE 022265

 SXI  .77710380 00   SYI  .19849447 00   SZI -.59725159 00   DAI -.36673309 02   RAI  .14328600 02
 SXO -.77518323 00   SYO  .63128952 00   SZO  .23756120-01   DAO  .13612515 01   RAO  .14084150 03

 BTC  .22379497 05   BRC -.93644235 04     B  .24259727 05   THA  .33729373 03    T VECTOR IN  ECLIPTIC PLANE

    HELIOCENTRIC                                                                           ECLIPTIC COORDINATES

   X  .59001217 08     Y  .13525276 09     Z -.41570000 04    DX -.29676149 02    DY  .21399603 02    DZ -.54944124 01
   R  .14756169 09   LAT -.16140947-02   LON  .66431758 02     V  .36997370 02   PTH  .12089898 02    AZ  .98735356 02
  XE  .58995549 08    YE  .13525209 09    ZE -.33000000 03   DXE -.27792202 02   DYE  .11815832 02   DZE  .15556812-03
  XT -.13850512 09    YT  .20267817 09    ZT  .76614060 07   DXT -.19062307 02   DYT -.11620746 02   DZT  .22182012 00
 LTE -.12813608-03   LDE  .66433669 02   LTT  .17875885 01   LDT  .12434771 03   RST  .24560294 09   VST  .22326273 02
 EPS  .65134214 02   ESP  .13988227-01   SEP  .11486336 03   EPM  .28249721 02   EMP  .48000350 00   MEP  .15127023 03
 MPS  .61567036 02   MSP  .13507880 00   SMP  .11829815 03   SEM  .61571418 02   EMS  .11829583 03   ESM  .13270400 00
 EPT  .39785299 02   ETP  .27453512-18   TEP  .14021349 03   TPS  .85283946 02   TSP  .57933486 02   STP  .36782563 02
 SET  .85286588 02   STE  .36781888 02   EST  .57931519 02   RPM  .39431215 06   RPT  .20883893 09   SPN -.29894790 01
 SAC  .22280601-09
 GCE  .24098695 03   GCT  .27673355 03   SIP  .85283019 02   CPT  .84329569 02   SIN  .84328642 02
 REP  .68729157 04   VFP  .11206614 02   CPE  .12085570 03   CPS  .10111911 03

  0 DAYS  0 HRS.  9 MIN. 49.244 SEC.       235700551646202437164374 J.D.= 2438728.13734078  NOV. 28,1964 15 17 46.244
 PROBE IS LEAVING EARTH'S    SHADOW

  2 DAYS  0 HRS. 52 MIN.  3.000 SEC.       235700677340202000000000 J.D.= 2438730.16666666  NOV. 30,1964 16 00 00.000

  2 DAYS  0 HRS. 52 MIN. 18.000 SEC.       235700677343202600000000 J.D.= 2438730.16684028  NOV. 30,1964 16 00 15.000

 215542322602   214412016141   614626031437   601731456722   204537405524   601471557132                     EARTH
                 21189808915                   17481859072                  000000000000                   INITIAL

 623733473151   223571732535   222507660544   602504407717   201741457741   200715435157                     EARTH
                                                             235700677343   202600000000                     END
```

J MATRIX — ITERATION NUMBER 1

	X	Y	Z	DX	DY	DZ	MM	AU
X	.86586481 07	.34045452 07	-.50691355 07	-.21792881 10	.13770335 11	-.15816493 10	.23125263 07	-.77185333-04
Y	.34045452 07	.13396596 07	-.19929949 07	-.85587537 09	.54135596 10	-.62224241 09	.91247442 06	-.30475400-04
Z	-.50691355 07	-.19929949 07	.29680390 07	.12758964 10	-.80622930 10	.92586914 09	-.13499765 07	.45040778-04
DX	-.21792881 10	-.85587537 09	.12758964 10	.54958336 12	-.34665872 13	.39774309 12	-.58092013 09	.19371962-01
DY	.13770335 11	.54135596 10	-.80622930 10	-.34665872 13	.21901237 14	-.25151332 13	.36716555 10	-.12253934 00
DZ	-.15816493 10	-.62224241 09	.92586914 09	.39774309 12	-.25151332 13	.28909286 12	-.42327558 09	.14149069-01
MM	.23125263 07	.91247442 06	-.13499765 07	-.58092013 09	.36716555 10	-.42327558 09	.99999998 18	-.29593198-04
AU	-.77185333-04	-.30475400-04	.45040778-04	.19371962-01	-.12253934 00	.14149069-01	-.29593198-04	.39999999-01

CORRELATIONS BASED ON J MATRIX — ITERATION NUMBER 1

	X	Y	Z	DX	DY	DZ	MM	AU
X	-.10000000 01	-.99962436 00	.99994028 00	.99901687 00	-.99996582 00	.99969255 00	-.78588977-06	.13115346-06
Y	-.99962436 00	-.10000000 01	.99948009 00	.99746235 00	-.99942768 00	.99987035 00	-.78835797-06	.13165040-06
Z	.99994028 00	.99948009 00	-.99999999 00	-.99899622 00	.99997574 00	-.99953067 00	.78359453-06	-.13071971-06
DX	.99901687 00	.99746235 00	-.99899622 00	-.10000000 01	.99919678 00	-.99785440 00	.78360940-06	-.13065524-06
DY	-.99996582 00	-.99942768 00	.99997574 00	.99919678 00	-.10000000 01	.99955799 00	-.78456262-06	.13092157-06
DZ	.99969255 00	.99987035 00	-.99953067 00	-.99785440 00	.99955799 00	-.10000000 01	.78723525-06	-.13157676-06
MM	-.78588977-06	-.78835797-06	.78359453-06	.78360940-06	-.78456262-06	.78723525-06	-.10000000 01	.14796599-12
AU	.13115346-06	.13165040-06	-.13071971-06	-.13065524-06	.13092157-06	-.13157676-06	.14796599-12	-.10000000 01

MARS CHECK CASE - FIT SIMULATED DATA, THEN MAP

ITERATION NUMBER 1   EPOCH 64/11/28 150757.000   CLOCK 135150   SOS .20501 00   QSOS .20501 00

Q	DQ	STDEVDQ	APRIORI STDEVDQ	OLD Q	NEW Q	NOMINAL Q	DQ(NOM)
X	-.11623599-01	.75099736 00	.31622776 01	.56682222 04	.56682105 04	.56682222 04	-.11596680-01
Y	.13752168-01	.25575302 00	.31622776 01	.21466726 04	.21466863 04	.21466726 04	.13763428-01
Z	-.57554049-02	.77465767 00	.31622776 01	-.32403748 04	-.32403805 04	-.32403748 04	-.57678223-02
DX	-.15225409-04	.57259488-03	.99999999-01	-.18839477 01	-.18839629 01	-.18839477 01	-.15228987-04
DY	-.74521106-06	.38780906-03	.99999999-01	.10978654 02	.10978653 02	.10978654 02	-.71525574-06
DZ	-.12002572-05	.75434680-03	.99999999-01	-.12280548 01	-.12280560 01	-.12280548 01	-.12069941-05
MM	-.34015613-17	.99999997-09	.99999997-09	.32383419-06	.32383419-06	.32383419-06	-.35527136-14
AU	.28060658-08	.50000000 01	.50000000 01	.14959850 09	.14959850 09	.14959850 09	.00000000 00

J INVERSE ITERATION NUMBER 1

	X	Y	Z	DX	DY	DZ	MM	AU
X	.62999675-01	-.59524518-01	.11556153 00	.11487003-03	.47341748-04	.10028577-03	-.12224223-16	.16363926-07
Y	-.59524518-01	.65409607-01	-.67366365-01	-.88619571-04	-.22914837-04	-.46559043-04	-.28395455-16	.18269573-07
Z	.11556153 00	-.67366365-01	.60009450 00	.42117713-03	.29749136-03	.57407415-03	-.27951063-15	.26668629-06
DX	.11487003-03	-.88619571-04	.42117713-03	.32786490-06	.20192139-06	.39447369-06	-.14904260-18	.14775477-09
DY	.47341748-04	-.22914837-04	.29749136-03	.20192139-06	.15039588-06	.28756925-06	-.14411435-18	.13669769-09
DZ	.10028577-03	-.46559043-04	.57407415-03	.39447369-06	.28756925-06	.56903910-06	-.28010333-18	.25951601-09
MM	-.12224223-16	-.28395455-16	-.27951063-15	-.14904260-18	-.14411435-18	-.28010333-18	.99999998-18	.21195486-22
AU	.16363926-07	.18269573-07	.26668629-06	.14775477-09	.13669769-09	.25951601-09	.21195486-22	.25000000 02

COVARIANCE MATRIX OF ESTIMATED'PARAMETERS ITERATION NUMBER 1

	X	Y	Z	DX	DY	DZ	MM	AU
X	.62999675-01	-.59524518-01	.11556153 00	.11487003-03	.47341748-04	.10028577-03	-.12224223-16	.16363926-07
Y	-.59524518-01	.65409607-01	-.67366365-01	-.88619571-04	-.22914837-04	-.46559043-04	-.28395455-16	.18269573-07
Z	.11556153 00	-.67366365-01	.60009450 00	.42117713-03	.29749136-03	.57407415-03	-.27951063-15	.26668629-06
DX	.11487003-03	-.88619571-04	.42117713-03	.32786490-06	.20192139-06	.39447369-06	-.14904260-18	.14775477-09
DY	.47341748-04	-.22914837-04	.29749136-03	.20192139-06	.15039588-06	.28756925-06	-.14411435-18	.13669769-09
DZ	.10028577-03	-.46559043-04	.57407415-03	.39447369-06	.28756925-06	.56903910-06	-.28010333-18	.25951601-09
MM	-.12224223-16	-.28395455-16	-.27951063-15	-.14904260-18	-.14411435-18	-.28010333-18	.99999998-18	.21195486-22
AU	.16363926-07	.18269573-07	.26668629-06	.14775477-09	.13669769-09	.25951601-09	.21195486-22	.25000000 02

CORRELATION MATRIX OF ESTIMATED PARAMETERS ITERATION NUMBER 1

	X	Y	Z	DX	DY	DZ	MM	AU
X	.99999999 00	-.92726948 00	.59433910 00	.79926371 00	.48635924 00	.52966234 00	-.48702594-07	.13039122-07
Y	-.92726948 00	.10000000 01	-.34002631 00	-.60514773 00	-.23103514 00	-.24133051 00	-.11102686-06	.14286888-07
Z	.59433910 00	-.34002631 00	.10000000 01	.94952738 00	.99025392 00	.98239720 00	-.36081826-06	.68852682-07
DX	.79926371 00	-.60514773 00	.94952738 00	.10000000 01	.90932032 00	.91327070 00	-.26029327-06	.51608834-07
DY	.48635924 00	-.23103514 00	.99025392 00	.90932032 00	.10000000 01	.98299978 00	-.37161160-06	.70497417-07
DZ	.52966234 00	-.24133051 00	.98239720 00	.91327070 00	.98299978 00	.10000000 01	-.37131904-06	.68805492-07
MM	-.48702594-07	-.11102686-06	-.36081826-06	-.26029327-06	-.37161160-06	-.37131904-06	.99999999 00	.42390971-14
AU	.13039122-07	.14286888-07	.68852682-07	.51608834-07	.70497417-07	.68805492-07	.42390971-14	.99999999 00

STATION NUMBER 41 64/11/28 ITERATION NUMBER 1 PASS NUMBER 000000 PAGE 1

FREQUENCY2038516.0

TIME	TC	Q	DEC		HA		CC3	
160000	60	41	.78431416 01 .652-01	-.0009	.32882011 03 .659-01	.0012	.28456650 05 .130-01	.0007
170000	60	41	.10831269 02 .652-01	-.0016	.33477567 03 .664-01	.0007	.23700862 05 .130-01	-.0010
180000	60	41	.12099763 02 .652-01	.0016	.34646760 03 .667-01	.0015	.21835252 05 .130-01	.0005
190000	60	41	.12798196 02 .652-01	-.0012	.35971234 03 .667-01	-.0025	.20948827 05 .130-01	.0000
200000	60	41	.13218797 02 .652-01	.0010	.13594732 02 .669-01	.0000	.20512531 05 .130-01	.0002
210000	60	41	.13479367 02 .654-01	.0007	.27772787 02 .671-01	-.0011	.20302005 05 .131-01	-.0007
220000	60	41	.13639556 02 .657-01	.0013	.42085743 02 .676-01	-.0001	.20195438 05 .132-01	.0007
230000	60	41	.13732021 02 .674-01	-.0003	.56446052 02 .693-01	.0006	.20116875 05 .135-01	-.0005
					64/11/29			
000000	60	41	.13762374 02 .774-01	-.0016	.70780797 02 .796-01	.0010	.20016164 05 .155-01	.0005
150000	60	41	.14855866 02 .784-01	.0005	.28953924 03 .813-01	-.0007	.14764306 05 .157-01	.0005
160000	60	41	.14977514 02 .674-01	.0024	.30453431 03 .696-01	.0001	.14926591 05 .135-01	.0005
			FREQUENCY .0					
170000	60	0	.15058219 02 .657-01	.0033	.31962313 03 .681-01	-.0019		
180000	60	0	.15117300 02 .654-01	-.0001	.33475542 03 .676-01	-.0007		
190000	60	0	.15157664 02 .652-01	-.0009	.34990900 03 .676-01	.0006		
200000	60	0	.15180486 02 .652-01	.0009	.50660299 01 .674-01	.0013		
210000	60	0	.15187077 02 .652-01	.0027	.20210603 02 .676-01	.0010		
			FREQUENCY2038516.0					
220000	60	51	.15178905 02 .657-01	-.0023	.35328527 02 .679-01	-.0004		
230000	60	51	.15156356 02 .667-01	.0012	.50405889 02 .691-01	.0006		
					64/11/30			
000000	60	51	.15119074 02 .715-01	.0000	.65427979 02 .740-01	-.0003		
010000	60	51	.14819789 02 .111 01	.0010	.79978701 02 .115 01	-.0003		
			FREQUENCY .0					
150000	60	0	.15275558 02 .798-01	-.0010	.28933294 03 .828-01	-.0008		
160000	60	0	.15356074 02 .674-01	.0035	.30433643 03 .698-01	-.0008		

MARINER STATISTICS — STATION 41 — ITERATION 1

PASS	DATA TYPE	BEGINNING TIME	END TIME	NUMBER OF POINTS	STD DEV	RMS	FIRST MOMENT	SECOND MOMENT
000000	CC3	11/28-160000	11/29-160000	11	.574-03	.589-03	.133-03	.347-06
	HA	11/28-160000	11/30-160000	22	.101-02	.101-02	-.461-04	.103-05
	DEC	11/28-160000	11/30-160000	22	.158-02	.165-02	.459-03	.271-05

STATION NUMBER 51 64/11/28 ITERATION NUMBER 1 PASS NUMBER 000000 PAGE 2

FREQUENCY2038516.0

TIME	TC	Q	DEC		HA		CC3	
220000	60	41	.13129207 02 .735-01	.0017	.28861228 03 .754-01	.0004		
230000	60	41	.13532427 02 .667-01	.0005	.30329097 03 .686-01	.0046		
					64/11/29			
000000	60	41	.13838208 02 .654-01	-.0009	.31818084 03 .674-01	-.0044		
			FREQUENCY .0					
010000	60	0	.14068252 02 .652-01	.0010	.33319524 03 .671-01	.0026		
020000	60	0	.14235436 02 .649-01	-.0008	.34827475 03 .671-01	.0005		
030000	60	0	.14349870 02 .649-01	.0002	.33738108 01 .671-01	.0035		
040000	60	0	.14420789 02 .652-01	.0005	.18457121 02 .671-01	-.0048		
050000	60	0	.14456847 02 .652-01	.0009	.33498143 02 .674-01	.0005		
060000	60	0	.14465484 02 .659-01	-.0010	.48477208 02 .681-01	.0005		
070000	60	0	.14461425 02 .684-01	.0015	.63393088 02 .706-01	.0007		
080000	60	0	.14359558 02 .112 00	-.0004	.78067596 02 .116 00	.0057		
			FREQUENCY2038516.0					
220000	60	51	.14953242 02 .857-01	-.0002	.28509123 03 .886-01	-.0014	.14302250 05 .172-01	.0009
230000	60	51	.15068582 02 .676-01	.0000	.30005508 03 .698-01	.0017	.14459947 05 .135-01	.0001
					64/11/30			
000000	60	51	.15137918 02 .657-01	.0019	.31513791 03 .681-01	.0009	.14735132 05 .132-01	-.0002
010000	60	51	.15189322 02 .652-01	-.0002	.33026529 03 .676-01	-.0031	.15106839 05 .131-01	.0021
020000	60	51	.15225421 02 .649-01	.0009	.34541624 03 .674-01	.0017	.15546990 05 .130-01	-.0020
030000	60	51	.15246821 02 .649-01	.0002	.57495905 00 .674-01.	.0012	.16022491 05 .130-01	.0007
040000	60	51	.15254266 02 .652-01	.0004	.15727202 02 .674-01	.0012	.16497762 05 .130-01	-.0017
050000	60	51	.15248872 02 .652-01	.0009	.30859974 02 .676-01	-.0003	.16937468 05 .131-01	.0029
060000	60	51	.15231617 02 .659-01	.0003	.45960994 02 .681-01	.0005	.17309181 05 .132-01	.0002
070000	60	51	.15200640 02 .679-01	-.0001	.61013895 02 .703-01	-.0045	.17585710 05 .135-01	-.0012
080000	60	51	.15120052 02 .925-01	-.0006	.75933573 02 .959-01	-.0002	.17746981 05 .185-01	.0010

MARINER STATISTICS — STATION 51 — ITERATION 1

PASS	DATA TYPE	BEGINNING TIME	END TIME	NUMBER OF POINTS	STD DEV	RMS	FIRST MOMENT	SECOND MOMENT
000000	CC3	11/29-220000	11/30-080000	11	.144-02	.146-02	.255-03	.213-05
	HA	11/28-220000	11/30-080000	22	.267-02	.269-02	.334-03	.722-05
	DEC	11/28-220000	11/30-080000	22	.794-03	.850-03	.303-03	.723-06

0000 135231 OFFLINE CONTROL 127
0000 13523 KEY(5)
0000 13523 END DATA 10

```
CASE  1                                           IBSYS-JPTRAJ-SPACE 022265


DOUBLE PRECISION EPHEMERIS TAPE - EPHEMI

  GME  .39860063 06      J  .16234500-02      H -.57499999-05      D  .78749999-05     RE  .63781650 04    REM  .63783112 04
    G  .66709998-19      A  .88781796 29      B  .88800194 29      C  .88836976 29    OME  .41780741-02     AU  .14959850 09
  GMM  .49026293 04    GMS  .13271411 12    GMV  .32476627 06    GMA  .42977367 05    GMC  .37918700 08    GMJ  .12670935 09
  EGM  .39860320 06    MGM  .49027779 04     JA  .29200000-02     HA  .00000000 00     DA  .00000000 00     RA  .34170000 04
RADIATION PRESSURE INPUT
  ARA  .11120000 02     GB  .95999999-01    MAS  .25900000 03    GB1  .00000000 00    GB2  .00000000 00     SC  .10310000 09

INJECTION CONDITIONS            MARS       23570055142320220000000O J.D.= 2438728.13052083  NOV. 28,1964 15 07 57.000

GEOCENTRIC        XO .56682105 04  YO .21466863 04  ZO-.32403805 04 DXO-.18839629 01 DYO .10978653 02 DZO-.12280560 01
CARTESIAN         TO .54476999 05 GHA .29452970 03 GHO .66920765 02
DATE OF RUN 022265A  13525                  EARTH    IS THE CENTRAL BODY FOR INTEGRATION   COWELL EQUATIONS OF MOTION

     PROBE IS IN EARTH'S    SHADOW

  0 DAYS  0 HRS.  0 MIN.  0.000 SEC.       2357005514232022000000O J.D.= 2438728.13052083  NOV. 28,1964 15 07 57.000

     GEOCENTRIC                                                                                    EQUATORIAL COORDINATES

    X  .56682103 04      Y  .21466862 04      Z -.32403804 04     DX -.18839629 01     DY  .10978653 02     DZ -.12280559 01
    R  .68729131 04    DEC -.28129837 02     RA  .20742872 02      V  .11206616 02    PTH  .12650726 02     AZ  .90421329 02
    R  .68729129 04    LAT -.28129838 02    LON  .86213175 02     VE  .10775811 02    PTE  .13165397 02    AZE  .90439077 02
   XS -.58995549 08     YS -.12408705 09     ZS -.53810146 08    DXS  .27792202 02    DYS -.10840364 02    DZS -.47011071 01
   XM -.38523466 06     YM -.44736395 05     ZM  .18645579 05    DXM  .37058146-01    DYM -.92038371 00    DZM -.41497853 00
   XT -.19750066 09     YT  .58811766 08     ZT  .33854926 08    DXT  .87298950 01    DYT -.21590059 02    DZT -.91209471 01
   RS  .14755881 09     VS  .30199675 02     RM  .38827148 06     VM  .10102904 01     RT  .20883364 09     VT  .25010665 02
  GED -.28291938 02    ALT  .49950689 03    LDS  .31004216 03    RAS  .24457186 03    RAM  .18662395 03    LOM  .25209425 03
  DUT  .35000000 02     DT  .37500000 01     DR  .24543294 01    SHA  .62358811 04    DES -.21387223 02    DEM  .27525167 01
  CCL  .11901320 03    MCL  .21144487 03    TCL  .21574675 03

                                               GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE                2357005513262023545325OO J.D.= 2438728.12770658  NOV. 28,1964 15 03 53.849
  SMA -.41536060 05    ECC  .11580719 01      B  .24259711 05    SLR  .14169223 05    APO  .00000000 00    RCA  .65656862 04
   VH  .30978211 01     C3  .95964959 01     C1  .75152253 05    TFP  .24315096 03     TF -.28142471-02    LTF -.25588937-01
   TA  .23551788 02    MTA  .14971234 03     EA  .64722590 01     MA  .10390338 01                         TF1  .00000000 00

                                                          ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
    X  .56682103 04      Y  .21466862 04      Z -.32403804 04     DX -.18839629 01     DY  .10978653 02     DZ -.12280559 01
  INC  .28132733 02    LAN  .11163647 03    APF  .24566016 03     MX -.35740735 00     MY  .93392608 00     MZ -.64849760-02
   WX  .43829371 00     WY  .17385554 00     WZ  .88185763 00     PX  .89882977 00     PY -.86854203-01     PZ -.42960603 00
   QX  .19036494-02     QY  .98093352 00     QZ -.19433418 00     RX -.21994273 00     RY  .16164795 00     RZ -.96202654 00
   BX  .45496110 00     BY  .80323605 00     BZ -.38447660 00     TX  .59221295 00     TY  .80578150 00     TZ  .00000000 00
  SXI  .77710339 00    SYI  .41972664 00    SZI -.46897743 00    DAI -.27967940 02    RAI  .28374228 02
  SXO -.77518320 00    SYO  .56972458 00    SZO  .27295579 00    DAO  .15840229 02    RAO  .14368579 03

  BTQ  .24222561 05    BRQ  .13420647 04      B  .24259711 05    THA  .31712632 01     T VECTOR IN  EARTH EQUATOR PLANE

                                                          ALL VECTORS REFERENCED TO ECLIPTIC PLANE
    X  .56682103 04      Y  .68028036 03      Z -.38269499 04     DX -.18839629 01     DY  .95837699 01     DZ -.54945689 01
  INC  .42277902 02    LAN  .13934386 03    APF  .21231139 03     MX -.35740735 00     MY  .85424963 00     MZ -.37751494 00
   WX  .43829370 00     WY  .51035333 00     WZ  .73989060 00     PX  .89882980 00     PY -.25060437 00     PZ -.35958650 00
   QX  .19036569-02     QY  .82264020 00     QZ -.56855910 00     RX -.18420855-01     RY  .15001476-01     RZ -.99971775 00
   BX  .45496101 00     BY  .58396315 00     BZ -.67230762 00     TX  .63146777 00     TY  .77540213 00     TZ  .00000000 00



CASE  1                                           IBSYS-JPTRAJ-SPACE 022265                                                   2


  SXI  .77710346 00    SYI  .19849367 00    SZI -.59725243 00    DAI -.36673369 02    RAI  .14328550 02
  SXO -.77518328 00    SYO  .63128954 00    SZO  .23756519-01    DAO  .13612746 01    RAO  .14084150 03

  BTC  .22379481 05    BRC -.93644400 04      B  .24259718 05    THA  .33729368 03     T VECTOR IN  ECLIPTIC PLANE

     HELIOCENTRIC                                                                                    ECLIPTIC COORDINATES

    X  .59001217 08      Y  .13525276 09      Z -.41570000 04     DX -.29676165 02     DY  .21399602 02     DZ -.54944132 01
    R  .14756169 09    LAT -.16140947-02    LON  .66431758 02      V  .36997382 02    PTH  .12089884 02     AZ  .98735355 02
   XE  .58995549 08     YE  .13525209 09     ZE -.33000000 03    DXE -.27792202 02    DYE  .11815832 02    DZE  .15556812-03
   XT -.13850512 09     YT  .20267817 09     ZT  .76614060 07    DXT -.19062307 02    DYT -.11620746 02    DZT  .22182012 00
  LTE -.12813608-03    LDE  .66433669 02    LTT  .17875885 01    LOT  .12434771 03    RST  .24560294 09    VST  .22326273 02
  EPS  .65134159 02    ESP  .13988227-01    SEP  .11486342 03    EPM  .28249846 02    EMP  .47990158 00    MEP  .15127010 03
  MPS  .61567035 02    MSP  .13507880 00    SMP  .11829816 03    SEM  .61571418 02    EMS  .11829583 03    ESM  .13270400 00
  EPT  .39785456 02    ETP  .27453512-18    TEP  .14021333 03    TPS  .85283946 02    TSP  .57933486 02    STP  .36782563 02
  SET  .85286588 02    STE  .36781888 02    EST  .57931519 02    RPM  .39431214 06    RPT  .20883893 09    SPN -.29895868 01
  SAC  .22280601-09
  GCE  .24098679 03    GCT  .27673355 03    SIP  .85283019 02    CPT  .84329569 02    SIN  .84328642 02
  REP  .68729131 04    VEP  .11206616 02    CPE  .12085585 03    CPS  .10111911 03

   0 DAYS  0 HRS.  9 MIN. 49.241 SEC.       23570055164620243664470S J.D.= 2438728.13734075  NOV. 28,1964 15 17 46.241
  PROBE IS LEAVING EARTH'S    SHADOW

   8 DAYS 19 HRS. 24 MIN.  2.979 SEC.       23570133510720277535251 4 J.D.= 2438736.93888865   DEC. 7,1964 10 31 59.980

   8 DAYS 19 HRS. 24 MIN.  2.979 SEC.       23570133510720277535251 4 J.D.= 2438736.93888865   DEC. 7,1964 10 31 59.980
   CHANGE OF PHASE OCCURS AT THIS POINT    SUN     IS THE CENTRAL BODY FOR INTEGRATION   COWELL EQUATIONS OF MOTION

 225 DAYS  2 HRS. 44 MIN. 31.060 SEC.       2357232024272020075275 22 J.D.= 2438953.24476920  JULY 11,1965 17 52 28.060

     GEOCENTRIC                                                                                    EQUATORIAL COORDINATES

    X -.20952635 09      Y -.22337826 08      Z -.94661789 07     DX -.13367881 02     DY -.23273616 02     DZ -.10141585 02
    R  .21092624 09    DEC -.25722458 01     RA  .18608537 03      V  .28691692 02    PTH  .34373873 02     AZ  .11345038 03
    R  .21092624 09    LAT -.25722458 01    LON  .34854236 03     VE  .15343772 05    PTE  .60490716-01    AZE  .26996480 03
   XS -.50004426 08     YS  .13176278 09     ZS  .57140097 08    DXS -.27634650 02    DYS -.88887630 01    DZS -.38558931 01
   XM -.16125000 05     YM -.36611200 06     ZM -.16854550 06    DXM  .97207475 00    DYM -.20357370-01    DZM -.10283720 00
   XT -.21150188 09     YT -.22632994 08     ZT -.93652949 07    DXT -.92234842 01    DYT -.22096207 02    DZT -.10412922 02
   RS  .15207519 09     VS  .29283987 02     RM  .40336781 06     VM  .97771122 00     RT  .21291549 09     VT  .26110227 02
  GED -.25897513 01    ALT  .21091986 09    LOS  .27323891 03    RAS  .11078193 03    RAM  .26747809 03    LOM  .69935081 02
  DUT  .35000000 02     DT  .86399999 05     DR  .16199062 02    SHA -.20585269 09    DES  .22069798 02    DEM -.24698652 02
  CCL  .10206468 03    MCL  .18000385 03    TCL  .92811081 01
```

```
CASE  1                                 IBSYS-JPTRAJ-SPACE 022265                                        3

    HELIOCENTRIC                                                                         ECLIPTIC COORDINATES

  X -.15952193 09    Y -.16787898 09    Z  .20262100 06   DX  .14266770 02   DY -.15698153 02   DZ -.43642342-01
  R  .23158289 09  LAT  .50131026-01  LON  .22646218 03    V  .21212605 02  PTH  .41969292 01   AZ  .90121874 02
 XE  .50004426 08   YE -.14361901 09   ZE  .28500000 02  DXE  .27634650 02  DYE  .96890669 01  DZE  .11010766-02
 XT -.16149745 09   YT -.16810964 09   ZT  .41261150 06  DXT  .18411166 02  DYT -.14725897 02  DZT -.76102304 00
LTE  .10737647-04  LDE  .28919679 03  LTT  .10141465 00  LOT  .22614924 03  RST  .23311467 09  VST  .23588180 02
EPS  .39857595 02  ESP  .62734623 02  SEP  .77407780 02  EPM  .10835236 00  EMP  .98784596 02  MEP  .81107116 02
MPS  .39965850 02  MSP  .62679107 02  SMP  .77355039 02  SEM  .15847546 03  EMS  .21468911 02  ESM  .55952909-01
EPT  .17402787 03  ETP  .59161249 01  TEP  .54625775-01  TPS  .13982710 03  TSP  .31713545 00  STP  .39855781 02
SET  .77408314 02  STE  .39544090 02  EST  .63047593 02  RPM  .21086426 09  RPT  .19999992 07  SPN  .39855862 02
SAC  .90460970-10
GCE  .25793531 03  GCT  .87216419 02  SIP  .13973033 03  CPT  .93937702 02  SIN  .93840928 02
REP  .21092624 09  VEP  .28691692 02  CPE  .91869014 02  CPS  .82500247 02

                                         HELIOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE              23570024066020254752 7522 J.D.= 2438723.37336585  NOV. 23,1964 20 57 38.810
 SMA  .19063377 09  ECC  .22638500 00    B  .18568449 09  SLR  .18086375 09  APO  .23379039 09  RCA  .14747714 09
  VH  .20955964 02   C3 -.69617315 03   C1  .48993033 10  TFP  .19860889 08   TF -.47571538 01  PER  .52542087 03
  TA  .16533578 03  MTA  .18000000 03   EA  .16159514 03   MA  .15749984 03                     TFI  .22511424 03

                                                      ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
  X -.15952193 09    Y -.15410060 09    Z -.66606276 08   DX  .14266770 02   DY -.14384853 02   DZ -.62856916 01
INC  .23492319 02  LAN  .30826009 00  APF  .60843575 02   MX  .72491694 00   MY -.63112116 00   MZ -.27600995 00
 WX  .21446739-02   WY -.39862036 00   WZ  .91711352 00   PX  .48287950 00   PY  .80351821 00   PZ  .34811732 00
 QX -.87568406 00   QY  .44210871 00   QZ  .19420888 00   RX  .17931470 00   RY  .29838215 00   RZ -.93745086 00
 BX  .87568416 00   BY -.44210876 00   BZ -.19420890 00   TX  .85713101 00   TY -.51509847 00   TZ  .00000000 00
DAP  .20372204 02  RAP  .58995964 02

BTQ  .18165617 09  BRQ  .38467694 08    B  .18568449 09  THA  .11956381 02    T VECTOR IN  EARTH EQUATOR PLANE

                                                      ALL VECTORS REFERENCED TO ECLIPTIC PLANE
  X -.15952193 09    Y -.16787898 09    Z  .20262100 06   DX  .14266770 02   DY -.15698153 02   DZ -.43642342-01
INC  .13177922 00  LAN  .68820811 02  APF  .35230551 03   MX  .72491693 00   MY -.68883299 00   MZ -.21271140-02
 WX  .21446737-02   WY -.83096782-03   WZ  .99999736 00   PX  .48287949 00   PY  .87568647 00   PZ -.30795250-03
 QX -.87568391 00   QY  .48287887 00   QZ  .22793191-02   RX -.14870399-03   RY -.26966991-03   RZ -.99999969 00
 BX  .87568413 00   BY -.48287899 00   BZ -.22793196-02   TX  .87568673 00   TY -.48287963 00   TZ  .00000000 00
DAP -.17645793-01  RAP  .61126355 02

BTC  .18568398 09  BRC  .42323416 06    B  .18568446 09  THA  .13059492 00    T VECTOR IN  ECLIPTIC PLANE

                                                      ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
  X  .17224305 09    Y -.15479968 09    Z -.16642050 06   DX  .15289946 02   DY  .14689711 02   DZ  .63605690 00
INC  .17264500 01  LAN  .31941926 03  APF  .19329738 03   MX  .66815475 00   MY  .74341242 00   MZ  .30118211-01
 WX -.19598038-01   WY -.22880996-01   WZ  .99954606 00   PX -.88868259 00   PY  .45847028 00   PZ -.69293238-02
 QX -.45810362 00   QY -.88841500 00   QZ -.29319061-01   RX  .61581179-02   RY -.31769657-02   RZ -.99997587 00
 BX  .45810368 00   BY  .88841512 00   BZ  .29319065-01   TX  .45848135 00   TY  .88870403 00   TZ  .00000000 00
DAP -.39702438 00  RAP  .15271084 03

BTO  .18560465 09  BRO -.54442254 07    B  .18568448 09  THA  .35831986 03    T VECTOR IN  ORBIT PLANE OF TARGET

225 DAYS  2 HRS. 44 MIN. 31.060 SEC.     23572320242720200752 7522 J.D.= 2438953.24476920  JULY 11,1965 17 52 28.060
 CHANGE OF PHASE OCCURS AT THIS POINT    MARS     IS THE CENTRAL BODY FOR INTEGRATION   COWELL EQUATIONS OF MOTION
```

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CASE  1                                 IBSYS-JPTRAJ-SPACE 022265                                        4

225 DAYS  2 HRS. 44 MIN. 31.060 SEC.     23572320242720200752 7522 J.D.= 2438953.24476920  JULY 11,1965 17 52 28.060
     GEOCENTRIC                                                                        EQUATORIAL COORDINATES

  X -.20952635 09    Y -.22337827 08    Z -.94661791 07   DX -.13367881 02   DY -.23273616 02   DZ -.10141585 02
  R  .21092624 09  DEC -.25722458 01   RA  .18608537 03    V  .28691692 02  PTH  .34373873 02   AZ  .11345038 03
  R  .21092624 09  LAT -.25722458 01  LON  .34854236 03   VE  .15343772 05  PTE  .60490716-01  AZE  .26996480 03
 XS -.50004427 08   YS  .13176278 09   ZS  .57140097 08  DXS -.27634650 02  DYS -.88887629 01  DZS -.38558930 01
 XM -.16126000 05   YM -.36611200 06   ZM -.16854537 06  DXM  .97207451 00  DYM -.20357370-01  DZM -.10283720 00
 XT -.21150188 09   YT -.22632995 08   ZT -.93652949 07  DXT -.92234842 01  DYT -.22096207 02  DZT -.10412922 02
 RS  .15207519 09   VS  .29283987 02   RM  .40336780 06   VM  .97771098 00   RT  .21291549 09   VT  .26110227 02
GED -.25897513 01  ALT  .21091986 09  LOS  .27323891 03  RAS  .11078193 03  RAM  .26747793 03  LDM  .69934925 02
DUT  .35000000 02   DT  .38400000 04   DR  .16199062 02  SHA -.20585269 09  DES  .22069798 02  DEM -.24698632 02
CCL  .10206468 03  MCL  .18000385 03  ICL  .92811038 01
    HELIOCENTRIC                                                                         ECLIPTIC COORDINATES

  X -.15952193 09    Y -.16787898 09    Z  .20262100 06   DX  .14266770 02   DY -.15698153 02   DZ -.43642342-01
  R  .23158289 09  LAT  .50131026-01  LON  .22646218 03    V  .21212605 02  PTH  .41969292 01   AZ  .90121874 02
 XE  .50004427 08   YE -.14361901 09   ZE  .27500000 02  DXE  .27634650 02  DYE  .96890667 01  DZE  .11010766-02
 XT -.16149745 09   YT -.16810964 09   ZT  .41261150 06  DXT  .18411166 02  DYT -.14725897 02  DZT -.76102304 00
LTE  .10360887-04  LOE  .28919679 03  LTT  .10141465 00  LOT  .22614924 03  RST  .23311467 09  VST  .23588180 02
EPS  .39857594 02  ESP  .62734623 02  SEP  .77407780 02  EPM  .10812639 00  EHP  .98784597 02  MEP  .81107116 02
MPS  .39965851 02  MSP  .62679107 02  SMP  .77355038 02  SEM  .15847546 03  EMS  .21468911 02  ESM  .55952909-01
EPT  .17402788 03  ETP  .59161291 01  TEP  .54625775-01  TPS  .13982710 03  TSP  .31721256 00  STP  .39855791 02
SET  .77408312 02  STE  .39544090 02  EST  .63047594 02  RPM  .21086426 09  RPT  .20000000 07  SPN  .39855861 02
SAC  .90460971-10
GCE  .25793531 03  GCT  .87216416 02  SIP  .13973032 03  CPT  .93937700 02  SIN  .93840926 02
REP  .21092624 09  VEP  .28691692 02  CPE  .91869014 02  CPS  .82500245 02
     AREOCENTRIC                                                                         ECLIPTIC COORDINATES

  X  .19755248 07    Y  .23066303 06    Z -.20999099 06   DX -.41443964 01   DY -.97225593 00   DZ  .71738064 00
  R  .20000000 07  DEC -.60269085 01   RA  .66597225 01    V  .43169362 01  PTH -.82615601 02   AZ  .29904489 03
ALT  .19966220 07  SHA -.12817149 07  ALP  .17289476 03   DR -.42811324 01   DP  .15894875-04  ASO  .96773534-01
HGE  .32014240 03  SVL  .59718631 01  HNG  .14019883 03  SIA  .17393110 03
SAC  .90460971-10

                                                                          AREOCENTRIC EQUATORIAL COORDINATES

  X -.28159035 06    Y  .18703261 07    Z  .65006682 06   DX  .10731629 01   DY -.40344328 01   DZ -.10989137 01
  R  .19999999 07  DEC  .18967598 02   RA  .98561966 02    V  .43169362 01  PTH -.82615601 02   AZ  .30389252 03
  R  .20000000 07  LAT  .18967598 02  LON  .21477832 03   VP  .13459592 03  PTP -.18227299 01  AZP  .27013177 03
RAE  .99052002 02 . DEE  .24866261 02  RAS  .14029968 03  DES  .15866048 02  LOE  .21526835 03  LOS  .25651603 03

                                         AREOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE              23572354253720240352 7522 J.D.= 2438958.55775496  JULY 17,1965 01 23 10.029
 SMA -.23114860 04  ECC  .11133878 03    B  .25734764 06  SLR  .28651617 08  APO  .00000000 00  RCA  .25504654 06
  VH  .43119555 01   C3  .18592960 02   C1  .11096716 07  TFP -.45904197 06   TF  .23042723 03  LTF  .23039799 03
  TA -.83125959 02  MTA  .90514614 02   EA -.15702370 03   MA -.49063444 05                     TFI  .22511424 03
 ZAE  .16848501 03  ZAP  .14587674 03  ZAC  .98962530 02  DEF  .10293611 01   IR  .51987771 04   GP  .84749242 01
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CASE  1                                    IBSYS-JPTRAJ-SPACE 022265                                    5

                                                          ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
  X  .19755248 07     Y  .29516781 06     Z -.10088414 06    DX -.41443964 01    DY -.11774092 01    DZ  .27133758 00
INC  .17357811 03   LAN  .34183582 03   APF  .56319054 02    HX  .15201859 00    HY -.98332328 00    HZ  .99828441-01
 WX -.34867790-01    WY -.10627491 00    WZ -.99372528 00    PX  .26914820 00    PY -.95859092 00    PZ  .93073576-01
 QX -.96246738 00    QY -.26421408 00    QZ  .62027644-01    RX -.60466938-01    RY -.17183313-01    RZ -.99802227 00
 BX  .27778184 00    BY -.95617919 00    BZ  .92512715-01    TX -.27335371 00    TY  .96191359 00    TZ  .00000000 00
SXI -.96001118 00   SYI -.27281309 00   SZI  .62861092-01   DAI  .36040509 01   RAI  .19586392 03
SXO -.96484594 00   SYO -.25559374 00   SZO  .61189193-01   DAO  .35080731 01   RAO  .19483720 03
ETE  .32002128 02   ETS  .14294957 03   ETC  .23281654 03

BTQ -.25623962 06   BRQ -.23855108 05     B  .25734764 06   THA  .18531872 03    T VECTOR IN  EARTH EQUATOR PLANE

                                                          ALL VECTORS REFERENCED TO ECLIPTIC PLANE
  X  .19755248 07     Y  .23066303 06     Z -.20999099 06    DX -.41443964 01    DY -.97225593 00    DZ  .71738064 00
INC  .15038975 03   LAN  .35595333 03   APF  .70857026 02    HX  .15201845 00    HY -.86242815 00    HZ  .48281090 00
 WX -.34867758-01    WY -.49286372 00    WZ -.86940663 00    PX  .26914808 00    PY -.84242503 00    PZ  .46677369 00
 QX -.96246739 00    QY -.21772405 00    QZ  .16202702 00    RX -.16181709 00    RY -.37972899-01    RZ -.98608989 00
 BX  .27778195 00    BY -.84043626 00    BZ  .46530000 00    TX -.22845947 00    TY  .97355343 00    TZ  .00000000 00
SXI -.96001119 00   SYI -.22528158 00   SZI  .16621285 00   DAI  .95676999 01   RAI  .19320638 03
SXO -.96484594 00   SYO -.21014895 00   SZO  .15782811 00   DAO  .90808550 01   RAO  .19228744 03
ETE  .54838743 02   ETS  .16578618 03   ETC  .25565315 03

BTC -.22689608 06   BRC -.12143301 06     B  .25734764 06   THA  .20815534 03    T VECTOR IN  ECLIPTIC PLANE

                                                          ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
  X -.28159081 06     Y  .19730736 07     Z -.16639353 06    DX  .10731639 01    DY -.41327579 01    DZ  .63605730 00
INC  .14925252 03   LAN  .90054571 02   APF  .73760504 02    HX  .84781782 00    HY  .16353827 00    HZ  .50443871 00
 WX  .51125324 00    WY  .48695213-03    WZ -.85942896 00    PX  .82487204 00    PY  .28043826 00    PZ  .49085507 00
 QX  .24125624 00    QY -.95987187 00    QZ  .14297356 00    RX  .37050490-01    RY -.14264319 00    RZ -.98908047 00
 BX  .82267265 00    BY  .28904839 00    BZ  .48955159 00    TX -.96788319 00    TY -.25140034 00    TZ  .00000000 00
SXI  .24865517 00   SYI -.95731436 00   SZI  .14737645 00   DAI  .84749191 01   RAI  .28456039 03
SXO  .23383784 00   SYO -.96235193 00   SZO  .13855914 00   DAO  .79644786 01   RAO  .28365738 03
ETE  .56350271 02   ETS  .16729771 03   ETC  .25716468 03

BTO -.22361396 06   BRO -.12737582 06     B  .25734764 06   THA  .20966686 03    T VECTOR IN  ORBIT PLANE OF TARGET

                                                    ALL VECTORS REFERENCED TO AREOCENTRIC EQUATOR PLANE
  X -.28159081 06     Y  .18703260 07     Z  .65006682 06    DX  .10731639 01    DY -.40344325 01    DZ -.10989137 01
INC  .14172193 03   LAN  .12438140 03   APF  .11477325 03    HX  .84781858 00    HY -.55648232-01    HZ  .52735849 00
 WX  .51125371 00    WY  .34981902 00    WZ -.78501359 00    PX  .82487278 00    PY  .56678651-01    PZ  .56246990 00
 QX  .24125622 00    QY -.93510115 00    QZ -.25957899 00    RX -.65441985-01    RY  .24595948 00    RZ -.96706837 00
 BX  .82267267 00    BY  .65075067-01    BZ  .56477866 00    TX -.96637878 00    TY -.25712262 00    TZ  .00000000 00
SXI  .24865516 00   SYI -.93455437 00   SZI -.25451664 00   DAI -.14744945 02   RAI  .28489939 03
SXO  .23383781 00   SYO -.93557250 00   SZO -.26462040 00   DAO -.15344397 02   RAO  .28403305 03
ETE  .62416562 02   ETS  .17336400 03   ETC  .26323097 03

BTT -.20890083 06   BRT -.15029387 06     B  .25734764 06   THA  .21573316 03    T VECTOR IN  TRUE TARGET EQU. PLANE

230 DAYS 10 HRS. 21 MIN.  2.322 SEC.        23572354266620265114 7325 J.D.= 2438958.56179771  JULY 17,1965 01 28 59.322
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CASE  1                                    IBSYS-JPTRAJ-SPACE 022265                                    6

      GEOCENTRIC                                                                          EQUATORIAL COORDINATES

  X -.21527995 09     Y -.33370439 08     Z -.14273386 08    DX -.11678219 02    DY -.24713026 02    DZ -.10779755 02
  R  .21831805 09   DEC -.37486067 01    RA  .18881126 03     V  .29382266 02   PTH  .32988816 02    AZ  .11331624 03
  R  .21831805 09   LAT -.37486067 01   LON  .23189716 03    VE  .15863321 05   PTE  .57782545-01   AZE  .26996476 03
 XS -.62485360 08    YS  .12716259 09    ZS  .55144967 08   DXS -.26664940 02   DYS -.11125287 02   DZS -.48248740 01
 XM  .35175000 06    YM -.16575950 06    ZM -.11054600 06   DXM  .45401406 00   DYM  .79613352 00   DZM  .32725155 00
 XT -.21534786 09    YT -.33127602 08    ZT -.14298221 08   DXT -.74922993 01   DYT -.23570404 02   DZT -.11052582 02
 RS  .15203851 09    VS  .29292839 02    RM  .40425820 06    VM  .97316541 00    RT  .21834967 09    VT  .27089815 02
GED -.37740790 01   ALT  .21831167 09   LOS  .15925455 03   RAS  .11616865 03   RAM  .33476820 03   LOM  .17854099 02
DUT  .35000000 02    DT  .95999999 03    DR  .15997919 02   SHA -.21117487 09   DES  .21266347 02   DEM -.15869899 02
CCL  .10175299 03   HCL  .18001457 03   TCL  .32801724 03

     HELIOCENTRIC                                                                           ECLIPTIC COORDINATES

  X -.15279459 09     Y -.17489919 09     Z  .18206950 06    DX  .14986720 02    DY -.14835227 02    DZ -.57264804-01
  R  .23224114 09   LAT  .44918739-01   LON  .22885904 03     V  .21087651 02   PTH  .35678491 01    AZ  .90158692 02
 XE  .62485360 08    YE -.13860480 09    ZE  .36950000 03   DXE  .26664940 02   DYE  .12126476 02   DZE  .25510788-03
 XT -.15286250 09    YT -.17468628 09    ZT  .62669500 05   DXT  .19172641 02   DYT -.13895480 02   DZT -.76217288 00
LTE  .13924623-03   LOE  .29426664 03   LTT  .15469524-01   LOT  .22881184 03   RST  .23212549 09   VST  .23690830 02
EPS  .39289430 02   ESP  .65407611 02   SEP  .75302954 02   EPM  .66719594-01   EMP  .38905585 02   MEP  .14102778 03
MPS  .39355420 02   MSP  .65497911 02   SMP  .75146666 02   SEM  .14310437 03   EMS  .36804360 02   ESM  .91192092-01
EPT  .97133889 02   ETP  .82800138 02   TEP  .65610602-01   TPS  .62814820 02   TSP  .55071707-01   STP  .11712955 03
SET  .75244898 02   STE  .39300298 02   EST  .65454801 02   RPM  .21863250 09   RPT  .25337335 06   SPN  .39287756 02
SAC  .89948905-10
GCE  .25824700 03   GCT  .46264244 02   SIP  .62050924 02   CPT  .47739595 02   SIN  .46975699 02
REP  .21831805 09   VFP  .29382266 02   CPE  .91154633 02   CPS  .82009783 02

      AREOCENTRIC                                                                           ECLIPTIC COORDINATES

  X  .67905585 05     Y -.21290933 06     Z  .11940061 06    DX -.41859201 01    DY -.93974701 00    DZ  .70490804 00
  R  .25337335 06   DEC  .28115064 02    RA  .28768963 03     V  .43476369 01   PTH  .00000000 00    AZ  .28059274 03
ALT  .24999535 06   SHA  .22549665 06   ALP  .16413254 03    DR  .46250916-07    DP  .98313903-03   ASD  .76389518 00
HGE  .32071056 03   SVL -.28109262 02   HNG  .58804424 02   SIA  .96369993 02
SAC  .89948905-10

                                                                           AREOCENTRIC EQUATORIAL COORDINATES

  X  .20844761 06     Y  .13603512 05     Z  .14339664 06    DX  .10420695 01    DY -.40671214 01    DZ -.11289647 01
  R  .25337335 06   DEC  .34468284 02    RA  .37338876 01     V  .43476368 01   PTH  .29456472-06    AZ  .25164103 03
  R  .25337335 06   LAT  .34468285 02   LON  .54251868 02    VP  .18982457 02   PTP -.44976981-07   AZP  .26586315 03
RAE  .10224721 03   DEE  .24671811 02   RAS  .14291916 03   DES  .15017378 02   LOE  .15276519 03   LOS  .19343714 03

                                              AREOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE                   2357235426662026510746 00 J.D.= 2438958.56179770  JULY 17,1965 01 28 59.321
SMA -.23152535 04   ECC  .11043655 03     B  .25567811 06   SLR  .28235053 08   APO  .00000000 00   RCA  .25337335 06
 VH  .43084458 01    C3  .18562705 02    C1  .11015753 07   TFP  .65103445-03    TF  .23043127 03   LTF  .23040201 03
 TA  .25613208-05   HTA  .90518817 02    EA  .00000000 00    MA  .69414259-04                       TFI  .23043127 03
ZAE  .16978730 03   ZAP  .14321075 03   ZAC  .98950581 02   DEF  .10376917 01    IR  .52012245 04    GP  .84832144 01
```

```
CASE  1                              IBSYS-JPTRAJ-SPACE 022265                                    7

                                                            ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
    X  .67905585 05     Y -.24283757 06     Z  .24835528 05    DX -.41859201 01    DY -.11426220 01    DZ  .27282742 00
  INC  .17331640 03   LAN  .34281734 03   APF  .57372230 02    HX -.96280351 00    HY -.26281448 00    HZ  .62753035-01
   WX -.34382693-01    WY -.11119170 00    WZ -.99320403 00    PX .26800603 00     PY -.95841794 00    PZ  .98019490-01
   QX -.96280351 00    QY -.26281449 00    QZ  .62753035-01    RX -.61238094-01    RY -.17311678-01    RZ -.99797304 00
   BX  .27671320 00    BY -.95599888 00    BZ  .97447246-01    TX -.27203356 00    TY  .96228777 00    TZ  .00000000 00
  SXI -.96033725 00   SYI -.27148216 00   SZI  .63638026-01   DAI  .36486554 01   RAI  .19578531 03
  SXO -.96519082 00   SYO -.25412526 00   SZO  .61862898-01   DAO  .35467473 01   RAO  .19475065 03
  ETE  .46388492 02   ETS  .14413840 03   ETC  .23280735 03

  BTQ -.25445631 06   BRQ -.24965733 05     B  .25567811 06   THA  .18560358 03     T VECTOR IN  EARTH EQUATOR PLANE

                                                            ALL VECTORS REFERENCED TO ECLIPTIC PLANE
    X  .67905585 05     Y -.21290933 06     Z  .11940061 06    DX -.41859201 01    DY -.93974701 00    DZ  .70490804 00
  INC  .15010870 03   LAN  .35604388 03   APF  .71013729 02    HX -.96280351 00    HY -.21615121 00    HZ  .16213590 00
   WX -.34382693-01    WY -.49716855 00    WZ -.86697247 00    PX  .26800602 00    PY -.84029880 00    PZ  .47124377 00
   QX -.96280351 00    QY -.21615121 00    QZ  .16213590 00    RX -.16205584 00    RY -.37757772-01    RZ -.98605894 00
   BX  .27671319 00    BY -.83830711 00    BZ  .46975632 00    TX -.22691466 00    TY  .97391465 00    TZ  .00000000 00
  SXI -.96033725 00   SYI -.22375123 00   SZI  .16639635 00   DAI  .95783617 01   RAI  .19311549 03
  SXO -.96519082 00   SYO -.20853347 00   SZO  .15786215 00   DAO  .90828306 01   RAO  .19219159 03
  ETE  .69235305 02   ETS  .16698522 03   ETC  .25565417 03

  BTC -.22479983 06   BRC -.12180449 06     B  .25567811 06   THA  .20845039 03     T VECTOR IN  ECLIPTIC PLANE

                                                            ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
    X  .20844761 06     Y  .70722138 05     Z  .12548319 06    DX  .10420693 01    DY -.41748402 01    DZ  .62189034 00
  INC  .14896956 03   LAN  .90114076 02   APF  .73889917 02    HX  .23968636 00    HY -.96025503 00    HZ  .14304100 00
   WX  .51549237 00    WY  .10263728-02    WZ -.85689357 00    PX  .82268951 00    PY  .27912224 00    PZ  .49525014 00
   QX  .23968636 00    QY -.96025502 00    QZ  .14304100 00    RX  .36859198-01    RY -.14284059 00    RZ -.98905911 00
   BX  .82048545 00    BY  .28780589 00    BZ  .49393461 00    TX -.96828207 00    TY -.24985965 00    TZ  .00000000 00
  SXI  .24712597 00   SYI -.95768820 00   SZI  .14751961 00   DAI  .84832127 01   RAI  .28446920 03
  SXO  .23222710 00   SYO -.96274309 00   SZO  .13855065 00   DAO  .79639885 01   RAO  .28356148 03
  ETE  .70745116 02   ETS  .16849503 03   ETC  .25716398 03

  BTO -.22151246 06   BRO -.12768525 06     B  .25567811 06   THA  .20996021 03     T VECTOR IN  ORBIT PLANE OF TARGET

                                                   ALL VECTORS REFERENCED TO AREOCENTRIC EQUATOR PLANE
    X  .20844761 06     Y  .13603502 05     Z  .14339664 06    DX  .10420693 01    DY -.40671214 01    DZ -.11289647 01
  INC  .14148794 03   LAN  .12412029 03   APF  .11464694 03    HX  .23968636 00    HY -.93547864 00    HZ -.25967318 00
   WX  .51549236 00    WY  .34928090 00    WZ -.78247714 00    PX  .82268953 00    PY  .53689554-01    PZ  .56594997 00
   QX  .23968636 00    QY -.93547863 00    QZ -.25967317 00    RX -.65045327-01    RY  .24608663 00    RZ -.96706279 00
   BX  .82048545 00    BY  .62158088-01    BZ  .56827810 00    TX -.96679774 00    TY -.25554284 00    TZ  .00000000 00
  SXI  .24712597 00   SYI -.93495411 00   SZI -.25453787 00   DAI -.14746201 02   RAI  .28480575 03
  SXO  .23722710 00   SYO -.93592642 00   SZO -.26478719 00   DAO -.15354307 02   RAO  .28393511 03
  ETE  .76774132 02   ETS  .17452404 03   ETC  .26319299 03

  BTT -.20687620 06   BRT -.15024492 06     B  .25567811 06   THA  .21598922 03     T VECTOR IN  TRUE TARGET EQU. PLANE

230 DAYS 10 HRS. 28 MIN. 31.060 SEC.        2357235430472020075275Z2 J.D.= 2438958.56699143  JULY 17,1965 01 36 28.060



CASE  I                              IBSYS-JPTRAJ-SPACE 022265                                    8

      GEOCENTRIC                                                                                 EQUATORIAL COORDINATES

    X -.21528519 09     Y -.33381530 08     Z -.14278223 08    DX -.11676525 02    DY -.24714124 02    DZ -.10780385 02
    R  .21832523 09   DEC -.37497550 01    RA  .18881394 03     V  .29382748 02   PTH  .32987712 02    AZ  .11331638 03
    R  .21832523 09   LAT -.37497550 01   LON  .23002497 03    VE  .15863822 05   PTE  .57779984-01   AZE  .26996476 03
   XS -.62497325 08    YS  .12715759 09    ZS  .55142802 08   DXS -.26663893 02   DYS -.11127437 02   DZS -.48258048 01
   XM  .35195200 06    YM -.16540250 06    ZM -.11039887 06   DXM  .45305043 00   DYM  .79657650 00   DZM  .32755005 00
   XT -.21535122 09    YT -.33138180 08    ZT -.14303181 08   DXT -.74905242 01   DYT -.23571790 02   DZT -.11053182 02
   RS  .15203847 09    VS  .29292856 02    RM  .40424757 06    VM  .97317924 00    RT  .21835491 09    VT  .27090775 02
  GED -.37752351 01   ALT  .21831886 09   LOS  .15738492 03   RAS  .11617388 03   RAM  .33482846 03   LOM  .16039501 02
  DUT  .35000000 02    DT  .95999999 03    DR  .15997706 02   SHA -.21117983 09   DES  .21265476 02   DEM -.15848649 02
  CCL  .10175268 03   MCL  .18001457 03   TCL  .32779482 03

     HELIOCENTRIC                                                                                  ECLIPTIC COORDINATES

    X -.15278787 09     Y -.17490584 09     Z  .18204450 06    DX  .14987368 02    DY -.14834143 02    DZ -.57407438-01
    R  .23224173 09   'LAT  .44913615-01  LON  .22886137 03     V  .21087349 02   PTH  .35668485 01    AZ  .90159081 02
   XE  .62497325 08    YE -.13859936 09    ZE  .36950000 03   DXE  .26663893 02   DYE  .12128819 02   DZE  .25391578-03
   XT -.15285389 09    YT -.17469252 09    ZT  .62328000 05   DXT  .19173369 02   DYT -.13894648 02   DZT -.76217318 00
  LTE  .13924627-03   LDE  .29427160 03   LTT  .15385855-01   LOT  .22881445 03   RST  .23212452 09   VST  .23690931 02
  EPS  .39288859 02   ESP  .65410233 02   SEP  .75300904 02   EPM  .66351990-01   EMP  .38847295 02   MEP  .14108616 03
  MPS  .39354758 02   MSP  .65500652 02   SMP  .75144586 02   SEM  .14304783 03   EMS  .36860782 02   ESM  .91192092-01
  EPT  .96693188 02   ETP  .83240775 02   TEP  .66351990-01   TPS  .62418076 02   TSP  .55514057-01   STP  .11752649 03
  SET  .75242820 02   STE  .39300033 02   EST  .65457144 02   RPM  .21863992 09   RPT  .25338079 06   SPN  .39287185 02
  SAC  .89948448-10
  GCE  .25824731 03   GCT  .46042143 02   SIP  .61654202 02   CPT  .47651963 02   SIN  .46888088 02
  REP  .21832523 09   VEP  .29382748 02   CPE  .91153933 02   CPS  .82009314 02

      AREOCENTRIC                                                                                  ECLIPTIC COORDINATES

    X  .66027186 05     Y -.21333097 06     Z  .11971690 06    DX -.41860009 01    DY -.93949461 00    DZ  .70476573 00
    R  .25338079 06   DEC  .28195282 02    RA  .28719760 03     V  .43476370 01   PTH  .43719955 00    AZ  .28036057 03
  ALT  .25000279 06   SHA  .22469740 06   ALP  .16379697 03    DR  .33174608-01    DP  .98308158-03   ASD  .76387384 00
  HGE  .32071114 03   SVL -.28189059 02   HNG  .58310008 02   SIA  .95929314 02
  SAC  .89948448-10

                                                                                     AREOCENTRIC EQUATORIAL COORDINATES

    X  .20891517 06     Y  .11778436 05     Z  .14289000 06    DX  .10418224 01    DY -.40671375 01    DZ -.11291355 01
    R  .25338080 06   DEC  .34328284 02    RA  .32268656 01     V  .43476371 01   PTH  .43719955 00    AZ  .25135458 03
    R  .25338079 06   LAT  .34328285 02   LON  .51903004 02    VP  .19002142 02   PTP  .10002983 00   AZP  .26580524 03
  RAE  .10225037 03   DEE  .24671581 02   RAS  .14292172 03   DES  .15016530 02   LOE  .15092650 03   LOS  .19159786 03

                                                  AREOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE                 23572354266620265170572Z J.D.= 2438958.56179777  JULY 17,1965 01 28 59.327
  SMA -.23152520 04   ECC  .11043662 03     B  .25567811 06   SLR  .28235069 08   APD  .00000000 00   RCA  .25337335 06
   VH  .43084471 01    C3  .18562716 02    C1  .11015757 07   TFP  .44873269 03    TF  .23043127 03   LTF  .23040201 03
   TA  .44115593 00   HTA  .90518817 02    EA  .43718589 00    MA  .47844590 02                       TFI  .23043647 03
  ZAE  .16978823 03   ZAP  .14320822 03   ZAC  .98950570 02   DEF  .10378332 01    IR  .52012236 04    GP  .84832033 01
```

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CASE  1                              IBSYS-JPTRAJ-SPACE 022265                                      9

                                                                   ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
   X  .66027186 05     Y -.24335024 06     Z  .24957948 05    DX -.41860009 01    DY -.11423338 01    DZ  .27279727 00
 INC  .17331641 03   LAN  .34281740 03   APF  .57372299 02    MX -.96483854 00    MY -.25542721 00    MZ  .61996301-01
  WX -.34382542-01    WY -.11119166 00    WZ -.99320404 00    PX  .26800593 00    PY -.95841796 00    PZ  .98019493-01
  QX -.96280352 00    QY -.26281441 00    QZ  .62752869-01    RX -.61237934-01  . RY -.17311628-01    RZ -.99797302 00
  BX  .27671310 00    BY -.95599890 00    BZ  .97447249-01    TX -.27203348 00    TY  .96228779 00    TZ  .00000000 00
 SXI -.96033726 00   SYI -.27148208 00   SZI  .63637859-01   DAI  .36486460 01   RAI  .19578530 03
 SXO -.96519083 00   SYO -.25412519 00   SZO  .61862732-01   DAO  .35467370 01   RAO  .19475064 03
 ETE  .46403853 02   ETS  .14413949 03   ETC  .23280735 03

 BTQ -.25445630 06   BRQ -.24965732 05     B  .25567811 06   THA  .18560358 03    T VECTOR IN  EARTH EQUATOR PLANE

                                                                   ALL VECTORS REFERENCED TO ECLIPTIC PLANE
   X  .66027186 05     Y -.21333097 06     Z  .11971690 06    DX -.41860009 01    DY -.93949461 00    DZ  .70476573 00
 INC  .15010870 03   LAN  .35604390 03   APF  .71013749 02    MX -.96483853 00    MY -.20967486 00    MZ  .15850254 00
  WX -.34382543-01    WY -.49716853 00    WZ -.86697250 00    PX  .26800593 00    PY -.84029881 00    PZ  .47124378 00
  QX -.96280353 00    QY -.21615121 00    QZ  .16213572 00    RX -.16205567 00    RY -.37757728-01    RZ -.98605895 00
  BX  .27671310 00    BY -.83830713 00    BZ  .46975634 00    TX -.22691465 00    TY  .97391465 00    TZ  .00000000 00
 SXI -.96033727 00   SYI -.22375123.00   SZI  .16639617 00   DAI  .95783515 01   RAI  .19311549 03
 SXO -.96519084 00   SYO -.20853347 00   SZO  .15786198 00   DAO  .90828213 01   RAO  .19219159 03
 ETE  .69250666 02   ETS  .16698631 03   ETC  .25565417 03

 BTC -.22479982 06   BRC -.12180449 06     B  .25567811 06   THA  .20845039 03    T VECTOR IN  ECLIPTIC PLANE

                                                                   ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
   X  .20891516 06     Y  .68848766 05     Z  .12576220 06    DX  .10418234 01    DY -.41749240 01    DZ  .62174067 00
 INC  .14896956 03   LAN  .90114108 02   APF  .73889938 02    MX  .23334517 00    MY -.96237565 00    MZ  .13922333 00
  WX  .51549223 00    WY  .10266641-02    WZ -.85689364 00    PX  .82268954 00    PY  .27912237 00    PZ  .49525006 00
  QX  .23968664 00    QY -.96025498 00    QZ  .14304079 00    RX  .36859183-01    RY -.14284037 00    RZ -.98905915 00
  BX  .82048546 00    BY  .28780600 00    BZ  .49393454 00    TX -.96828200 00    TY -.24985992 00    TZ  .00000000 00
 SXI  .24712624 00   SYI -.95768817 00   SZI  .14751939 00   DAI  .84831998 01   RAI  .28446922 03
 SXO  .23222739 00   SYO -.96274305 00   SZO  .13855045 00   DAO  .79639766 01   RAO  .28356149 03
 ETE  .70760472 02   ETS  .16849611 03   ETC  .25716397 03

 BTO -.22151248 06   BRO -.12768523 06     B  .25567811 06   THA  .20996020 03    T VECTOR IN  ORBIT PLANE OF TARGET

                                                             ALL VECTORS REFERENCED TO AREOCENTRIC EQUATOR PLANE
   X  .20891516 06     Y  .11778488 05     Z  .14289000 06    DX  .10418234 01    DY -.40671372 01    DZ -.11291355 01
 INC  .14148793 03   LAN  .12412032 03   APF  .11464695 03    MX  .23334517 00    MY -.93586417 00    MZ -.26402324 00
  WX  .51549222 00    WY  .34928120 00    WZ -.78247710 00    PX  .82268953 00    PY  .53689705-01    PZ  .56594993 00
  QX  .23968664 00    QY -.93547851 00    QZ -.25967335 00    RX -.65045446-01    RY  .24608678 00    RZ -.96706273 00
  BX  .82048546 00    BY  .62158233-01    BZ  .56827807 00    TX -.96679766 00    TY -.25554313 00    TZ  .00000000 00
 SXI  .24712624 00   SYI -.93495399 00   SZI -.25453804 00   DAI -.14746214 02   RAI  .28480576 03
 SXO  .23222738 00   SYO -.93592631 00   SZO -.26478736 00   DAO -.15354317 02   RAO  .28393513 03
 ETE  .76789494 02   ETS  .17452513 03   ETC  .26319299 03

 BTT -.20687620 06   BRT -.15024491 06     B  .25567811 06   THA  .21598922 03    T VECTOR IN  TRUE TARGET EQU. PLANE

 215542322304   214412017045   614626031734   601731460721   204537405516   601471557251                       EARTH
                 21189808915                   17481859072                  000000000000                     INITIAL

 220775513340   622733565354   217604377240   603414100141   601440622006   177435553167                        MARS
                                                             235723543047   202007527522                         END
```

U MATRIX FOR MAPPING FORWARD — ITERATION NUMBER 1

	X	Y	Z	DX	DY	DZ	MM	AU
X	-.14240628 06	.32833775 05	.12743440 05	-.32201795-01	.18749275-01	-.67970214-02	.00000000 00	.00000000 00
Y	-.55073909 05	.15447656 05	.55744004 04	-.12770882-01	.73212989-02	-.26537464-02	.00000000 00	.00000000 00
Z	.82201993 05	-.21762468 05	-.91111089 04	.18877931-01	-.10989078-01	.43940406-02	.00000000 00	.00000000 00
DX	.37202730 08	-.51210248 07	-.23455938 07	.80190345 01	-.47951245 01	.16743353 01	.00000000 00	.00000000 00
DY	-.22529723 09	.54473221 08	.21533065 08	-.51212858 02	.29795080 02	-.11093539 02	.00000000 00	.00000000 00
DZ	.25683868 08	-.66539341 07	-.19962635 07	.59071261 01	-.33589278 01	.10381906 01	.00000000 00	.00000000 00
MM	.21474836 11	.18468359 12	.74625055 11	-.14336000 06	.82944000 05	-.17536000 05	.10000000 01	.00000000 00
AU	-.46875000 00	-.71875000 00	-.29687500 00	.13411045-06	-.29429793-06	-.58207661-08	.00000000 00	.10000000 01

COVARIANCE MATRIX AT IMPACT — ITERATION NUMBER 1

	X	Y	Z	DX	DY	DZ	MM	AU
X	.10637680 05	.22420325 05	.12501384 05	-.29614010-02	.15642850-02	-.28561890-02	.21474894-07	-.11718800 02
Y	.22420325 05	.88347057 05	.47340614 05	-.28379472-01	.16219363-01	-.11518833-01	.18468361-06	-.17968771 02
Z	.12501384 05	.47340614 05	.34772597 05	-.11713876-01	.75178238-02	-.98098615-02	.74625093-07	-.74219149 01
DX	-.29614010-02	-.28379472-01	-.11713876-01	.20777808-07	-.12004298-07	.27655606-08	-.14335999-12	.33527526-05
DY	.15642850-02	.16219363-01	.75178238-02	-.12004298-07	.70263182-08	-.19162602-08	.82943994-13	-.73574456-05
DZ	-.28561890-02	-.11518833-01	-.98098615-02	.27655606-08	-.19162602-08	.29285971-08	-.17536011-13	-.14550667-06
MM	.21474894-07	.18468361-06	.74625093-07	-.14335999-12	.82943994-13	-.17536011-13	.99999998-18	.21195486-22
AU	-.11718800 02	-.17968771 02	-.74219149 01	.33527526-05	-.73574456-05	-.14550667-06	.21195486-22	.25000000 02

ENCOUNTER PARAMETERS AND STATISTICS 65/07/17 012859.322

B	.25568130 06	SMAA	.32174637 03
B.RO	-.12768892 06	SMIA	.83507688 02
B.TO	-.22151403 06	DEL T	.37226349 02
B.RC	-.12180449 06	DEL B	.33240677 03
B.TC	-.22479983 06	DEL S	.16038767 03
TL	.23040207 03	DEL BR	.10149567 03
THETA	.10699438 02	DEL BT	.31653260 03

N MATRIX

	B.RO	B.TO	TL	C3	S.TS	S.RS
B.RO	.10301371 05	-.17613031 05	-.17042226 04	.14831570-01	.10897963-02	.74349552-03
B.TO	-.17613032 05	.10019289 06	.10369679 05	.95422841-01	-.69411049-02	-.30035637-02
TL	-.17042227 04	.10369679 05	.13858011 04	.51374437-02	-.62122480-03	-.24740746-03
C3	.14831570-01	.95422841-01	.51374439-02	.66149723-06	-.11622786-07	-.69983611-08
S.TS	.10897963-02	-.69411049-02	-.62122480-03	-.11622786-07	.53718767-09	.25609643-09
S.RS	.74349549-03	-.30035638-02	-.24740745-03	-.69983607-08	.25609644-09	.15636082-09

NORMALIZED N MATRIX

	B.RO	B.TO	TL	C3	S.TS	S.RS
B.RO	.99999999 00	-.54823672 00	-.45105381 00	.17967000 00	.46327063 00	.58582360 00
B.TO	-.54823674 00	.10000000 01	.88002785 00	.37065500 00	-.94612197 00	-.75884733 00
TL	-.45105381 00	.88002785 00	.10000000 01	.16968076 00	-.72000467 00	-.53149401 00
C3	.17967001 00	.37065500 00	.16968077 00	.99999998 00	-.61657117 00	-.68812661 00
S.TS	.46327065 00	-.94612197 00	-.72000467 00	-.61657117 00	.99999999 00	.88364239 00
S.RS	.58582357 00	-.75884738 00	-.53149399 00	-.68812657 00	.88364241 00	.99999999 00

DM/DQO MATRIX

	B.RO	B.TO	TL	C3	S.TS	S.RS
X	.24330516 05	.64995540 05	-.29677574 05	.13145920 00	-.11157073-01	.56606676-03
Y	.98666986 04	.27841637 05	-.11310281 05	.49878439-01	-.44800132-02	.25911632-03
Z	-.13503961 05	-.40737256 05	.16973777 05	-.74298253-01	.66583250-02	-.28822134-03
DX	-.59392066 07	-.13507410 08	.79610852 07	-.35645702 02	.26993601 01	-.10983936 00
DY	.38196933 08	.10563821 09	-.46808109 08	.20666396 03	-.17838378 02	.87565422 00
DZ	-.49480323 07	-.12244892 08	.53021018 07	-.23715798 02	.20346128 01	-.14765713 00
MU	.24638750 01	-.72774732 01	.14250550 00	.43780724-03	.10143746-04	-.60035930-05

DM/DQ MATRIX

	B.RO	B.TO	TL	C3	S.TS	S.RS
X	-.14297395 00	-.16182701 00	.22580654 00	.28314228-06	.43595943-07	-.25130324-07
Y	-.28136354-01	.98867121 00	.40707545-01	-.11281551-05	-.47139432-07	.27172928-07
Z	-.99584158 00	.32882216-02	-.35173765-01	.66306711-06	.55314040-07	.26337118-07
DX	-.63716973 04	-.16846420 04	.91028766 04	-.84913467 01	-.36826590-03	.21228334-03
DY	-.85946945 04	.40625272 04	.13368759 05	-.13992037 01	.15366673-02	-.88579189-03
DZ	.10419841 05	-.11039756 03	-.84511326 04	.12437810 01	.18654026 00	.26722055 00
MU	.24778832 01	-.87136382 01	.23160733-01	.43191793-03	.10281612-04	-.59267003-05

N MATRIX FOR MANEUVER CALCULATIONS

	B.RC	B.TC	TL
B.RC	.11291969 05	-.19957052 05	-.22881360-01
B.TC	-.19957053 05	.99202292 05	.11945784 00
TL	-.22881360-01	.11945784 00	.18564079-06

0000 140311 OFFLINE CONTROL (27
0000 14031 TERMINATE JOB
0000 14031 END DATA (0

```
0000 141001      PAGE HEADING                                              (23
0000 14100       (VENUS CHECK CASE - STEP MAP)
0000 14100       EPOCH                                                     (01
0000 14100       620900500,2332000
0000 14100       GEOCENTRIC POSITION AND VELOCITY AT EPOCH                 (02
0000 14100       X=-.14245297E7 Y=-.19398640E7 Z=-.10071723E6
0000 14100       DX=-.17446099E1 DY=-.24232877E1 DZ=-.11048412E0
0000 14100       OTHER OPTIONS AND CONSTANTS                               (03
0000 14100       TARGET=(VENUS)
0000 14100       ESTIMATE THESE PARAMETERS                                 (04
0000 14100       X Y Z DX DY DZ MV AU
0000 14100       COVARIANCE MATRIX OF ESTIMATED PARAMETERS                 (10
0000 14100       DIAG=.1,.1,.1,.0001,.0001,.0001,.1E-17,25.
0000 14100       MAP COVARIANCE MATRIX TO                                  (24
0000 14100       621200700,0
0000 14100       OFFLINE CONTROL                                           (27
0000 14100       KEY(3) KEY(5)
0000 14100       END DATA                                                   (0
```

INPUT COVARIANCE MATRIX OF ESTIMATED PARAMETERS ITERATION NUMBER 0

	X	Y	Z	DX	DY	DZ	MV	AU
X	.99999999-01	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00
Y	.00000000 00	.99999999-01	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00
Z	.00000000 00	.00000000 00	.99999999-01	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00
DX	.00000000 00	.00000000 00	.00000000 00	.99999999-04	.00000000 00	.00000000 00	.00000000 00	.00000000 00
DY	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.99999999-04	.00000000 00	.00000000 00	.00000000 00
DZ	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.99999999-04	.00000000 00	.00000000 00
MV	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.99999998-18	.00000000 00
AU	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.25000000 02

INPUT J MATRIX OF ESTIMATED PARAMETERS ITERATION NUMBER 0

	X	Y	Z	DX	DY	DZ	MV	AU
X	.10000000 02	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00	.00000000 00
Y	.00000000 00	.10000000 02	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00
Z	.00000000 00	-.00000000 00	.10000000 02	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00
DX	.00000000 00	-.00000000 00	-.00000000 00	.10000000 05	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00
DY	.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	.10000000 05	-.00000000 00	-.00000000 00	-.00000000 00
DZ	.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	.10000000 05	-.00000000 00	-.00000000 00
MV	.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	.99999998 18	-.00000000 00
AU	.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	-.00000000 00	.39999999-01

```
CASE  1                              IBSYS-JPTRAJ-SPACE 022265                                        1

DOUBLE PRECISION EPHEMERIS TAPE - EPHEM1

  GME  .39860063 06    J  .16234500-02    H -.57499999-05    D  .78749999-05   RE  .63781650 04   REM  .63783112 04
    G  .66709998-19    A  .88781796 29    B  .88800194 29    C  .88836976 29  OME  .41780741-02    AU  .14959850 09
  GMM  .49026293 04  GMS  .13271411 12  GMV  .32476627 06  GMA  .42977368 05  GMC  .37918700 08   GMJ  .12670935 09
  EGM  .39860320 06  MGM  .49027779 04   JA  .29200000-02   HA  .00000000 00   DA  .00000000 00    RA  .34170000 04
RADIATION PRESSURE INPUT
  ARA  .38300000 01   GB  .38300000 00  MAS  .19822000 03  GB1  .00000000 00  GB2  .00000000 00    SC  .10310000 09

INJECTION CONDITIONS           VENUS        2355754006412020000000000 J.D.= 2437912.51634260  SEPT. 5,1962 00 23 32.000

GEOCENTRIC        X0-.14245297 07  Y0-.19398640 07  Z0-.10071723 06 DX0-.17446099 01 DY0-.24232877 01 DZ0-.11048412 00
CARTESIAN         T0 .14120000 04 GHA .34951873 03 GHD .34361929 03
DATE OF RUN 022265A  14103                 EARTH    IS THE CENTRAL BODY FOR INTEGRATION   COWELL EQUATIONS OF MOTION

   PROBE IS OUT OF EARTH'S    SHADOW

   0 DAYS  0 HRS.  0 MIN.  0.000 SEC.       2355754006412020000000000 J.D.= 2437912.51634260  SEPT. 5,1962 00 23 32.000

      GEOCENTRIC                                                                                 EQUATORIAL COORDINATES

    X -.14245296 07     Y -.19398639 07     Z -.10071723 06    DX -.17446098 01    DY -.24232875 01    DZ -.11048412 00
    R  .24088380 07   DEC -.23963223 01    RA  .23370847 03     V  .29880081 01   PTH  .89393198 02    AZ  .62816414 02
    R  .24088380 07   LAT -.23963223 01   LON  .24418974 03    VE  .17549891 03   PTE  .97549786 00   AZE  .27000472 03
   XS -.14343227 09    YS  .42810504 08    ZS  .18564279 08   DXS -.87218607 01   DYS -.25899198 02   DZS -.11230749 02
   XM -.27632510 06    YM -.27943325 06    ZM -.81923071 05   DXM  .72901663 00   DYM -.58854660 00   DZM -.27195625 00
   XT -.88139502 08    YT -.41412272 08    ZT -.22861356 08   DXT  .21205738 02   DYT -.90988722 01   DZT -.55559090 01
   RS  .15083166 09    VS  .29546049 02    RM  .40143479 06    VM  .97560880 00    RT  .10003094 09    VT  .23734804 02
  GED -.24126335 01   ALT  .24024598 07   LOS  .17386238 03   RAS  .16338111 03   RAM  .22532043 03   LOM  .23580169 03
  DUT  .35000000 02    DT  .19200000 04    DR  .29878406 01   SHA -.22750333 07   DES  .70698621 01   DEM -.11775395 02
  CCL  .60702505 02   MCL  .18217293 03   TCL  .33869367 03

                                                   GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE                 2355746127732023300000000 J.D.= 2437903.65534361  AUG. 27,1962 03 43 41.688
  SMA -.46363768 05   ECC  .11464198 01     B  .25992350 05   SLR  .14571132 05   APD  .00000000 00   RCA  .67885751 04
   VH  .29321057 01    C3  .85972439 01    CI  .76210645 05   TFP  .76559031 06    TF -.88609988 01   LTF -.88860067 01
   TA  .15011236 03   MTA  .15072477 03    EA  .25931107 03    MA  .27740861 04                       TFI  .00000000 00

                                                          ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
    X -.14245296 07     Y -.19398639 07     Z -.10071723 06    DX -.17446098 01    DY -.24232875 01    DZ -.11048412 00
  INC  .27271914 02   LAN  .23836288 03   APF  .20465420 03    MX  .70574093 00    MY -.54195777 00    MZ  .45648056 00
   WX -.39026894 00    WY  .24044364 00    WZ  .88884194 00    PX  .16105420 00    PY  .96826562 00    PZ -.19121377 00
   QX -.90656441 00    QY  .68592011-01    QZ -.41660539 00    RX  .21574512-01    RY  .29972926-01    RZ -.99931781 00
   BX -.71196419 00    BY  .53327496 00    BZ -.45686411 00    TX -.81161130 00    TY  .58419782 00    TZ  .00000000 00
  SXI -.30283033 00   SYI  .87814137 00   SZI -.37051435 00   DAI -.21747342 02   RAI  .10902694 03
  SXO -.58379930 00   SYO -.81105764 00   SZO -.36930149-01   DAO -.21164212 01   RAO  .23425365 03

  BTQ  .24871152 05   BRQ -.75521459 04     B  .25992350 05   THA  .34310904 03     T VECTOR IN  EARTH EQUATOR PLANE

                                                          ALL VECTORS REFERENCED TO ECLIPTIC PLANE
    X -.14245296 07     Y -.18198130 07     Z  .67933540 06    DX -.17446098 01    DY -.22672196 01    DZ  .86269591 00
  INC  .43960422 02   LAN  .21470263 03   APF  .23385448 03    MX  .70574097 00    MY -.31562129 00    MZ  .63441003 00
   WX -.39026905 00    WY  .57420661 00    WZ  .71981946 00    PX  .16105420 00    PY  .81227206 00    PZ -.56063743 00
   QX -.90656441 00    QY -.10280938 00    QZ -.40950625 00    RX -.17609356 00    RY -.22888077 00    RZ -.95739468 00
   BX -.71196439 00    BY  .30750167 00    BZ -.63130772 00    TX -.79257140 00    TY  .60977912 00    TZ  .00000000 00
```

```
CASE  1                                    IBSYS-JPTRAJ-SPACE 022265                                        2

SXI -.30283033 00   SYI  .65825499 00   SZI -.68928400 00   DAI -.43573456 02   RAI  .11470480 03
SXO -.58379930 00   SYO -.75880365 00   SZO  .28878253 00   DAO  .16785081 02   RAO  .23242646 03

BTC  .25821250 05   BRC -.29777056 04     B  .25992357 05   THA  .35342171 03    T VECTOR IN  ECLIPTIC PLANE

                                                                ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
  X -.21047606 07     Y  .49300253 06     Z  .62163449 06    DX -.26151033 01    DY  .12088622 01    DZ  .79251463 00
INC  .46529416 02   LAN  .14007295 03   APF  .23072292 03    MX -.14000245 00    MY -.72132412 00    MZ  .67822014 00
 WX  .46573257 00    WY  .55647604 00    WZ  .68798206 00    PX  .82730393 00    PY  .20775199-02    PZ -.56172740 00
 QX -.31406365 00    QY  .83080683 00    QZ -.45939320 00    RX -.24082291 00    RY  .11130159 00    RZ -.96416608 00
 BX  .13066194 00    BY  .72572865 00    BZ -.67545940 00    TX  .41953216 00    TY  .90774047 00    TZ  .00000000 00
SXI  .56802335 00   SYI  .40812293 00   SZI -.71463701 00   DAI -.45613458 02   RAI  .35697122 02
SXO -.87521258 00   SYO  .40449869 00   SZO  .26529930 00   DAO  .15384736 02   RAO  .15519494 03

BTO  .25569498 05   BRO -.46834718 04     B  .25994920 05   THA  .34962039 03    T VECTOR IN  ORBIT PLANE OF TARGET

 0 DAYS  8 HRS. 28 MIN. 56.404 SEC.        23557541756320206355205S J.D.= 2437912.86977319  SEPT. 5,1962 08 52 28.404

 0 DAYS  8 HRS. 28 MIN. 56.404 SEC.        23557541756320206355205S J.D.= 2437912.86977319  SEPT. 5,1962 08 52 28.404
 CHANGE OF PHASE OCCURS AT THIS POINT    SUN       IS THE CENTRAL BODY FOR INTEGRATION   COWELL EQUATIONS OF MOTION

95 DAYS 14 HRS. 14 MIN. 19.059 SEC.        2356053015172026074046ll J.D.= 2438008.10961873   DEC. 9,1962 14 37 51.059

    HELIOCENTRIC                                                                         EQUATORIAL COORDINATES

  X -.51022567 07     Y  .99263157 08     Z  .46385104 08    DX -.36494257 02    DY -.58201960 01    DZ -.33262712 01
  R  .10968494 09   LAT  .25017435 02   LON  .92942489 02     V  .37104845 02   PTH -.77073126 01    AZ  .92101531 02
 XE  .33012548 08    YE  .13172989 09    ZE  .57121301 08   DXE -.29507274 02   DYE  .60187032 01   DZE  .26093430 01
 XT -.57926326 07    YT  .97856442 08    ZT  .44437148 08   DXT -.35091492 02   DYT -.26941798 01   DZT  .10045215 01
LTE  .22812463 02   LOE  .75930981 02   LTT  .24385356 02   LOT  .93387681 02   RST  .10762945 09   VST  .35209096 02
EPS  .12889057 03   ESP  .15695707 02   SEP  .35413715 02   EPM  .78819662-01   EMP  .11190031 02   MEP  .16873061 03
MPS  .12896821 03   MSP  .15754195 02   SMP  .35277586 02   SEM  .15551557 03   EMS  .24425661 02   ESM  .57674939-01
EPT  .13652545 03   ETP  .41616420 02   TEP  .18581345 01   TPS  .34321386 02   TSP  .75043170 00   STP  .14492821 03
SET  .34151903 02   STE  .12978488 03   EST  .16063212 02   RPM  .51564817 08   RPT  .25000001 07   SPN  .12888343 03
SAC  .22900140-09
GCE  .87219501 02   GCT  .32905271 03   SIP  .34179292 02   CPT  .72719283 02   SIN  .72577188 02
REP  .51206375 08   VEP  .14973609 02   CPE  .80195375 02   CPS  .10226691 03

                                                HELIOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE                2356076050232024274046ll J.D.= 2438037.01349749   JAN. 7,1963 12 19 26.184
SMA  .12722493 09   ECC  .19144548 00     B  .12487168 09   SLR  .12256196 09   APO  .15158156 09   RCA  .10286829 09
 VH  .26606638 02    C3 -.10431455 04    CI  .40330759 10   TFP -.24972951 07    TF  .12449715 03   PER  .28646125 03
 TA -.52176583 02   MTA  .18000000 03    EA -.43934634 02    MA -.36323921 02                        TFI  .95593274 02

                                                                ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
  X -.51022567 07     Y  .99263157 08     Z  .46385104 08    DX -.36494257 02    DY -.58201960 01    DZ -.33262712'01
INC  .25099883 02   LAN  .35798326 03   APF  .14666950 03    MX -.99880593 00    MY -.35811769-01    MZ -.33229952-01
 WX -.14928005-01    WY -.42393483 00    WZ  .90556966 00    PX -.81748708 00    PY  .52667570 00    PZ  .23308281 00
 QX -.57575346 00    QY -.73681204 00    QZ -.35442347 00    RX -.19593895 00    RY  .12623598 00    RZ -.97245689 00
 BX  .57575345 00    BY  .73681203 00    BZ  .35442346 00    TX  .54159284 00    TY  .84064094 00    TZ  .00000000 00
DAP  .13478637 02   RAP  .14720786 03

BTQ  .11628279 09   BRQ -.45510967 08     B  .12487168 09   THA  .33862552 03    T VECTOR IN  EARTH EQUATOR PLANE




CASE  1                                    IBSYS-JPTRAJ-SPACE 022265                                        3


                                                                ALL VECTORS REFERENCED TO ECLIPTIC PLANE
  X -.51022567 07     Y  .10952328 09     Z  .30665980 07    DX -.36494257 02    DY -.66630823 01    DZ -.73627064 00
INC  .18528344 01   LAN  .33250316 03   APF  .17232764 03    MX -.99880594 00    MY -.46875705-01    MZ -.16240136-01
 WX -.14928005-01    WY -.28680307-01    WZ  .99947717 00    PX -.81748705 00    PY  .57593065 00    PZ  .43166742-02
 QX -.57575334 00    QY -.81699520 00    QZ -.32043274-01    RX -.35288584-02    RY  .24861283-02    RZ -.99999059 00
 BX  .57575339 00    BY  .81699527 00    BZ  .32043277-01    TX  .57593606 00    TY  .81749474 00    TZ  .00000000 00
DAP  .24732883 00   RAP  .14483478 03

BTC  .12480754 09   BRC -.40013342 07     B  .12487166 09   THA  .35816372 03    T VECTOR IN  ECLIPTIC PLANE

                                                                ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
  X  .10522015 09     Y  .30951192 08     Z  .12362223 07    DX -.15093336 02    DY  .33785281 02    DZ -.27414238 01
INC  .42377940 01   LAN  .20514100 03   APF  .22340356 03    MX -.28065725 00    MY  .95702555 00    MZ -.73031397-01
 WX -.31394514-01    WY  .66895422-01    WZ  .99726595 00    PX  .36657532 00    PY  .92900173 00    PZ -.50776334-01
 QX -.92985851 00    QY  .36397899 00    QZ -.53687768-01    RX -.18637393-01    RY -.47232232-01    RZ -.99871081 00
 BX  .92985854 00    BY -.36397900 00    BZ  .53687770-01    TX  .93020169 00    TY -.36704881 00    TZ  .00000000 00
DAP -.29105203 01   RAP  .68466271 02

BTO  .12469110 09   BRO -.67127396 07     B  .12487166 09   THA  .35691845 03    T VECTOR IN  ORBIT PLANE CF TARGET

95 DAYS 14 HRS. 14 MIN. 19.059 SEC.        2356053015172026074046ll J.D.= 2438008.10961873   DEC. 9,1962 14 37 51.059
 CHANGE OF PHASE OCCURS AT THIS POINT    VENUS     IS THE CENTRAL BODY FOR INTEGRATION   COWELL EQUATIONS OF MOTION

95 DAYS 14 HRS. 14 MIN. 19.059 SEC.        2356053015172026074046ll J.D.= 2438008.10961873   DEC. 9,1962 14 37 51.059

     GEOCENTRIC                                                                          EQUATORIAL COORDINATES

  X -.38114804 08     Y -.32466730 08     Z -.10736197 08    DX -.69869830 01    DY -.11838899 02    DZ -.59356140 01
  R  .51206374 08   DEC -.12102736 02    RA  .22042483 03     V  .14973609 02   PTH  .68707168 02    AZ  .12448867 03
  R  .51206373 08   LAT -.12102736 02   LON  .28310597 03    VE  .36465785 04   PTE  .21920980 00   AZE  .26995161 03
 XS -.33012548 08    YS -.13172989 09    ZS -.57121301 08   DXS  .29507273 02   DYS -.60187031 01   DZS -.26093429 01
 XM  .21915150 06    YM  .27889500 06    ZM  .87959625 05   DXM -.85011053 00   DYM  .59271705 00   DZM  .29599153 00
 XT -.38805180 08    YT -.33873445 09    ZT -.12684154 08   DXT -.55842184 01   DYT -.87128830 01   DZT -.16048215 01
 RS  .14732764 09    VS  .30227680 02    RM  .36544041 06    VM  .10777812 01    RT  .53048469 08    VT  .10472501 02
GED -.12182757 02   ALT  .51199996 08   LOS  .31861212 03   RAS  .25593098 03   RAM  .51840267 02   LOM  .11452140 03
OUT  .35000000 02    DT  .38400000 04    DR  .13951461 02   SHA -.29672879 08   DES -.22812463 02   DEM  .13927554 02
CCL  .27278050 03   MCL  .17997891 03   TCL  .61833203 02

    HELIOCENTRIC                                                                         EQUATORIAL COORDINATES

  X -.51022566 07     Y  .99263156 08     Z  .46385104 08    DX -.36494256 02    DY -.58201960 01    DZ -.33262711 01
  R  .10968493 09   LAT  .25017435 02   LON  .92942489 02     V  .37104844 02   PTH -.77073143 01    AZ  .92101531 02
 XE  .33012548 08    YE  .13172989 09    ZE  .57121301 08   DXE -.29507273 02   DYE  .60187031 01   DZE  .26093429 01
 XT -.57926326 07    YT  .97856442 08    ZT  .44437148 08   DXT -.35091492 02   DYT -.26941798 01   DZT  .10045215 01
LTE  .22812463 02   LOE  .75930981 02   LTT  .24385356 02   LOT  .93387681 02   RST  .10762945 09   VST  .35209096 02
EPS  .12889057 03   ESP  .15695704 02   SEP  .35413715 02   EPM  .78819662-01   EMP  .11190073 02   MEP  .16873057 03
MPS  .12896821 03   MSP  .15754195 02   SMP  .35277587 02   SEM  .15551562 03   EMS  .24425606 02   ESM  .58516955-01
EPT  .13652545 03   ETP  .41616422 02   TEP  .18580818 01   TPS  .34321389 02   TSP  .75039911 00   STP  .14492820 03
SET  .34151904 02   STE  .12978488 03   EST  .16063212 02   RPM  .51564818 08   RPT  .25000000 07   SPN  .12888343 03
SAC  .22900140-09
GCE  .87219499 02   GCT  .32905271 03   SIP  .34179296 02   CPT  .72719279 02   SIN  .72577184 02
REP  .51206374 08   VEP  .14973609 02   CPE  .80195375 02   CPS  .10226691 03
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CASE  1                                  IBSYS-JPTRAJ-SPACE 022265                                         4

  APHRODIOCENTRIC                                                                     EQUATORIAL COORDINATES

   X  .69037591 06     Y  .14067148 07     Z  .19479566 07    DX -.14027647 01    DY -.31260163 01    DZ -.43307926 01
   R  .25000000 07   DEC  .51185796 02    RA  .63859499 02     V  .55222722 01   PTH -.88684816 02    AZ  .24853760 03
 ALT  .24938001 07   SHA  .14365062 07   ALP  .50235695 02    DR -.55208174 01    DP  .29047796-05   ASD  .14209440 00
 HGE  .23110942 03   SVL  .29805915 02   HNG  .17862165 02   SIA  .13638335 03
 SAC  .22900140-09

                                           APHRODIOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE              235605634232202757404611 J.D.= 2438013.29235961  DEC. 14,1962 19 00 59.871
 SMA -.10741161 05   ECC  .54573169 01     B  .57624974 05   SLR  .30915540 06   APO  .00000000 00   RCA  .47876758 05
  VH  .54986978 01    C3  .30235677 02    C1  .31686472 06   TFP -.44778881 06    TF  .10077602 03   LTF  .10073765 03
  TA -.99240591 02   MTA  .10055855 03    EA -.25498362 03    MA -.13134227 05                       TFI  .95593274 02
 ZAE  .13728729 03   ZAP  .34431163 02   ZAC  .72681574 02   DEF  .21117187 02    IR  .13100778 05    GP -.29764390 02

                                                           ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
   X  .69037591 06     Y  .14067148 07     Z  .19479566 07    DX -.14027647 01    DY -.31260163 01    DZ -.43307926 01
 INC  .12568504 03   LAN  .18063363 03   APF  .20564144 03    MX  .96106519 00    MY -.15408769 00    MZ -.22933716 00
  WX -.89823426-02    WY  .81217684 00    WZ -.58332922 00    PX  .90424851 00    PY -.24244515 00    PZ -.35148387 00
  QX -.42689480 00    QY -.53064020 00    QZ -.73224367 00    RX  .32102521 00    RY  .71553693 00    RZ -.62044313 00
  BX  .96716951 00    BY -.14110654 00    BZ -.21135770 00    TX -.91238207 00    TY  .40933966 00    TZ  .00000000 00
 SXI -.25397198 00   SYI -.56608119 00   SZI -.78425141 00   DAI -.51651496 02   RAI  .24583663 03
 SXO -.58536138 00   SYO -.47722978 00   SZO -.65543945 00   DAO -.40952978 02   RAO  .21918946 03
 ETE  .30676850 03   ETS  .41834750 02   ETC  .25151733 03

 BTQ -.54178344 05   BRQ  .19630194 05     B  .57624974 05   THA  .16008325 03     T VECTOR IN  EARTH EQUATOR PLANE

                                                           ALL VECTORS REFERENCED TO ECLIPTIC PLANE
   X  .69037591 06     Y  .20655587 07     Z  .12275376 07    DX -.14027647 01    DY -.45909108 01    DZ -.27297031 01
 INC  .14912599 03   LAN  .18100294 03   APF  .20613286 03    MX  .96107515 00    MY -.23260884 00    MZ -.14910819 00
  WX -.89822391-02    WY  .51307865 00    WZ -.85829785 00    PX  .90425774 00    PY -.36226754 00    PZ -.22602173 00
  QX -.42689838 00    QY -.77814811 00    QZ -.46069866 00    RX  .14442028 00    RY  .47274711 00    RZ -.86928300 00
  BX  .96716970 00    BY -.21354349 00    BZ -.13777493 00    TX -.95636865 00    TY  .29216260 00    TZ  .00000000 00
 SXI -.25397199 00   SYI -.83135503 00   SZI -.49431472 00   DAI -.29624573 02   RAI  .25301252 03
 SXO -.58536812 00   SYO -.69858971 00   SZO -.41148134 00   DAO -.24297925 02   RAO  .23003940 03
 ETE  .31756582 03   ETS  .52632071 02   ETC  .26231466 03

 BTC -.56896602 05   BRC  .91331112 04     B  .57624970 05   THA  .17088060 03     T VECTOR IN  ECLIPTIC PLANE

                                                           ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
   X  .21701731 07     Y -.11002964 06     Z  .12362209 07    DX -.47923321 01    DY  .11675437 00    DZ -.27414251 01
 INC  .14982375 03   LAN  .99025410 02   APF  .19958971 03    MX  .94519880-03    MY -.99591691 00    MZ -.90300711-01
  WX  .49644364 00    WY  .78854661-01    WZ -.86448325 00    PX -.13846385 00    PY -.97592482 00    PZ -.16853506 00
  QX -.85695557 00    QY  .20336746 00    QZ -.47357037 00    RX  .49628792 00    RY -.12062964-01    RZ -.86807415 00
  BX  .20910910-01    BY -.99666294 00    BZ -.78903148-01    TX  .24299205-01    TY  .99970473 00    TZ  .00000000 00
 SXI -.86781784 00   SYI  .21093512-01   SZI -.49643450 00   DAI -.29764388 02   RAI  .17860762 03
 SXO -.81707303 00   SYO  .37875450 00   SZO -.43466907 00   DAO -.25764239 02   RAO  .15512990 03
 ETE  .31229757 03   ETS  .71005011 02   ETC  .27321265 03

 BTO -.57386433 05   BRO  .52377827 04     B  .57624970 05   THA  .17478494 03     T VECTOR IN  ORBIT PLANE OF TARGET

100 DAYS 19 HRS. 23 MIN. 26.074 SEC.     235605635514202411434156 J.D.= 2438013.32428326  DEC. 14,1962 19 46 58.075
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CASE  1                                  IBSYS-JPTRAJ-SPACE 022265                                         5

    GEOCENTRIC                                                                        EQUATORIAL COORDINATES

   X -.41051080 08     Y -.38291325 08     Z -.13671191 08    DX -.74626395 01    DY -.14910036 02    DZ -.72400016 0
   R  .57778180 08   DEC -.13686847 02    RA  .22300789 03     V  .18177398 02   PTH  .68362926 02    AZ  .11985724 0
   R  .57778180 08   LAT -.13686847 02   LON  .20326984 03    VE  .40878328 04   PTE  .23682742 00   AZE  .26995322 0
  XS -.19597573 08    YS -.13388624 09    ZS -.58055864 08   DXS  .29999834 02   DYS -.35449458 01   DZS -.15359250 01
  XM -.22533850 06    YM  .28651450 06    ZM  .12794737 06   DXM -.85853022 00   DYM -.53210795 00   DZM -.13040236 00
  XT -.41081809 08    YT -.38295325 08    ZT -.13647331 08   DXT -.44356764 01   DYT -.10890376 02   DZT -.26676137 01
  RS  .14724155 09    VS  .30247574 02    RM  .38631403 06    VM  .10184389 01    RT  .57797029 08    VT  .12057847 02
 GED -.13776577 02   ALT  .57771803 08   LOS  .24193441 03   RAS  .26167247 03   RAM  .12818441 03   LOM  .10844636 03
 DUT  .35000000 02    DT  .24000000 03    DR  .16896584 02   SHA -.35388548 08   DES -.23221698 02   DEM  .19341652 02
 CCL  .27338213 03   MCL  .17998010 03   TCL  .32543668 03

   HELIOCENTRIC                                                                       EQUATORIAL COORDINATES

   X -.21453506 08     Y  .95594916 08     Z  .44384672 08    DX -.37462473 02    DY -.11365090 02    DZ -.57040765 01
   R  .10755761 09   LAT  .24372012 02   LON  .10264880 03     V  .39561833 02   PTH -.72353166 01    AZ  .95856804 02
  XE  .19597573 08    YE  .13388624 09    ZE  .58055864 08   DXE -.29999834 02   DYE  .35449458 01   DZE  .15359250 01
  XT -.21484235 08    YT  .95590916 08    ZT  .44408532 08   DXT -.34435511 02   DYT -.73454299 01   DZT -.11316886 01
 LTE  .23221698 02   LOE  .81672475 02   LTT  .24382966 02   LOT  .10266685 03   RST  .10757004 09   VST  .35228403 02
 EPS  .12302097 03   ESP  .19209271 02   SEP  .37769753 02   EPM  .37800648 00   EMP  .80678812 02   MEP  .98943153 02
 MPS  .12339864 03   MSP  .19106508 02   SMP  .37494848 02   SEM  .13666413 03   EMS  .43232903 02   ESM  .10231507 00
 EPT  .11879526 03   ETP  .61170761 02   TEP  .33542591-01   TPS  .10851589 03   TSP  .18504685-01   STP  .71464353 02
 SET  .37796579 02   STE  .12297788 03   EST  .19225541 02   RPM  .57839493 08   RPT  .39109093 05   SPN  .12301465 03
 SAC  .23814957-09
 GCE  .86617870 02   GCT  .23205454 03   STP  .99394255 02   CPT  .11992423 03   SIN  .11080259 03
 REP  .57778180 08   VEP  .18177398 02   SPE  .80314971 02   CPS  .10271893 03

  APHRODIOCENTRIC                                                                     EQUATORIAL COORDINATES

   X  .30728787 05     Y  .40000217 04     Z -.23859226 05    DX -.30269631 01    DY -.40196605 01    DZ -.45723879 01
   R  .39109093 05   DEC -.37594455 02    RA  .74165933 01     V  .67990372 01   PTH  .75343634-06    AZ  .21192412 03
 ALT  .32909093 05   SHA -.37080350 05   ALP  .12618129 02    DR  .74910647-07    DP  .99607556-02   ASD  .91216356 01
 HGE  .23697902 03   SVL -.32544186 02   HNG  .11213077 03   SIA  .10967362 03
 SAC  .23814957-09

                                           APHRODIOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE              235605635514202411425570 J.D.= 2438013.32428326  DEC. 14,1962 19 46 58.075
 SMA -.10964912 05   ECC  .45667493 01     B  .48858741 05   SLR  .21771052 06   APO  .00000000 00   RCA  .39109093 05
  VH  .54423050 01    C3  .29618684 02    C1  .26590418 06   TFP  .98913489-04    TF  .10080794 03   LTF  .10077252 03
  TA  .25613208-05   MTA  .10264878 03    EA  .00000000 00    MA  .28129103-05                       TFI  .10080794 03
 ZAE  .13776038 03   ZAP  .39971175 02   ZAC  .71965344 02   DEF  .25297576 02    IR  .13206245 05    GP -.30444610 02

                                                           ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
   X  .30728787 05     Y  .40000217 04     Z -.23859226 05    DX -.30269631 01    DY -.40196605 01    DZ -.45723879 01
 INC  .11477088 03   LAN  .20822792 03   APF  .22221299 03    MX -.44520467 00    MY -.59121025 00    MZ -.67250520 00
  WX -.42946162 00    WY  .80000596 00    WZ -.41899068 00    PX  .78571975 00    PY  .10227857 00    PZ -.61006849 00
  QX -.44520466 00    QY -.59121024 00    QZ -.67250520 00    RX  .33778184 00    RY  .71389431 00    RZ -.61339898 00
  BX  .86413916 00    BY  .22925609 00    BZ -.44800129 00    TX -.90392323 00    TY  .42769475 00    TZ  .00000000 00
 SXI -.26234753 00   SYI -.55446560 00   SZI -.78977317 00   DAI -.52164318 02   RAI  .24467864 03
 SXO -.60645214 00   SYO -.59925832 00   SZO -.52259473 00   DAO -.31506462 02   RAO  .22465815 03
 ETE  .30229105 03   ETS  .29230400 02   ETC  .25076851 03
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CASE  1                         IBSYS-JPTRAJ-SPACE 022265                               6

BTQ -.33373639 05   BRQ  .35684405 05     B  .48858741 05   THA  .13308353 03    T VECTOR IN  EARTH EQUATOR PLANE

                                                              ALL VECTORS REFERENCED TO ECLIPTIC PLANE
  X  .30728787 05     Y -.58220504 04     Z -.23481196 05   DX -.30269631 01   DY -.55069064 01   DZ -.25958396 01
INC  .13464185 03   LAN  .21712739 03   APF  .23754776 03   HX -.44520466 00   HY -.80995385 00   HZ -.38179517 00
 WX -.42946161 00    WY  .56728598 00    WZ -.70267300 00   PX  .78571975 00   PY -.14886692 00   PZ -.60040245 00
 QX -.44520467 00    QY -.80995385 00    QZ -.38179519 00   RX  .15308934 00   RY  .48018908 00   RZ -.86370255 00
 BX  .86413918 00    RY  .32104934-01    BZ -.50222781 00   TX -.95275255 00   TY  .30374755 00   TZ  .00000000 00
SXI -.26234753 00   SYI -.82289482 00   SZI -.50400189 00  DAI -.30265119 02  RAI  .25231716 03
SXO -.60645215 00   SYO -.75769880 00   SZO -.24105666 00  DAO -.13948913 02  RAO  .23132667 03
ETE  .31365265 03   ETS  .40592002 02   ETC  .26213010 03

BTC -.39749469 05   BRC  .28410497 05     B  .48858742 05   THA  .14444512 03    T VECTOR IN  ECLIPTIC PLANE

                                                              ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
  X  .15995859 04     Y -.32570000 05     Z -.21590682 05   DX -.60659888 01   DY  .14842515 01   DZ -.26884349 01
INC  .13722957 03   LAN  .13851610 03   APF  .23438793 03   HX -.89218352 00   HY  .21830320 00   HZ -.39541406 00
 WX  .44981742 00    WY  .50871417 00    WZ -.73408052 00   PX  .40900621-01   PY -.83279864 00   PZ -.55206295 00
 QX -.89218351 00    QY  .21830318 00    QZ -.39541406 00   RX  .50638494 00   RY -.18010652-01   RZ -.86211938 00
 BX  .23527313 00    BY -.86038996 00    BZ -.45207930 00   TX  .35544639-01   TY  .99936808 00   TZ  .00000000 00
SXI -.86157462 00   SYI  .30643724-01   SZI -.50670514 00  DAI -.30444610 02  RAI  .17796301 03
SXO -.87948699 00   SYO  .39536650 00   SZO -.26493010 00  DAO -.15362798 02  RAO  .15579407 03
ETE  .30926123 03   ETS  .61084647 02   ETC  .27339349 03

BTO -.41602414 05   BRD  .25620609 05     B  .48858741 05   THA  .14837340 03    T VECTOR IN  ORBIT PLANE OF TARGET

100 DAYS 19 HRS. 26 MIN. 19.059 SEC.     2356056355672026074046l1 J.D.= 2438013.32628540  DEC. 14,1962 19 49 51.059

    GEOCENTRIC                                                                            EQUATORIAL COORDINATES

  X -.41052372 08     Y -.38293904 08     Z -.13672441 08    DX -.74907017 01    DY -.14914270 02    DZ -.72176348 01
  R  .57781104 08   DEC -.13687417 02    RA  .22300891 03     V  .18183518 02   PTH  .68464816 02    AZ  .11972255 03
  R  .57781103 08   LAT -.13687417 02   LON  .20254812 03    VE  .40880465 04   PTE  .23706050 00   AZE  .26995361 03
 XS -.19592383 08    YS -.13388685 09    ZS -.58056129 08   DXS  .29999978 02   DYS -.35439873 01   DZS -.15355094 01
 XM -.22548650 06    YM  .28642300 06    ZM  .12792500 06   DXM -.85825494 00   DYM -.53245151 00   DZM -.13055575 00
 XT -.41082576 08    YT -.38297208 08    ZT -.13647793 08   DXT -.44351359 01   DYT -.10891180 02   DZT -.26680171 01
 RS  .14724152 09    VS  .30247584 02    RM  .38632512 06    VM  .10184061 01    RT  .57798931 08    VT  .12058464 02
GED -.13777151 02   ALT  .57774727 08   LOS  .24121388 03   RAS  .26167468 03   RAM  .12821159 03   LOM  .10775079 03
OUT  .35000000 02    DT  .24000000 03    OR  .16914169 02   SHA -.35391055 08   DES -.23221815 02   DEM  .19337558 02
CCL  .27338252 03   MCL  .17998012 03   TCL  .32423100 03

    HELIOCENTRIC                                                                          EQUATORIAL COORDINATES

  X -.21459989 08     Y  .95592949 08     Z  .44383688 08    DX -.37490680 02    DY -.11370283 02    DZ -.56021254 01
  R  .10755675 09   LAT  .24371643 02   LON  .10265275 03     V  .39586879 02   PTH -.72124065 01    AZ  .95825815 02
 XE  .19592383 08    YE  .13388685 09    ZE  .58056129 08   DXE -.29999978 02   DYE  .35439873 01   DZE  .15355094 01
 XT -.21490192 08    YT  .95589645 08    ZT  .44408336 08   DXT -.34435114 02   DYT -.73471930 01   DZT -.11325077 01
LTE  .23221815 02   LOE  .81674687 02   LTT  .24382856 02   LOT  .10267041 03   RST  .10757002 09   VST  .35228410 02
EPS  .12301850 03   ESP  .19210847 02   SEP  .37770653 02   EPM  .37800648 00   EMP  .80703614 02   MEP  .98918331 02
MPS  .12339619 03   MSP  .19108037 02   SMP  .37495776 02   SEM  .13664028 03   EMS  .43256699 02   ESM  .10326686 00
EPT  .11708922 03   ETP  .62876250 02   TEP  .33542591-01   TPS  .10981217 03   TSP  .15639313-01   STP  .70168220 02
SET  .37797812 02   STE  .12297543 03   EST  .19226755 02   RPM  .57842254 08   RPT  .39123598 05   SPN  .12301217 03
SAC  .23815338-09
GCE  .86617480 02   GCT  .23084848 03   SIP  .10069395 03   CPT  .12031818 03   SIN  .11119995 03
REP  .57781104 08   VEP  .18183518 02   CPE  .80314979 02   CPS  .10271903 03
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CASE  1                         IBSYS-JPTRAJ-SPACE 022265                               7

  APHRODIOCENTRIC                                                                         EQUATORIAL COORDINATES

  X  .30202689 05     Y  .33043787 04     Z -.24648217 05    DX -.30555658 01    DY -.40230900 01    DZ -.45496177 01
  R  .39123598 05   DEC -.39050781 02    RA  .62437123 01     V  .67985849 01   PTH  .14131968 01    AZ  .21265149 03
ALT  .32923599 05   SHA -.36803285 05   ALP  .14175582 02    DR  .16766977 00    DP  .99533717-02   ASD  .91182247 01
HGE  .23698150 03   SVL -.33361545 02   HNG  .11394177 03   SIA  .10797099 03
SAC  .23815338-09

                                          APHRODIOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE              23560563551420241l466611 J.D.= 2438013.32428326  DEC. 14,1962 19 46 58.075
SMA -.10964909 05   ECC  .45667502 01     B  .48858736 05   SLR  .21771055 06   APO  .00000000 00   RCA  .39109092 05
 VH  .54423057 01    C3  .29618692 02    C1  .26590420 06   TFP  .17298361 03    TF  .10080794 03   LTF  .10077252 03
 TA  .17226236 01   HTA  .10264878 03    EA  .13790468 01    MA  .49193246 01                       TFI  .10080994 03
ZAE  .13776068 03   ZAP  .39973169 02   ZAC  .71965352 02   DEF  .25297576 02    IR  .13206244 05    GP -.30444603 02

                                                              ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
  X  .30202689 05     Y  .33043787 04     Z -.24648217 05   DX -.30555658 01   DY -.40230900 01   DZ -.45496177 01
INC  .11477088 03   LAN  .20822792 03   APF  .22221299 03   HX -.46862293 00   HY -.59401770 00   HZ -.65386199 00
 WX -.42946165 00    WY  .80000593 00    WZ -.41899072 00   PX  .78571969 00   PY  .10227852 00   PZ -.61006853 00
 QX -.44520469 00    QY -.59121028 00    QZ -.67250511 00   RX  .33778185 00   RY  .71389419 00   RZ -.61339908 00
 BX  .86413912 00    BY  .22925603 00    BZ -.44800140 00   TX -.90392319 00   TY  .42769483 00   TZ  .00000000 00
SXI -.26234762 00   SYI -.55446566 00   SZI -.78977307 00  DAI -.52164309 02  RAI  .24467864 03
SXO -.60645213 00   SYO -.59925835 00   SZO -.52259466 00  DAO -.31506458 02  RAO  .22465815 03
ETE  .30228987 03   ETS  .29226401 02   ETC  .25076850 03

BTQ -.33373633 05   BRQ  .35684404 05     B  .48858736 05   THA  .13308352 03    T VECTOR IN  EARTH EQUATOR PLANE

                                                              ALL VECTORS REFERENCED TO ECLIPTIC PLANE
  X  .30202689 05     Y -.67741585 04     Z -.23928315 05   DX -.30555658 01   DY -.55009941 01   DZ -.25735845 01
INC  .13464185 03   LAN  .21712739 03   APF  .23754777 03   HX -.46862293 00   HY -.80511276 00   HZ -.36357392 00
 WX -.42946164 00    WY  .56728595 00    WZ -.70267301 00   PX  .78571969 00   PY -.14886698 00   PZ -.60040247 00
 QX -.44520470 00    QY -.80995385 00    QZ -.38179508 00   RX  .15308934 00   RY  .48018896 00   RZ -.86370259 00
 BX  .86413913 00    RY  .32104841-01    BZ -.50222789 00   TX -.95275253 00   TY  .30374763 00   TZ  .00000000 00
SXI -.26234761 00   SYI -.82289483 00   SZI -.50400177 00  DAI -.30265111 02  RAI  .25231716 03
SXO -.60645214 00   SYO -.75769880 00   SZO -.24105658 00  DAO -.13948908 02  RAO  .23132667 03
ETE  .31365147 03   ETS  .40588005 02   ETC  .26213010 03

BTC -.39749463 05   BRC  .28410495 05     B  .48858736 05   THA  .14444512 03    T VECTOR IN  ECLIPTIC PLANE

                                                              ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
  X  .55016583 03     Y -.32310610 05     Z -.22053972 05   DX -.60669988 01   DY  .15147077 01   DZ -.26679470 01
INC  .13722957 03   LAN  .13851610 03   APF  .23438794 03   HX -.89300985 00   HY  .24323921 00   HZ -.37863977 00
 WX  .44981735 00    WY  .50871418 00    WZ -.73408053 00   PX  .40900556-01   PY -.83279862 00   PZ -.55206300 00
 QX -.89218354 00    QY  .21830321 00    QZ -.39541396 00   RX  .50638483 00   RY -.18010689-01   RZ -.86211945 00
 BX  .23527304 00    BY -.86018993 00    BZ -.45207940 00   TX  .35544721-01   TY  .99936808 00   TZ  .00000000 00
SXI -.86157468 00   SYI  .30643796-01   SZI -.50670503 00  DAI -.30444602 02  RAI  .17796300 03
SXJ -.87948700 00   SYO  .39536648 00   SZO -.26493001 00  DAO -.15362793 02  RAO  .15579407 03
ETE  .30926022 03   ETS  .61081146 02   ETC  .27339349 03

BTO -.41602410 05   BRJ  .25620611 05     B  .48858738 05   THA  .14837339 03    T VECTOR IN  ORBIT PLANE OF TARGET
```

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CASE  1                                IBSYS-JPTRAJ-SPACE 022265                                8

 625535100735   625730503775   621602710213   601700276504   602465436600   575674117131           EARTH
                 21172191649                   17448304640                  000000000000          INITIAL

 217727454543   214522350406   617601552025   602611220703   603400724620   603442741665           VENUS
                                                             235605635567   202607404611            END


        U MATRIX FOR MAPPING FORWARD                         ITERATION  NUMBER       0

            X            Y            Z            DX           DY           DZ           MV           AU

 X     .39773183 01  .21087921 01  .10280934 01  .40090036-06  .12381001-05  .60017031-06  .00000000 00  .00000000 00
 Y     .42917053 00  .30646667 00  .21520492 00  .14571548-06 -.55214985-08  .10965675-06  .00000000 00  .00000000 00
 Z     .15201560 00  .16563731 00 -.13895442 00  .55276687-07  .73585203-07 -.18714900-06  .00000000 00  .00000000 00
 DX    .13987192 08  .68392637 07  .33544449 07  .16401137 01  .40547289 01  .19595172 01  .00000000 00  .00000000 00
 DY    .36532307 07  .79637667 07  .19422097 07  .14248229 01  .25076387 01  .14931677 01  .00000000 00  .00000000 00
  ODPX+14130


621200700,0000000
 X=    -.36497317E+08  Y=   -.29912202E+08  Z=   -.94567338E+07  $      0 0 0   1
 DX=   -.73404306E+01 DY=   -.10826458E+02 DZ=   -.54166483E+01  $      0 0 0   2
R01 24347426137221062600114 5/8      2425763152052070143632 12/8 $      0 0 0   3
    2415664720732066222720 12/8      21455747502416167211032 0/8 $      0 0 0   4
    2156546163401626035256 74/8      21463565673516126531143 3/8 $      0 0 0   5
    5434036716215103600077 41/8      17757373651714452000000 0/8 $      0 0 0   6
R02 2425763152052070143632 12/8      24252363526520743061224 2/8 $      0 0 0   7
    2414354260122065502015 33/8      21445302017016150715450 4/8 $      0 0 0   8
    2154743607711624366766 72/8      21447734313616173106443 5/8 $      0 0 0   9
    5445025337765111642140 12/8      20050701302014556000000 0/8 $      0 0 0  10
  ODPX+14130


R03 2415664720732066222720 11/8      24143542601220655020153 4/8 $      0 0 0  11
    2407142435072055601275 35/8      21344305076716041305470 6/8 $      0 0 0  12
    2145017707321615540513 15/8      21277221302515717263642 7/8 $      0 0 0  13
    5445506524675110635312 27/8      20040607547414544000000 0/8 $      0 0 0  14
R04 2145574750241616721103 22/8      21445302017016150715450 4/8 $      0 0 0  15
    2134430507671604130547 06/8      16642061360413312533110 4/8 $      0 0 0  16
    1674472426641341046550 56/8      16643473463513352546231 4/8 $      0 0 0  17
    5175513627344646442334 10/8      55077461264051570000000 0/8 $      0 0 0  18
R05 2156546163401626035256 74/8      21547436077116243667667 3/8 $      0 0 0  19
    2145017707321615540513 15/8      16744724266413410465505 6/8 $      0 0 0  20
  ODPX+14130


    1705073270071353604062 04/8      16746756010413472555212 6/8 $      0 0 0  21
    5207241311334650154370 24/8      15451307226612114000000 0/8 $      0 0 0  22
R06 2146356567351612653114 33/8      21447734313616173106443 5/8 $      0 0 0  23
    2127722130251571726364 27/8      16643473463513352546231 4/8 $      0 0 0  24
    1674675601041347255521 26/8      16647711444313323056552 5/8 $      0 0 0  25
    5214235514054666115426 05/8      15365616724212074000000 0/8 $      0 0 0  26
R07 5434036716215103600077 41/8      54450253377651116421401 2/8 $      0 0 0  27
    5445506524675110635312 22/8      51755136273446464423341 0/8 $      0 0 0  28
    5207241311334650154370 24/8      52142355140546661154260 5/8 $      0 0 0  29
    1054471135640523511035 30/8      00000000000000000000000 0/8 $      0 0 0  30
 DZ    .18190670 07  .19553291 07  .48569464 07  .69472166 00  .15003603 01  .13430120 00  .00000000 00  .00000000 00
 MV   -.94537556 09 -.23478037 10 -.26254072 10 -.12541165 04 -.32486109 04 -.38261904 04  .10000000 01  .00000000 00
 AU    .14841206-01  .25548558-01  .20478152-01 -.23691501-08  .24669914-07  .16027430-07  .00000000 00  .10000000 01


                 CONDITIONS AFTER FORWARD MAPPING          62/09/05  002332.000  TO  62/12/07  000000.000

   X= -.36497317 08    Y= -.29912202 08    Z= -.94567338 07   DX= -.73404306 01   DY= -.10826458 02   DZ= -.54166483 01
                       STANDARD  DEVIATIONS

   X=  .14570403 06    Y=  .10678034 06    Z=  .62140492 05   DX=  .22809497-01   DY=  .49980155-01   DZ=  .24672443-01


          COVARIANCE  MATRIX  AFTER  MAPPING                   ITERATION  NUMBER       0

            X            Y            Z            DX           DY           DZ           MV           AU

 X     .21229665 11  .12831745 11  .62849716 10  .29409537 04  .68604511 04  .33107333 04 -.94537555-09  .37103015 00
 Y     .12831245 11  .11402042 11  .47906166 10  .23922537 04  .50635308 04  .25555497 04 -.23478037-08  .63871396 00
 Z     .62849716 10  .47906166 10  .38614407 10  .11643202 04  .25758895 04  .10125431 04 -.26254072-08  .51195380 00
 DX    .29409537 04  .23922537 04  .11643202 04  .52027313-03  .11265490-02  .54346325-03 -.12541165-14 -.59228753-07
 DY    .68604511 04  .50635308 04  .25758895 04  .11265490-02  .24980159-02  .11891137-02 -.32486109-14  .61674783-06
 DZ    .33107333 04  .25555497 04  .10125431 04  .54346325-03  .11891137-02  .60872945-03 -.38261903-14  .40068574-06
 MV   -.94537555-09 -.23478037-08 -.26254072-08 -.12541165-14 -.32486109-14 -.38261903-14  .99999998-18  .00000000 00
 AU    .37103015 00  .63871396 00  .51195380 00 -.59228753-07  .61674783-06  .40068574-06  .00000000 00  .25000000 02
```

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CASE  1                                           IBSYS-JPTRAJ-SPACE 022265

DOUBLE PRECISION EPHEMERIS TAPE - EPHEM1

  GME  .39860063 06     J  .16234500-02     H -.57499999-05     D  .78749999-05    RE  .63781650 04   REM  .63783112 04
    G  .66709998-19     A  .88781796 29     B  .88800194 29     C  .88836976 29   OME  .41780741-02    AU  .14959850 09
 'GMM  .49026293 04   GMS  .13271411 12   GMV  .32476627 06   GMA  .42977368 05   GMC  .37918700 08   GMJ  .12670935 09
  EGM  .39860320 06   MGM  .49027779 04    JA  .29200000-02    HA  .00000000 00    DA  .00000000 00    RA  .34170000 04
RADIATION PRESSURE INPUT
  ARA  .38300000 01    GB  .38300000 00   HAS  .19822000 03   GB1  .00000000 00   GB2  .00000000 00    SC  .10310000 09

INJECTION CONDITIONS           VENUS        23560512344020200000000 J.D.= 2438005.50000000   DEC. 7,1962 00 00 00.000

GEOCENTRIC          XO-.36497317 08  YO-.29912202 08  ZO-.94567338 07 DXO-.73404306 01 DYO-.10826458 02 DZO-.54166483 01
CARTESIAN           TO .00000000 00 GHA .75283983 02 GHO .75283983 02
DATE OF RUN 022265A  14135                 SUN       IS THE CENTRAL BODY FOR INTEGRATION   COWELL EQUATIONS OF MOTION

  2 DAYS 14 HRS. 37 MIN. 51.431 SEC.        23560530151720266711775 J.D.= 2438008.10962304   DEC. 9,1962 14 37 51.431

    HELIOCENTRIC                                                                                  EQUATORIAL COORDINATES

    X -.51022667 07     Y  .99263156 08     Z  .46385103 08    DX -.36494255 02    DY -.58201981 01    DZ -.33262720 01
    R  .10968493 09   LAT  .25017435 02   LON  .92942495 02     V  .37104844 02   PTH -.77073117 01    AZ  .92101534 02
   XE  .33012537 08    YE  .13172989 09    ZE  .57121303 08   DXE -.29507275 02   DYE  .60187012 01   DZE  .26093421 01
   XT -.57926456 07    YT  .97856441 08    ZT  .44437148 08   DXT -.35091491 02   DYT -.26941837 01   DZT  .10045197 01
  LTE  .22812464 02   LOE  .75930985 02   LTT  .24385356 02   LOT  .93387689 02   RST  .10762945 09   VST  .35209096 02
  EPS  .12889057 03   ESP  .15695705 02   SEP  .35413715 02   EPM  .79129368-01   EMP  .11190247 02   MEP  .16873040 03
  MPS  .12896821 03   MSP  .15754194 02   SMP  .35277588 02   SEM  .15551576 03   EMS  .24425467 02   ESM  .57674939-01
  EPT  .13652552 03   ETP  .41616356 02   TEP  .18581082 01   TPS  .34321412 02   TSP  .75039911 00   STP  .14492818 03
  SET  .34151907 02   STE  .12978487 03   EST  .16063214 02   RPM  .51564819 08   RPT  .25000001 07   SPN  .12888343 03
  SAC  .22900140-09
  GCE  .87219499 02   GCT  .32905257 03   SIP  .34179318 02   CPT  .72719297 02   SIN  .72577202 02
  REP  .51206376 08   VEP  .14973608 02   CPE  .80195375 02   CPS  .10226691 03

                                               HELIOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE                 23560760502320260711775 J.D.= 2438037.01350758   JAN. 7,1963 12 19 27.056
  SMA  .12722491 09   ECC  .19144538 00     B  .12487167 09   SLR  .12256195 09   APD  .15158153 09   RCA  .10286829 09
   VH  .26606642 02    C3 -.10431457 04    C1  .40330757 10   TFP -.24972956 07    TF  .31513507 02   PER  .28646119 03
   TA -.52176596 02   MTA  .18000000 03    EA -.43934648 02    MA -.36323937 02                       TFI  .26096230 01

                                                           ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
    X -.51022667 07     Y  .99263156 08     Z  .46385103 08    DX -.36494255 02    DY -.58201981 01    DZ -.33262720 01
  INC  .25099881 02   LAN  .35798326 03   APF  .14656952 03    MX -.99880594 00    MY -.35811855-01    MZ -.33229988-01
   WX -.14928002-01    WY -.42393484 00    WZ  .90556967 00    PX -.81748733 00    PY  .52667545 00    PZ  .23308269 00
   QX -.57575317 00    QY -.73681227 00    QZ -.35442357 00    RX -.19593890 00    RY  .12623585 00    RZ -.97245697 00
   BX  .57575314 00    BY  .73681223 00    BZ  .35442355 00    TX  .54159255 00    TY  .84064113 00    TZ  .00000000 00
  DAP  .13478631 02   RAP  .14720788 03

  BTQ  .11628278 09   BRQ -.45510973 08     B  .12487167 09   THA  .33862552 03     T VECTOR IN  EARTH EQUATOR PLANE

                                                           ALL VECTORS REFERENCED TO ECLIPTIC PLANE
    X -.51022667 07     Y  .10952327 09     Z  .30665980 07    DX -.36494255 02    DY -.66630846 01    DZ -.73627058 00
  INC  .18528344 01   LAN  .33250317 03   APF  .17232766 03    MX -.99880594 00    MY -.46075798-01    MZ -.16240136-01
   WX -.14928002-01    WY -.28680308-01    WZ  .99947717 00    PX -.81748730 00    PY  .57593041 00    PZ  .43166667-02
   QX -.57575309 00    QY -.81699546 00    QZ -.32043277-01    RX -.35288531-02    RY  .24861228-02    RZ -.99999066 00
   BX  .57575310 00    BY  .81699547 00    BZ  .32043278-01    TX  .57593579 00    TY  .81749494 00    TZ  .00000000 00


CASE  1                                           IBSYS-JPTRAJ-SPACE 022265

  DAP  .24732883 00   RAP  .14483480 03

  BTC  .12480753 09   BRC -.40013344 07     B  .12487165 09   THA  .35816372 03     T VECTOR IN  ECLIPTIC PLANE

                                                           ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
    X  .10522014 09     Y  .30951206 08     Z  .12362214 07    DX -.15093340 02    DY  .33785279 02    DZ -.27414236 01
  INC  .42377882 01   LAN  .20514101 03   APF  .22340358 03    MX -.28065739 00    MY  .95702552 00    MZ -.73031394-01
   WX -.31394514-01    WY  .66895417-01    WZ  .99726596 00    PX  .36657501 00    PY  .92900175 00    PZ -.50776340-01
   QX -.92985853 00    QY  .36397868 00    QZ -.53687747-01    RX -.18637381-01    RY -.47232243-01    RZ -.99870991 00
   BX  .92985865 00    BY -.36397873 00    BZ  .53687754-01    TX  .93020180 00    TY -.36704854 00    TZ  .00000000 00
  DAP -.29105203 01   RAP  .68466288 02

  BTO  .12469108 09   BRO -.67127359 07     B  .12487163 09   THA  .35691845 03     T VECTOR IN  ORBIT PLANE OF TARGET

  2 DAYS 14 HRS. 37 MIN. 51.431 SEC.        23560530151720266711775 J.D.= 2438008.10962304   DEC. 9,1962 14 37 51.431
  CHANGE OF PHASE OCCURS AT THIS POINT     VENUS     IS THE CENTRAL BODY FOR INTEGRATION   COWELL EQUATIONS OF MOTION
 PROBE IS LEAVING VENUS'      SHADOW

  2 DAYS 14 HRS. 37 MIN. 51.431 SEC.        23560530151720266711775 J.D.= 2438008.10962304   DEC. 9,1962 14 37 51.431

     GEOCENTRIC                                                                                   EQUATORIAL COORDINATES

    X -.38114804 08     Y -.32466733 08     Z -.10736199 08    DX -.69869809 01    DY -.11838899 02    DZ -.59356140 01
    R  .51206376 08   DEC -.12102737 02    RA  .22042483 03     V  .14973609 02   PTH  .68707164 02    AZ  .12448867 03
    R  .51206376 08   LAT -.12102737 02   LON  .28310441 03    VE  .36465785 04   PTE  .21920980 00   AZE  .26995161 03
   XS -.33012537 08    YS -.13172989 09    ZS -.57121302 08   DXS  .29507274 02   DYS -.60187012 01   DZS -.26093421 01
   XM  .21915100 06    YM  .27889500 06    ZM  .87959750 05   DXM -.85011119 00   DYM  .59271622 00   DZM  .29599127 00
   XT -.38805183 08    YT -.33873448 08    ZT -.12684155 08   DXT -.55842176 01   DYT -.87128849 01   DZT -.16048224 01
   RS  .14732764 09    VS  .30227679 02    RM  .36544014 06    VM  .10777812 01    RT  .53048472 08    VT  .10472502 02
  GED -.12182759 02   ALT  .51199998 08   LOS  .31861057 03   RAS  .25593098 03   RAM  .51840329 02   LOM  .11451991 03
  DUT  .35000000 02    DT  .38400000 04    DR  .13951460 02   SHA -.29672880 08   DES -.22812463 02   DEM  .13927585 02
  CCL  .27278050 03   MCL  .17997891 03   TCL  .61833078 02

    HELIOCENTRIC                                                                                  EQUATORIAL COORDINATES

    X -.51022667 07     Y  .99263155 08     Z  .46385103 08    DX -.36494254 02    DY -.58201981 01    DZ -.33262720 01
    R  .10968493 09   LAT  .25017435 02   LON  .92942495 02     V  .37104843 02   PTH -.77073126 01    AZ  .92101534 02
   XE  .33012537 08    YE  .13172989 09    ZE  .57121302 08   DXE -.29507274 02   DYE  .60187012 01   DZE  .26093421 01
   XT -.57926456 07    YT  .97856441 08    ZT  .44437148 08   DXT -.35091491 02   DYT -.26941837 01   DZT  .10045197 01
  LTE  .22812463 02   LOE  .75930985 02   LTT  .24385356 02   LOT  .93387689 02   RST  .10762945 09   VST  .35209096 02
  EPS  .12889057 03   ESP  .15695707 02   SEP  .35413716 02   EPM  .79129368-01   EMP  .11190135 02   MEP  .16873051 03
  MPS  .12896821 03   MSP  .15754197 02   SMP  .35277589 02   SEM  .15551569 03   EMS  .24425541 02   ESM  .58516955-01
  EPT  .13652552 03   ETP  .41616357 02   TEP  .18581082 01   TPS  .34321416 02   TSP  .75039911 00   STP  .14492818 03
  SET  .34151907 02   STE  .12978487 03   EST  .16063214 02   RPM  .51564819 08   RPT  .25000001 07   SPN  .12888343 03
  SAC  .22900140-09
  GCE  .87219499 02   GCT  .32905258 03   SIP  .34179322 02   CPT  .72719294 02   SIN  .72577199 02
  REP  .51206376 08   VEP  .14973609 02   CPE  .80195375 02   CPS  .10226691 03
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CASE  1                              IBSYS-JPIRAJ-SPACE 022265                                      3

  APHRODIOCENTRIC                                                                     EQUATORIAL COORDINATES

    X  .69037884 06     Y  .14067148 07     Z  .19479556 07    DX -.14027633 01    DY -.31260145 01    DZ -.43307917 01
    R  .25000001 07   DEC  .51185758 02    RA  .63859402 02     V  .55222701 01   PTH -.88684723 02    AZ  .24853656 03
  ALT  .24938001 07   SHA  .14365071 07   ALP  .50235550 02    DR -.55208152 01    DP  .29049545-05   ASD  .14209440 00
  HGE  .23110942 03   SVL  .29805898 02   HNG  .17862250 02   SIA  .13638342 03
  SAC  .22980140-09

                                          APHRODIOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE               235605634233202077117775 J.D.= 2438013.27236682  DEC. 14,1962 19 01 00.493
  SMA -.10761169 05   ECC  .54575904 01     B  .57628458 05   SLR  .30918769 06   APO  .00000000 00   RCA  .47879731 05
   VH  .54986957 01    C3  .30235654 02    C1  .31688127 06   TFP -.44778906 06    TF  .77923667 01   LTF  .77539993 01
   TA -.99239987 02   MTA  .10055802 03    EA -.25498070 03    MA -.13134219 05                       TFI  .26096230 01
  ZAE  .13728728 03   ZAP  .34431171 02   ZAC  .72681565 02   DEF  .21116094 02    IR  .13100782 05    GP -.29764401 02

                                                              ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
    X  .69037884 06     Y  .14067148 07     Z  .19479556 07    DX -.14027633 01    DY -.31260145 01    DZ -.43307917 01
  INC  .12568510 03   LAN  .18063479 03   APF  .20564165 03    MX  .96107241 00    MY -.15407576 00    MZ -.22934989 00
   WX -.89988358-02    WY  .81218591 00    WZ -.58333008 00    PX  .90426000 00    PY -.24242755 00    PZ -.35148785 00
   QX -.42688758 00    QY -.53064471 00    QZ -.73224507 00    RX  .32102514 00    RY  .71553710 00    RZ -.62044296 00
   BX  .96716951 00    BY -.14109259 00    BZ -.21136701 00    TX -.91238214 00    TY  .40933950 00    TZ  .00000000 00
  SXI -.25397181 00   SYI -.56608108 00   SZI -.78425155 00   DAI -.51651508 02   RAI  .24583664 03
  SXO -.58534882 00   SYO -.47724057 00   SZO -.65544458 00   DAO -.40953367 02   RAO  .21919069 03
  ETE  .30676850 03   ETS  .41834766 02   ETC  .25151734 03

  BTQ -.54181293 05   BRQ  .19632282 05     B  .57628458 05   THA  .16008230 03    T VECTOR IN  EARTH EQUATOR PLANE

                                                              ALL VECTORS REFERENCED TO ECLIPTIC PLANE
    X  .69037884 06     Y  .20655583 07     Z  .12275367 07    DX -.14027633 01    DY -.45909088 01    DZ -.27297030 01
- INC  .14912548 03   LAN  .18100483 03   APF  .20613378 03    MX  .96107233 00    MY -.23260024 00    MZ -.14912356 00
   WX -.89992301-02    WY  .51308132 00    WZ -.85829328 00    PX  .90426026 00    PY -.36224872 00    PZ -.22603090 00
   QX -.42688763 00    QY -.77815399 00    QZ -.46069870 00    RX  .14442024 00    RY  .47274729 00    RZ -.86928288 00
   BX  .96716973 00    BY -.21353375 00    BZ -.13778981 00    TX -.95636871 00    TY  .29216244 00    TZ  .00000000 00
  SXI -.25397181 00   SYI -.83135495 00   SZI -.49431489 00   DAI -.29624584 02   RAI  .25301253 03
  SXO -.58534893 00   SYO -.69860452 00   SZO -.41148313 00   DAO -.24298037 02   RAO  .23004092 03
  ETE  .31756582 03   ETS  .52632085 02   ETC  .26231466 03

  BTC -.56899888 05   BRC  .91346706 04     B  .57628461 05   THA  .17087959 03    T VECTOR IN  ECLIPTIC PLANE

                                                              ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
    X  .21701734 07     Y -.11003277 06     Z  .12362202 07    DX -.47923297 01    DY  .11675377 00    DZ -.27414250 01
  INC  .14982230 03   LAN  .99027389 02   APF  .19959053 03    MX  .95282354-03    MY -.99590256 00    MZ -.90315392-01
   WX  .49653698 00    WY  .78871185-01    WZ -.86447056 00    PX -.13844413 00    PY -.97591341 00    PZ -.16854260 00
   QX -.85695887 00    QY  .20335195 00    QZ -.47357019 00    RX  .49628808 00    RY -.12062912-01    RZ -.86807405 00
   BX  .20919794-01    BY -.99666157 00    BZ -.78918122-01    TX  .24299092-01    TY  .99970473 00    TZ  .00000000 00
  SXI -.86781774 00   SYI  .21093411-01   SZI -.49643467 00   DAI -.29764399 02   RAI  .17860762 03
  SXO -.81708372 00   SYO  .37872508 00   SZO -.43467082 00   DAO -.25764349 02   RAO  .15513188 03
  ETE  .31229757 03   ETS  .71005016 02   ETC  .27321265 03

  BTO -.57389813 05   BRO  .52390984 04     B  .57628455 05   THA  .17478394 03    T VECTOR IN  ORBIT PLANE OF TARGET

   7 DAYS 19 HRS. 46 MIN. 58.744 SEC.     235605635514202537267173 J.D.= 2438013.32429101  DEC. 14,1962 19 46 58.745
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CASE  1                              IBSYS-JPIRAJ-SPACE 022265

     GEOCENTRIC                                                                       EQUATORIAL COORDINATES

    X -.41051080 08     Y -.38291332 08     Z -.13671194 08    DX -.74625149 01    DY -.14909948 02    DZ -.72400025 01
    R  .57778186 08   DEC -.13686849 02    RA  .22300790 03     V  .18177275 02   PTH  .68362656-02    AZ  .11985742 03
    R  .57778184 08   LAT -.13686849 02   LON  .20326704 03    VE  .40878331 04   PTE  .23682486 00   AZE  .26995322 03
   XS -.19597553 08    YS -.13388624 09    ZS -.58055864 08   DXS  .29999834 02   DYS -.35449421 01   DZS -.15359235 0.
   XM -.22533900 06    YM  .78651450 06    ZM  .12794737 06   DXM -.85852918 00   DYM -.53210926 00   DZM -.13040295 00
   XT -.41081011 08    YT -.38295332 08    ZT -.13647333 08   DXT -.44356744 01   DYT -.10890379 02   DZT -.26676153 01
   RS  .14724155 09    VS  .30247574 02    RM  .38631431 06    VM  .10184388 01    RT  .57797036 08    VT  .12057849 02
  GEU -.13776580 02   ALT  .57771808 08   LOS  .24193162 03   RAS  .26167248 03   RAM  .12818447 03   LOM  .10844362 03
  OUT  .35000000 02    DT  .24000000 03    DR  .16896438 02   SHA -.35388552 08   DES -.23221698 02   DEM  .19341637 02
  CCL  .27338213 03   MCL  .17998010 03   TCL  .32543787 03

     HELIOCENTRIC                                                                     EQUATORIAL COORDINATES

    X -.21453526 08     Y  .95594911 08     Z  .44384671 08    DX -.37462349 02    DY -.11365006 02    DZ -.57040790 01
    R  .10755761 09   LAT  .24372011 02   LON  .10264881 03     V  .39561692 02   PTH -.72352603 01    AZ  .95856866 02
   XE  .19597553 08    YE  .13388624 09    ZE  .58055864 08   DXE -.29999834 02   DYE  .35449421 01   DZE  .15359235 01
   XT -.21484258 08    YT  .95590911 08    ZT  .44408531 08   DXT -.34435508 02   DYT -.73454367 01   DZT -.11316918 01
  LTE  .23221698 02   LOE  .81672483 02   LTT  .24382966 02   LOT  .10266686 03   RST  .10757004 09   VST  .35228403 02
  EPS  .12302097 03   ESP  .19209272 02   SEP  .37769755 02   EPM  .37807118 00   EMP  .80678866 02   MEP  .98943098 02
  MPS  .12339863 03   MSP  .19106513 02   SPP  .37494852 02   SEM  .13666407 03   EMS  .43232956 02   ESM  .10279207 00
  EPT  .11079603 03   ETP  .61169990 02   TEP  .33542591-01   TPS  .10851572 03   TSP  .18504685-01   STP  .71464527 02
  SET  .37796585 02   STE  .12297786 03   EST  .19225546 02   RPM  .57839499 08   RPT  .39112531 05   SPN  .12301464 03
  SAC  .23814957-09
  GCE  .86617867 02   GCT  .23205574 03   SIP  .99394888 02   CPT  .11992330 03   SIN  .11080247 03
  REP  .57778186 08   VEP  .18177275 02   CPE  .80314970 02   CPS  .10271893 03

   APHRODIOCENTRIC                                                                    EQUATORIAL COORDINATES

    X  .30731973 05     Y  .40003297 04     Z -.23860705 05    DX -.30268405 01    DY -.40195693 01    DZ -.45723873 01
    R  .39112531 05   DEC -.37593313 02    RA  .74163977 01     V  .67989284 01   PTH  .50229894-06    AZ  .21192407 03
  ALT  .32912531 05   SHA -.37083647 05   ALP  .12617437 02    DR  .74904063-07    DP  .99597208-02   ASD  .91208270 01
  HGE  .23697903 03   SVL -.32543115 02   HNG  .11213028 03   SIA  .10967520 03
  SAC  .23814957-09

                                          APHRODIOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE               235605635514202537260442 J.D.= 2438013.32429101  DEC. 14,1962 19 46 58.745
  SMA -.10964920 05   ECC  .45670602 01     B  .48862267 05   SLR  .21774181 06   APO  .00000000 00   RCA  .39112530 05
   VH  .54423031 01    C3  .29618663 02    C1  .26592329 06   TFP  .10186252-03    TF  .78242908 01   LTF  .77888724 01
   TA  .34150945-05   MTA  .10264791 03    EA  .85377364-06    MA  .28967721-05                       TFI  .78242910 01
  ZAE  .13776036 03   ZAP  .39971185 02   ZAC  .71965335 02   DEF  .25295833 02    IR  .13206249 05    GP -.30444619 02

                                                              ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
    X  .30731973 05     Y  .40003297 04     Z -.23860705 05    DX -.30268405 01    DY -.40195693 01    DZ -.45723873 01
  INC  .11477124 03   LAN  .20822719 03   APF  .22221180 03    MX -.44519378 00    MY -.59120630 00    MZ -.67251588 00
   WX -.42945022 00    WY  .80000903 00    WZ -.41899652 00    PX  .78573214 00    PY  .10227745 00    PZ -.61005268 00
   QX -.44519376 00    QY -.59120628 00    QZ -.67251587 00    RX  .33778178 00    RY  .71339443 00    RZ -.61339881 00
   BX  .86414488 00    BY  .22924567 00    BZ -.44799561 00    TX -.90392327 00    TY  .42769463 00    TZ  .00000000 00
  SXI -.26234739 00   SYI -.55446547 00   SZI -.78977326 00   DAI -.52164327 02   RAI  .24467865 03
  SXO -.60643400 00   SYO -.59925466 00   SZO -.52261993 00   DAO -.31508156 02   RAO  .22465883 03
  ETE  .30229105 03   ETS  .29230405 02   ETC  .25076851 03
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CASE  1                                  IBSYS-JPTRAJ-SPACE 022265                                           5

BTQ -.33376521 05   BRQ  .35686536 05     B  .48862267 05   THA  .13308429 03    T VECTOR IN  EARTH EQUATOR PLANE

                                                                  ALL VECTORS REFERENCED TO ECLIPTIC PLANE
  X  .30731973 05     Y -.58223563 04     Z -.23482676 05    DX -.30268405 01    DY -.55068224 01    DZ -.25958754 01
INC  .13464238 03   LAN  .21712663 03   APF  .23754634 03    MX -.44519377 00    MY -.80995448 00    MZ -.38180656 00
 WX -.42945021 00    WY  .56728648 00    WZ -.70267956 00    PX  .78573216 00    PY -.14886166 00    PZ -.60038753 00
 QX -.44519377 00    QY -.80995446 00    QZ -.38180655 00    RX  .15308931 00    RY  .48018924 00    RZ -.86370243 00
 BX  .86414488 00    BY  .32097629-01    BZ -.50221846 00    TX -.95275260 00    TY  .30374742 00    TZ  .00000000 00
SXI -.26234738 00   SYI -.82289474 00   SZI -.50400203 00   DAI -.30265128 02   RAI  .25231717 03
SXO -.60643401 00   SYO -.75770547 00   SZO -.24108124 00   DAO -.13950363 02   RAD  .23132775 03
ETE  .31365265 03   ETS  .40592005 02   ETC  .26213010 03

BTC -.39752716 05   BRC  .28412022 05     B  .48862270 05   THA  .14444588 03    T VECTOR IN  ECLIPTIC PLANE

                                                                  ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
  X  .16000420 04     Y -.32573250 05     Z -.21591972 05    DX -.60658784 01    DY  .14841501 01    DZ -.26884647 01
INC  .13723007 03   LAN  .13851527 03   APF  .23438643 03    MX -.89218155 00    MY  .21829178 00    MZ -.39542477 00
 WX  .44982056 00    WY  .50870284 00    WZ -.73408642 00    PX  .40908683-01    PY -.83280857 00    PZ -.55204743 00
 QX -.89218155 00    QY  .21829177 00    QZ -.39542477 00    RX  .50638509 00    RY -.18010562-01    RZ -.86211930 00
 BX  .23526740 00    BY -.86039665 00    BZ -.45206955 00    TX  .35544453-01    TY  .99936809 00    TZ  .00000000 00
SXI -.86157454 00   SYI  .30643560-01   SZI -.50670528 00   DAI -.30444619 02   RAI  .17796302 03
SXO -.87948921 00   SYO  .39534584 00   SZO -.26495350 00   DAO -.15364189 02   RAD  .15579524 03
ETE  .30926123 03   ETS  .61084645 02   ETC  .27339349 03

BTO -.41605758 05   BRO  .25621909 05     B  .48862269 05   THA  .14837416 03    T VECTOR IN  ORBIT PLANE OF TARGET

  7 DAYS 19 HRS. 49 MIN. 51.431 SEC.         235605635567202667117775 J.D.= 2438013.32628971  DEC. 14,1962 19 49 51.431

    GEOCENTRIC                                                                                 EQUATORIAL COORDINATES

  X -.41052371 08     Y -.38293907 08     Z -.13672442 08    DX -.74905246 01    DY -.14914175 02    DZ -.72176794 01
  R  .57781104 08   DEC -.13687418 02    RA  .22300892 03     V  .18183384 02   PTH  .68464354 02    AZ  .11972300 03
  R  .57781103 08   LAT -.13687418 02   LON  .20254657 03    VE  .40880464 04   PTE  .23705879 00   AZE  .26995361 03
 XS -.19592373 08    YS -.13388685 09    ZS -.58056130 08   DXS  .29999978 02   DYS -.35439852 01   DZS -.15355085 01
 XM -.22548700 06    YM  .28642250 06    ZM  .12792487 06   DXM -.85825437 00   DYM -.53245234 00   DZM -.13055608 00
 XT -.41082577 08    YT -.38297212 08    ZT -.13647794 08   DXT -.44351348 01   DYT -.10891182 02   DZT -.26680179 01
 RS  .14724152 09    VS  .30247584 02    RM  .38632500 06    VM  .10184061 01    RT  .57798935 08    VT  .12058465 02
GED -.13777152 02   ALT  .57774727 08   LOS  .24121233 03   RAS  .26167468 03   RAM  .12821170 03   LOM  .10774934 03
DUT  .35000000 02    DT  .24000000 03    DR  .16913991 02   SHA -.35391056 08   DES -.23221815 02   DEM  .19337545 02
CCL  .27338252 03   MCL  .17998012 03   TCL  .32423443 03

   HELIOCENTRIC                                                                                EQUATORIAL COORDINATES

  X -.21459998 08     Y  .95592947 08     Z  .44383687 08    DX -.37490503 02    DY -.11370190 02    DZ -.56821710 01
  R  .10755675 09   LAT  .24371643 02   LON  .10265276 03     V  .39586691 02   PTH -.72123937 01    AZ  .95825938 02
 XE  .19592373 08    YE  .13388685 09    ZE  .58056130 08   DXE -.29999978 02   DYE  .35439852 01   DZE  .15355085 01
 XT -.21490205 08    YT  .95589642 08    ZT  .44408336 08   DXT -.34435113 02   DYT -.73471968 01   DZT -.11325095 01
LTE  .23221815 02   LOE  .81674692 02   LTT  .24382856 02   LOT  .10267042 03   RST  .10757002 09   VST  .35228410 02
EPS  .12301850 03   ESP  .19210845 02   SEP  .37770653 02   EPM  .37807118 00   EMP  .80703716 02   MEP  .98918229 02
MPS  .12339618 03   MSP  .19108037 02   SMP  .37495777 02   SEM  .13664018 03   EMS  .43256800 02   ESM  .10231507 00
EPT  .11709311 03   ETP  .62872362 02   TEP  .34970568-01   TPS  .10980964 03   TSP  .18504685-01   STP  .70170748 02
SET  .37797815 02   STE  .12297542 03   EST  .19226759 02   RPM  .57842254 08   RPT  .39126984 05   SPN  .12301217 03
SAC  .23815338-09
GCE  .86617479 02   GCT  .23085190 03   SIP  .10069221 03   CPT  .12031658 03   SIN  .11119915 03
REP  .57781104 08   VEP  .18183384 02   CPE  .80314978 02   CPS  .10271903 03


CASE  1                                  IBSYS-JPTRAJ-SPACE 022265                                           6


  APHRODIOCENTRIC                                                                              EQUATORIAL COORDINATES

  X  .30206808 05     Y  .33059017 04     Z -.24648340 05    DX -.30553899 01    DY -.40229929 01    DZ -.45496615 01
  R  .39126984 05   DEC -.39046991 02    RA  .62457221 01     V  .67984777 01   PTH  .14106330 01    AZ  .21265003 03
ALT  .32926984 05   SHA -.36807055 05   ALP  .14171916 02    DR  .16736299 00    UP  .99523646-02   ASD  .91174290 01
HGE  .23698150 03   SVL -.33359017 02   HNG  .11393792 03   SIA  .10797568 03
SAC  .23815338-09

                                             APHRODIOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE                 235605635514202537325475 J.D.= 2438013.32429103  DEC. 14,1962 19 46 58.745
SMA -.10964917 05   ECC  .45670611 01     B  .48862266 05   SLR  .21774185 06   APO  .00000000 00   RCA  .39112531 05
 VH  .54423037 01    C3  .29618670 02    C1  .26592331 06   TFP  .17268546 03    TF  .78242908 01   LTF  .77888724 01
 TA  .17194770 01   PTA  .10264791 03    EA  .13765490 01    MA  .49108403 01                       TFI  .78262896 01
ZAE  .13776067 03   ZAP  .39973174 02   ZAC  .71965343 02   DEF  .25295826 02    IR  .13206248 05    GP -.30444612 02

                                                                  ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
  X  .30206808 05     Y  .33059017 04     Z -.24648340 05    DX -.30553899 01    DY -.40229929 01    DZ -.45496615 01
INC  .11477125 03   LAN  .20822719 03   APF  .22221180 03    MX -.46857002 00    MY -.59400908 00    MZ -.65390773 00
 WX -.42945024 00    WY  .80000898 00    WZ -.41899656 00    PX  .78573211 00    PY  .10227740 00    PZ -.61005274 00
 QX -.44519381 00    QY -.59120634 00    QZ -.67251579 00    RX  .33778181 00    RY  .71389434 00    RZ -.61339893 00
 BX  .86414484 00    BY  .22924561 00    BZ -.44779571 00    TX -.90392326 00    TY  .42769471 00    TZ  .00000000 00
SXI -.26234747 00   SYI -.55446555 00   SZI -.78977318 00   DAI -.52164319 02   RAI  .24467864 03
SXO -.60643400 00   SYO -.59925471 00   SZO -.52261987 00   DAO -.31508153 02   RAD  .22465883 03
ETE  .30228987 03   ETS  .29226412 02   ETC  .25076851 03

BTQ -.33376518 05   BRQ  .35686538 05     B  .48862266 05   THA  .13308428 03    T VECTOR IN  EARTH EQUATOR PLANE

                                                                  ALL VECTORS REFERENCED TO ECLIPTIC PLANE
  X  .30206808 05     Y -.67728103 04     Z -.23929034 05    DX -.30553899 01    DY -.55009224 01    DZ -.25736633 01
INC  .13464238 03   LAN  .21712664 03   APF  .23754635 03    MX -.46857002 00    MY -.80512304 00    MZ -.36361931 00
 WX -.42945024 00    WY  .56728643 00    WZ -.70267960 00    PX  .78573209 00    PY -.14886173 00    PZ -.60038754 00
 QX -.44519382 00    QY -.80995450 00    QZ -.38180645 00    RX  .15308932 00    RY  .48018912 00    RZ -.86370252 00
 BX  .86414484 00    BY  .32097534-01    BZ -.50221853 00    TX -.95275257 00    TY  .30374750 00    TZ  .00000000 00
SXI -.26234749 00   SYI -.82289480 00   SZI -.50400192 00   DAI -.30265120 02   RAI  .25231716 03
SXO -.60643402 00   SYO -.75770550 00   SZO -.24108117 00   DAO -.13950360 02   RAD  .23132775 03
ETE  .31365147 03   ETS  .40588012 02   ETC  .26213010 03

BTC -.39752710 05   BRC  .28412022 05     B  .48862266 05   THA  .14444588 03    T VECTOR IN  ECLIPTIC PLANE

                                                                  ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
  X  .55244946 03     Y -.32314327 05     Z -.22054476 05    DX -.60668877 01    DY  .15145495 01    DZ -.26680164 01
INC  .13723007 03   LAN  .13851527 03   APF  .23438645 03    MX -.89300736 00    MY  .24318280 00    MZ -.37868185 00
 WX  .44982048 00    WY  .50870296 00    WZ -.73408640 00    PX  .40908606-01    PY -.83280846 00    PZ -.55204755 00
 QX -.89218161 00    QY  .21829185 00    QZ -.39542464 00    RX  .50638496 00    RY -.18010642-01    RZ -.86211938 00
 BX  .23526730 00    BY -.86039658 00    BZ -.45206972 00    TX  .35544620-01    TY  .99936808 00    TZ  .00000000 00
SXI -.86157462 00   SYI  .30643707-01   SZI -.50670516 00   DAI -.30444610 02   RAI  .17796301 03
SXO -.87948925 00   SYO  .39534587 00   SZO -.26495338 00   DAO -.15364182 02   RAD  .15579524 03
ETE  .30926021 03   ETS  .61081140 02   ETC  .27339348 03

BTO -.41605749 05   BRO  .25621916 05     B  .48862266 05   THA  .14837414 03    T VECTOR IN  ORBIT PLANE OF TARGET
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CASE 1 IBSYS-JPTRAJ-SPACE 022265 7

632427135666	631706661666 21174200096	630437201056	603730124337 17448304640	604531616254	603532066024 000000000000	EARTH INITIAL
217727515530	214622511174	617601553043	602611205256	603400721472 235605635567	603442743230 202667117775	VENUS END

U MATRIX FOR MAPPING FORWARD ITERATION NUMBER 0

	X	Y	Z	DX	DY	DZ	MV	AU
X	.10966738 01	.22628337 00	.95824143-01	.38971570-04	.29859219-04	-.13719305-04	.00000000 00	.00000000 00
Y	.26646167 00	.10270700 01	.15926470 00	.38408640-04	-.12657212-04	-.40772528-05	.00000000 00	.00000000 00
Z	.14890519 00	.18058750 00	.92539933 00	-.46092930-07	.31993660-05	-.22687172-04	.00000000 00	.00000000 00
DX	.75527639 06	.15126123 06	.61127321 05	.27719612 02	.20412752 02	-.94570649 01	.00000000 00	.00000000 00
DY	.16940998 06	.67661268 06	.87107397 05	.25112386 02	-.75215715 01	-.23777418 01	.00000000 00	.00000000 00
DZ	.90707747 05	.10145706 06	.62498159 06	-.10337408 01	.21220986 01	-.14140570 02	.00000000 00	.00000000 00
MV	-.11663469 11	-.12298928 11	-.11436336 11	-.11459470 07	-.46888873 06	.27653503 06	.10000000 01	.00000000 00
AU	.10846571 00	.76123422-01	.54280288-01	.20273964-04	.53912774-05	-.67916350-05	.00000000 00	.10000000 01

COVARIANCE MATRIX AT IMPACT ITERATION NUMBER 0

	X	Y	Z	DX	DY	DZ	MV	AU
X	.47175286 11	.38625947 11	.20113070 11	.24072435 07	.73161593 06	-.88647863 06	-.15561391-07	.34610615 01
Y	.38625947 11	.34565694 11	.17722058 11	.20495190 07	.54127742 06	-.74744181 06	-.18174269-07	.31844926 01
Z	.20113070 11	.17722058 11	.10110164 11	.10488527 07	.28992393 06	-.41058659 06	-.17080953-07	.22685311 01
DX	.24072435 07	.20495190 07	.10488527 07	.12505391 03	.35761035 02	-.45555512 02	-.13852334-11	.55924926-03
DY	.73161593 06	.54127742 06	.28992393 06	.35761035 02	.12487717 02	-.13385001 02	-.48508475-12	.13441655-03
DZ	-.88647863 06	-.74744181 06	-.41058659 06	-.45555512 02	-.13385001 02	.17365259 02	.43232970-12	-.19567239-03
MV	-.15561391-07	-.18174269-07	-.17080953-07	-.13852334-11	-.48508475-12	.43232970-12	.99999998-18	.00000000 00
AU	.34610615 01	.31844926 01	.22685311 01	.55924926-03	.13441655-03	-.19567239-03	.00000000 00	.25000000 02

U PRODUCT MATRIX OF STEP MAPPING ITERATION NUMBER 0

	X	Y	Z	DX	DY	DZ	MV	AU
X	.56437986 01	.42107851 01	.21757652 01	.27753481-03	.95502075-04	-.10171062-03	.00000000 00	.00000000 00
Y	.70343361 00	.48017091 00	.36603342 00	.32273659-04	.12872889-04	-.14935375-04	.00000000 00	.00000000 00
Z	.22739587 00	.21858858 00	-.19479862 00	.15866207-04	.21757187-05	.23402609-05	.00000000 00	.00000000 00
DX	.19764677 08	.13985615 08	.72116839 07	.95289662 03	.34895230 03	-.34874327 03	.00000000 00	.00000000 00
DY	.80540421 07	.11420462 08	.46543167 07	.54908483 03	.27889194 02	-.16720472 03	.00000000 00	.00000000 00
DZ	.40302329 07	.44308611 07	.52374215 07	.20256576 03	.48287167 02	-.15515567 03	.00000000 00	.00000000 00
MV	-.15561391 11	-.18174269 11	-.17080953 11	-.13852334 07	-.48508476 06	.43232971 06	.10000000 01	.00000000 00
AU	.13844246 00	.12737971 00	.90741242-01	.22369971-04	.53766621-05	-.78268958-05	.00000000 00	.10000000 01

ENCOUNTER PARAMETERS AND STATISTICS 62/12/14 194658.745

B	.48863381 05	SMAA	.13827722 06
B.RO	.25623516 05	SMIA	.46289093 05
B.TO	-.41606075 05	DEL T	.31379607 05
B.RC	.28412022 05	DEL B	.14581931 06
B.TC	-.39752716 05	DEL S	.17077879 06
TL	.10077253 03	DEL BR	.92950071 05
THETA	.37570843 02	DEL BT	.11317444 06

N MATRIX

	B.RO	B.TO	TL	C3	S.TS	S.RS
B.RO	.84548154 10	-.82051087 10	.26191344 10	-.59891937 05	.22538312 06	.11646524 06
B.TO	-.82051090 10	.12808455 11	-.30171756 10	.64743844 05	-.28456252 06	-.14590043 06
TL	.26191345 10	-.30171755 10	.98467973 09	-.20929726 05	.80506390 05	.41782426 05
C3	-.59891386 05	.64743775 05	-.20929769 05	.45701790 00	-.17441461 01	-.90371404 00
S.TS	.22538313 06	-.28456251 06	.80506391 05	-.17441487 01	.70437215 01	.36340356 01
S.RS	.11646524 06	-.14590043 06	.41782426 05	-.90371227 00	.36340358 01	.18758385 01

NORMALIZED N MATRIX

	B.RO	B.TO	TL	C3	S.TS	S.RS
B.RO	.10000000 01	-.78846768 00	.90773319 00	-.96349549 00	.92356662 00	.92479722 00
B.TO	-.78846771 00	.99999999 00	-.84958083 00	.84622042 00	-.94738878 00	-.94126186 00
TL	.90773323 00	-.84958081 00	.10000000 01	-.98661894 00	.96667782 00	.97218390 00
C3	-.96348663 00	.84621952 00	-.98662093 00	.10000000 01	-.97210949 00	-.97603794 00
S.TS	.92356665 00	-.94738875 00	.96667784 00	-.97211093 00	.10000000 01	.99974760 00
S.RS	.97479726 00	-.94126187 00	.97218390 00	-.97603603 00	.99974765 00	.99999999 00

DM/DQD MATRIX

	B.RD	B.TD	TL	C3	S.TS	S.RS
X	.19432538 01	-.30687803 01	.71810839 00	-.15502912-04	.67876250-04	.34794829-04
Y	.12661832 00	-.37872949 00	.99066247-01	-.15491778-05	.79940872-05	.41622495-05
Z	.34317390 00	-.17255082 00	-.66687256-02	.86614341-06	.37648641-05	.17358850-05
DX	.64180771 07	-.11189817 08	.23966677 07	-.51176269 02	.23588366 03	.12053721 03
DY	.65818714 07	-.15729188 07	.16748565 07	-.41520920 02	.11365567 03	.60119785 02
DZ	-.18816308 06	-.63123703 05	.11391386 07	-.15014267 02	.43341703 02	.24794701 02
MU	-.56560455-01	-.96096551-01	-.26623533-01	.14224868-03	.50777522-06	.40448822-06

DM/DQ MATRIX

	B.RD	B.TD	TL	C3	S.TS	S.RS
X	.21496986 00	-.71465895 00	.55341266-01	.33640446-03	.10118067-04	.62313123-05
Y	.60157931 00	.64188397 00	.14796535 00	-.11025433-03	.20658079-05	.12722483-05
Z	-.91472661 00	-.98744307-01	.97671857-01	-.23437026-03	-.56003876-05	-.51622475-06
DX	-.11462816 04	-.42096133 04	-.67860414 03	-.71121789 01	-.20354937-01	-.12535793-01
DY	.42021899 04	-.25239673 04	.46801974 03	-.10266800 02	.17521200-01	.10790601-01
DZ	.82683492 04	-.68900916 03	.67421384 03	-.53769287 01	-.57946112-01	.42589657-01
MU	-.33843363-01	-.14002395 00	.17583676-02	.91201498-04	.18249393-05	.11239068-05

N MATRIX FOR MANEUVER CALCULATIONS

	B.RC	B.TC	TL
B.RC	.95964167 10	-.84255963 10	.32634384 05
B.TC	-.84255966 10	.11666853 11	-.32763030 05
TL	.32634384 05	-.32763030 05	.13190690 00

```
0000 141631      OFFLINE CONTROL                                    127
0000 14163       TERMINATE JOB
9000 14163       END DATA                                           10
```

SOURCE PROGRAM LISTING

```
*N1     DDPX     N9
*N9     LA9      X,N11,N1,N4
55164/=1.0E14
*N12    LA12     X
*N13    SPACE    X
                 SCFDRF=2
*       WANT     N9,(MODPH1),200,(MOTOR,BRNOPT),18
*       WANT     N11,(TAPEX),6
*       WANT     N12,(XNJ,INJX),1,(XNJ-1,INJY),1
*       ETC      (XNJ-2,INJZ),1,(XNJ-3,INJDX),1
*       ETC      (XNJ-4,INJDY),1,(XNJ-5,INJDZ),1
*       ETC      (EPOCH,INJT),1,(EPOCH-1,INJT+1),1
*       ETC      (OUT,GRAV-2),1,(AU,SCALE1+1),1
*       ETC      (RE,SCALE1),1,(PORE,HARMN+5),1
*       ETC      (QD,HARMN+4),1,(QH,HARMN+3),1
*       ETC      (QJ,HARMN+2),1,(GRAVE,GRAV),1
*       ETC      (GRAVM,GRAV+1),1,(GRAVS,GRAV+2),1
*       ETC      (GRAVV,GRAV+3),1,(GRAVR,GRAV+4),1
*       ETC      (GRAVJ,GRAV+6),1,(STEP,H),1
*       ETC      (TARGET,TARBCO),1,(AREA,RADOPT+3),1
*       ETC      (GMO,RADOPT+4),1,(FMASS,RADOPT+5),1
*       ETC      (FA0,GASOPT+9),1,(FB0,GASOPT+12)
*       ETC      (FC0,GASOPT+15),1,(FA1,GASOPT+8)
*       ETC      (FB1,GASOPT+11),1,(FC1,GASOPT+14)
*       ETC      (FA2,GASOPT+7),1,(FB2,GASOPT+10)
*       ETC      (FC2,GASOPT+13),1,(JETON,GASOPT),1
*       ETC      (JETON,GASOPT+2),1,(JETON-1,GASOPT+3),1
*       ETC      (JETOFF,GASOPT+5),1,(JETOFF-1,GASOPT+6),1
*       ETC      (TFIN,SECP50),1,(TFIN-1,SECP50+1),1
*       ETC      (FMASS,GASOPT+16),1
GASOPT+1=(CANOPU)
INJBCO=(EARTH)
*N11    LA11     N4,N6,N12
*       WANT     N9,(C137),1
*       WANT     N13,(CLPT,TRADE+1),1,(CLPT+1,TRADE),1
*       ETC      (CLPBTC,TRADE+2),1,(CLPRRC,TRADE+3),1
*       ETC      (CLPBTT,TRADE+4),1,(CLPBRT,TRADE+5),1
*       ETC      (TAPEX),6
*N2     LA2      N12,X
*       WANT     N11,(EPOX),14
*N2A    LA2A     N9,N12
*N3     LA3      N9,N10
*N4     LA4      N6,N12
*N5     LA5      N9,N12
*N6     LA6      N12
*N7     LA7      N9,N10,N12
*       WANT     N9,(APRIOR-19,APRIOR-19),20
*N8     LA8      N9,N12
*N10    LA10     N8,N9
*X      END                                                       10
```

THERE WERE NO GLARING SOURCE DECK ERRORS.

THE OBJECT STRING HAS 00514 OCTAL OR 332 DECIMAL WORDS.

```
0000 141751     PAGE HEADING                                               (23
0000 14175      (MOON CHECK CASE - PREDICTIONS)
0000 14175      EPOCH                                                      (01
0000 14175      640702910,2758000
0000 14175      GEOCENTRIC POSITION AND VELOCITY AT EPOCH                  (02
0000 14175      X=.15667453E6 Y=.63041615E5 Z=.80777204E4
0000 14175      DX=.14342616E1 DY=.97256996E0 DZ=.28116199E0
0000 14175      OTHER OPTIONS AND CONSTANTS                                (03
0000 14175      SYNFRQ=2038516.
0000 14175      TFREQ=7590830.
0000 14175      POINTING TIMES, SAMPLE RATE, COUNT TIMES                   (17
0000 14175      JETGL2=640702911,0,640703011,0,1800.,60.
0000 14175      TRANSMITTER ID TABLE                                       (26
0000 14175      2,2038516.
0000 14175      OFFLINE CONTROL                                            (27
0000 14175      KEY(8) KEY(13)
0000 14175      END DATA                                                    (0


CASE  1                             IBSYS-JPTRAJ-SPACE 022265                               1


DOUBLE PRECISION EPHEMERIS TAPE - EPHEM1

  GME  .39860063 06     J  .16234500-02     H -.57499999-05     D  .78749999-05    RE  .63781650 04   REM  .63783112 04
    G  .66709998-19     A  .88781796 29     B  .88800194 29     C  .88836976 29   OME  .41780741-02    AU  .14959850 09
  GMM  .49026293 04   GMS  .13271411 12   GMV  .32476627 06   GMA  .42977368 05   GMC  .37918700 08   GMJ  .12670935 09
  EGM  .39860320 06   MGM  .49027779 04    JA  .29200000-02    HA  .00000000 00    DA  .00000000 00    RA  .34170000 04

INJECTION CONDITIONS            MOON        2356665063532024000000000 J.D.= 2438605.93608796  JULY 29,1964 10 27 58.000

GEOCENTRIC          XO .15667453 06  YO .63041615 05  ZO .80777203 04 DXO .14342616 01 DYO .97256996 00 DZO .28116199 00
CARTESIAN           ID .37678000 05 GHA .10409373 03 GHO .30667227 03
DATE OF RUN 022265A  14185                      EARTH    IS THE CENTRAL BODY FOR INTEGRATION   COWELL EQUATIONS OF MOTION

  0 DAYS  0 HRS.  0 MIN.  0.000 SEC.        2356665063532024000000000 J.D.= 2438605.93608796  JULY 29,1964 10 27 58.000

      GEOCENTRIC      .                                                                        EQUATORIAL COORDINATES

    X  .15667452 06     Y  .63041612 05     Z  .80777202 04    DX  .14342615 01    DY  .97256992 00    DZ  .28116198 00
    R  .16907513 06   DEC  .27384004 01    RA  .21918529 02     V  .17555769 01   PTH  .76231923 02    AZ  .61412202 02
    R  .16907512 06   LAT  .27384004 01   LON  .27782479 03    VE  .12070910 02   PTE  .81207508 01   AZE  .27095862 03
   XS -.89949372 08    YS  .11227336 09    ZS  .48686598 08   DXS -.23515989 02   DYS -.16077681 02   DZS -.69719988 01
   XM  .38246410 06    YM  .27456507 05    ZM -.26012551 05   DXM -.83439888-01   DYM  .93230192 00   DZM  .40985490 00
   XT  .38246410 06    YT  .27456507 05    ZT -.26012551 05   DXT -.83439888-01   DYT  .93230192 00   DZT  .40985490 00
   RS  .15187686 09    VS  .29327501 02    RM  .38432968 06    VM  .10218268 01    RT  .38432968 06    VT  .10218268 01
  GED  .27570333 01   ALT  .16269697 06   LOS  .24606715 02   RAS  .12870045 03   RAM  .41061295 01   LOM  .26001239 03
  DUT  .35000000 02    DT  .12000000 03    DR  .17051340 01   SHA  .16335718 06   DES  .18697172 02   DEM -.38809109 01
  CCL  .25840724 03   MCL  .11052996 00   TCL  .11052996 00

                                                 GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE                 2356664500622026213000000 J.D.= 2438605.21642518  JULY 28,1964 17 11 39.136
  SMA  .24408791 06   ECC  .97401695 00     B  .55279828 05   SLR  .12519505 05   APO  .48183367 06   RCA  .63421468 04
   VH  .14661061 00    C3 -.16330208 01    C1  .70641933 05   TFP  .62178864 05    TF -.17271907 02   PER  .20002258 05
   TA  .16192549 03   MTA  .18000000 03    EA  .71607988 02    MA  .18651553 02   C3J -.20370820 01   TFI  .00000000 00

                                                          ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
    X  .15667452 06     Y  .63041612 05     Z  .80777202 04    DX  .14342615 01    DY  .97256992 00    DZ  .28116198 00
  INC  .28707658 02   LAN  .16908121 02   APF  .20378273 03    MX -.34898680 00    MY  .80607909 00    MZ  .47795833 00
   WX  .13970111 00    WY -.45957623 00    WZ  .87708195 00    PX -.77265498 00    PY -.60455107 00    PZ -.19370658 00
   QX  .61926389 00    QY -.65062065 00    QZ -.43955031 00    RX  .15255788 00    RY  .11936638 00    RZ -.98105948 00
   BX -.61926406 00    BY  .65062083 00    BZ  .43955042 00    TX -.61622264 00    TY  .78757200 00    TZ  .00000000 00
  OAP -.11169176 02   RAP  .21804081 03

  BTQ  .49421011 05   BRQ -.24767379 05     B  .55279828 05   THA  .33338222 03    T VECTOR IN  EARTH EQUATOR PLANE


CASE  1                             IBSYS-JPTRAJ-SPACE 022265                               2


     HELIOCENTRIC    .                                                                         EQUATORIAL COORDINATES

    X  .90106046 08     Y -.11221032 09     Z -.48678520 08    DX  .24950250 02    DY  .17050251 02    DZ  .72531608 01
    R  .15192055 09   LAT -.18688381 02   LON  .30876483 03     V  .31077876 02   PTH -.21988086 00    AZ  .75813410 02
   XE  .89949372 08    YE -.11227336 09    ZE -.48686598 08   DXE  .23515989 02   DYE  .16077681 02   DZE  .69719988 01
   XT  .90331836 08    YT -.11224590 09    ZT -.48712610 08   DXT  .23432549 02   DYT  .17009983 02   DZT  .73818538 01
  LTE -.18697172 02   LOE  .30870045 03   LTT -.18680121 02   LOT  .30882598 03   RST  .15209175 09   VST  .29881694 02
  EPS  .74994993 02   ESP  .61373100-01   SEP  .10494339 03   EPM  .14723361 03   EMP  .13773981 02   MEP  .18992403 02
  MPS  .13777126 03   MSP  .58933450-01   SMP  .42170224 02   SEM  .12393574 03   EMS  .55944139 02   ESM  .12012787 00
  RPM  .23110470 06   SPN  .72833120 02
  GCE  .10159276 03   GCT  .28170329 03   SIP  .13734034 03   CPT  .92025110 02   SIN  .91594195 02
  REP  .16907513 06   VEP  .17555769 01   CPE  .97484351 02   CPS  .76877815 02

  1 DAYS  0 HRS. 32 MIN.  2.000 SEC.        2356665614542020000000000 J.D.= 2438606.95833333  JULY 30,1964 11 00 00.000

      GEOCENTRIC                                                                               EQUATORIAL COORDINATES

    X  .25084050 06     Y  .13402614 06     Z  .30322890 05    DX  .81614400 00    DY  .67379618 00    DZ  .22454298 00
    R  .28601301 06   DEC  .60858957 01    RA  .28115954 02     V  .10819020 01   PTH  .77274393 02    AZ  .61615284 02
    R  .28601300 06   LAT  .60858957 01   LON  .27500634 03    VE  .20556600 02   PTE  .29427204 01   AZE  .27031620 03
   XS -.92013117 08    YS  .11083678 09    ZS  .48063660 08   DXS -.23214413 02   DYS -.16451548 02   DZS -.71338363 01
   XM  .36449540 06    YM  .10819357 06    ZM  .10548403 05   DXM -.32284243 00   DYM  .88717703 00   DZM  .41420339 00
   XT  .36449540 06    YT  .10819357 06    ZT  .10548403 05   DXT -.32284243 00   DYT  .88717703 00   DZT  .41420339 00
   RS  .15185954 09    VS  .29333497 02    RM  .38036037 06    VM  .10309582 01    RT  .38036037 06    VT  .10309582 01
  GED  .61270553 01   ALT  .27963504 06   LOS  .16588743 02   RAS  .12969836 03   RAM  .16532524 02   LOM  .26342290 03
  DUT  .35000000 02    DT  .48000000 03    DR  .10553263 01   SHA  .28251917 06   DES  .18451435 02   DEM  .15891664 01
  CCL  .25920166 03   MCL  .11192516 01   TCL  .11192516 01

                                                 GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE                 2356664503332025444000000 J.D.= 2438605.22424520  JULY 28,1964 17 22 54.785
  SMA  .24654005 06   ECC  .97607359 00     B  .53607772 05   SLR  .11656495 05   APO  .48718128 06   RCA  .58988163 04
   VH  .13991439 00    C3 -.16167784 01    C1  .68163673 05   TFP  .14982521 06    TF -.17084226 02   PER  .20304432 05
   TA  .16934513 03   MTA  .18000000 03    EA  .99441039 02    MA  .44273647 02   C3J -.20471674 01   TFI  .24533889 02

                                                          ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
    X  .25084050 06     Y  .13402614 06     Z  .30322890 05    DX  .81614400 00    DY  .67379618 00    DZ  .22454298 00
  INC  .28976671 02   LAN  .17015325 02   APF  .20329595 03    MX -.45905374 00    MY  .75220646 00    MZ  .47271026 00
   WX  .14176438 00    WY -.46324717 00    WZ  .87481701 00    PX -.77702823 00    PY -.59959958 00    PZ -.19159193 00
   QX  .61329434 00    QY -.65259660 00    QZ -.44495799 00    RX  .15168230 00    RY  .11704677 00    RZ -.98147467 00
   BX -.61329438 00    BY  .65259664 00    BZ  .44495801 00    TX -.61091702 00    TY  .79169463 00    TZ  .00000000 00
  OAP -.11045703 02   RAP  .21765584 03

  BTQ  .47782174 05   BRQ -.24303436 05     B  .53607772 05   THA  .33304076 03    T VECTOR IN  EARTH EQUATOR PLANE
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```
CASE  1                                  IBSYS-JPTRAJ-SPACE 022265                                         3

    HELIOCENTRIC                                                                         EQUATORIAL COORDINATES

   X  .92263957 08     Y -.11070276 09     Z -.48033337 08    DX  .24030557 02    DY  .17125344 02    DZ  .73583793 01
   R  .15190437 09   LAT -.18433738 02   LON  .30980913 03     V  .30412018 02   PTH -.39832041 00    AZ  .75360793 02
  XE  .92013117 08    YE -.11083678 09    ZE -.48063660 08   DXE  .23214413 02   DYE  .16451548 02   DZE  .71338363 01
  XT  .92377612 08    YT -.11072859 09    ZT -.48053111 08   DXT  .22891571 02   DYT  .17338725 02   DZT  .75480396 01
 LTE -.18451435 02   LOE  .30969836 03   LTT -.18429768 02   LOT  .30983725 03   RST  .15199850 09   VST  .29692226 02
 EPS  .80928671 02   ESP  .10653118 00   SEP  .98964764 02   EPM  .13630553 03   EMP  .31295930 02   MEP  .12398535 02
 MPS  .14275634 03   MSP  .25217635-01   SMP  .37216690 02   SEM  .11136139 03   EMS  .68505077 02   ESM  .13343921 00
 RPM  .11821924 06   SPM  .79650888 02
 GCE  .10079833 03   GCT  .28191758 03   SIP  .14191393 03   CPT  .93302061 02   SIN  .92459653 02
 REP  .28601301 06   VEP  .10819020 01   CPE  .98321564 02   CPS  .76978757 02

  1 DAYS  0 HRS. 36 MIN.  2.000 SEC.       23566656155020200000000 J.D.= 2438606.96111111  JULY 30,1964 11 04 00.000

     GEOCENTRIC                                                                          EQUATORIAL COORDINATES

   X  .25103626 06     Y  .13418778 06     Z  .30376764 05    DX  .81519112 00    DY  .67322571 00    DZ  .22440404 00
   R  .28626616 06   DEC  .60913377 01    RA  .28126082 02     V  .10807990 01   PTH  .77275751 02    AZ  .61614519 02
   R  .28626615 06   LAT  .60913377 01   LON  .27401373 03    VE  .20574902 02   PTE  .29371153 01   AZE  .27031557 03
  XS -.92018688 08    YS  .11083283 09    ZS  .48061947 08   DXS -.23213584 02   DYS -.16452559 02   DZS -.71342736 01
  XM  .36441784 06    YM  .10840647 06    ZM  .10647809 05   DXM -.32348484 00   DYM  .88698269 00   DZM  .41418345 00
  XT  .36441784 06    YT  .10840647 06    ZT  .10647809 05   DXT -.32348484 00   DYT  .88698269 00   DZT  .41418345 00
  RS  .15185950 09    VS  .29333513 02    RM  .38034944 06    VM  .10309843 01    RT  .38034944 06    VT  .10309843 01
 GED  .61325336 01   ALT  .27988819 06   LOS  .15588715 02   RAS  .12970107 03   RAM  .16566608 02   LOM  .26245425 03
 DUT  .35000000 02    DT  .48000000 03    DR  .10542562 01   SHA  .28277598 06   DES  .18450759 02   DEM  .16041929 01
 CCL  .25920271 03   MCL  .11199342 01   TCL  .11199342 01

                                              GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE                23566645033520200600000 J.D.= 2438605.22430609  JULY 28,1964 17 23 00.047
 SMA  .24655219 06   ECC  .97608645 00     B  .53596202 05   SLR  .11650884 05   APO  .48720843 06   RCA  .58959386 04
  VH  .13987292 00    C3 -.16166988 01    C1  .68147266 05   TFP  .15005995 06    TF -.17082765 02   PER  .20305931 05
  TA  .16935879 03   MTA  .18000000 03    EA  .99498608 02    HA  .44339739 02   C3J -.20471971 01   TFI  .24600555 02

                                                           ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
   X  .25103626 06     Y  .13418778 06     Z  .30376764 05    DX  .81519112 00    DY  .67322571 00    DZ  .22440404 00
 INC  .28978429 02   LAN  .17016156 02   APF  .20329300 03    HX -.45922455 00    HY  .75209822 00    HZ  .47271731 00
  WX  .14177917 00    WY -.46327146 00    WZ  .87480215 00    PX -.77705276 00    PY -.59957162 00    PZ -.19157992 00
  QX  .61325999 00    QY -.65260538 00    QZ -.44499313 00    RX  .15167722 00    RY  .11703370 00    RZ -.98147700 00
  BX -.61325984 00    BY  .65260523 00    BZ  .44499303 00    TX -.61088707 00    TY  .79171775 00    TZ  .00000000 00
 DAP -.11045001 02   RAP  .21765367 03

 BTQ  .47770919 05   BRQ -.24300045 05     B  .53596202 05   THA  .33303853 03    T VECTOR IN  EARTH EQUATOR PLANE
```

```
CASE  1                                  IBSYS-JPTRAJ-SPACE 022265

    HELIOCENTRIC                                                                         EQUATORIAL COORDINATES

   X  .92269724 08     Y -.11069865 09     Z -.48031570 08    DX  .24028775 02    DY  .17125784 02    DZ  .73586777 01
   R  .15190432 09   LAT -.18433041 02   LON  .30981194 03     V  .30410929 02   PTH -.39840322 00    AZ  .75359724 02
  XE  .92018688 08    YE -.11083283 09    ZE -.48061947 08   DXE  .23213584 02   DYE  .16452559 02   DZE  .71342736 01
  XT  .92383105 08    YT -.11072443 09    ZT -.48051299 08   DXT  .22890099 02   DYT  .17339541 02   DZT  .75484571 01
 LTE -.18450759 02   LOE  .30970107 03   LTT -.18429081 02   LOT  .30983999 03   RST  .15199824 09   VST  .29691674 02
 EPS  .80937248 02   ESP  .10653118 00   SEP  .98956090 02   EPM  .13628907 03   EMP  .31338248 02   MEP  .12372678 02
 MPS  .14276421 03   MSP  .25217635-01   SMP  .37208888 02   SEM  .11132686 03   EMS  .68539587 02   ESM  .13343921 00
 RPM  .11793766 06   SPM  .79660594 02
 GCE  .10079728 03   GCT  .28191721 03   SIP  .14191979 03   CPT  .93304393 02   SIN  .92459974 02
 REP  .28626616 06   VEP  .10807990 01   CPE  .98322790 02   CPS  .76979031 02

 222462325467   220750470430   215753222173   201560037436   200757472061   177435677052                     EARTH
                 21187169515                   17515413504                  000000000000                   INITIAL

 222753160271   222404413161   217725145467   200642503745   200527270151   176711206656                     EARTH
                                                             235666561550   202000000000                       END
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TIME	R	DR	EL	AZ	DEC	HA	C1	CC3	C3	RU
110000	.16755796 06	.15050596 01	47.636	136.455	1.705	332.326	1010789.13	1023069.11	1023069.11	001144252115
113000	.17028671 06	.15274765 01	51.590	146.347	1.846	339.850	1010960.92	1023412.66	1023412.66	001156233643
120000	.17305866 06	.15529082 01	54.596	157.866	1.982	347.384	1011155.81	1023802.44	1023802.44	001170336233
123000	.17587845 06	.15804852 01	56.389	170.809	2.113	354.924	1011367.16	1024225.10	1024225.10	001202572225
130000	.17874913 06	.16093108 01	56.767	184.499	2.238	2.466	1011588.06	1024666.91	1024666.91	001215165375
133000	.18167214 06	.16384802 01	55.686	197.936	2.358	10.006	1011811.61	1025114.00	1025114.00	001227722501
140000	.18464729 06	.16670989 01	53.281	210.238	2.473	17.540	1012030.93	1025552.64	1025552.64	001242621237
143000	.18767281 06	.16943014 01	49.800	220.972	2.584	25.066	1012239.39	1025969.58	1025969.58	001255656163
150000	.19074539 06	.17192679 01	45.509	230.131	2.690	32.580	1012430.72	1026352.23	1026352.23	001271043153
153000	.19386032 06	.17412398 01	40.635	237.930	2.791	40.079	1012599.08	1026688.97	1026688.97	001304347341
160000	.19701158 06	.17595327 01	35.353	244.648	2.890	47.561	1012739.23	1026969.29	1026969.29	001317757503
163000	.20019198 06	.17735484 01	29.790	250.542	2.985	55.024	1012846.56	1027183.99	1027183.99	001333456273
170000	.20339335 06	.17827840 01	24.042	255.830	3.078	62.466	1012917.20	1027325.29	1027325.29	001347224263
173000	.20660669 06	.17868442 01	18.179	260.685	3.171	69.884	1012948.01	1027386.95	1027386.95	001363020561
180000	.20982235 06	.17854687 01	12.248	265.250	3.261	77.281	1012936.66	1027364.27	1027364.27	001376621343
183000	.21303024 06	.17787053 01	6.368	269.642	3.392	84.596	1012881.63	1027254.27	1027254.27	001412403511
190000	.21622002 06	.17707772 01	.803	273.967	3.697	91.643	1012782.75	1027056.52	1027056.52	001426123757
				64/07/30						
070000	.27016468 06	.74415302 00	1.327	84.522	5.232	267.906	1004988.50	1011468.10	1011468.10	001733233605
073000	.27150337 06	.73977832 00	7.101	88.762	5.109	275.090	1004928.05	1011347.15	1011347.15	001740144427
080000	.27283360 06	.73864767 00	13.138	93.055	5.125	282.487	1004916.70	1011324.41	1011324.41	001745035411
083000	.27416693 06	.74363618 00	19.237	97.503	5.181	289.962	1004954.21	1011399.38	1011399.38	001751734177
090000	.27551468 06	.75475478 00	25.283	102.228	5.234	297.453	1005039.15	1011569.20	1011569.20	001756665755
093000	.27688772 06	.77173927 00	31.236	107.375	5.289	304.964	1005169.18	1011829.23	1011829.23	001763676773
100000	.27829630 06	.79419018 00	37.030	113.131	5.344	312.493	1005341.17	1012173.16	1012173.16	001771012373
103000	.27974982 06	.82159878 00	42.574	119.735	5.398	320.037	1005551.19	1012593.16	1012593.16	001776252055
110000	.28125670 06	.85336002 00	47.745	127.498	5.450	327.594	1005794.57	1013079.91	1013079.91	002003655402

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0000 142041    POINTING TIMES                                    (17
0000 14204     JETGLV=640702911,0,640703011,0,1800.,60.
0000 14204     TRANSMITTER ID TABLE                              (26
0000 14204     1,2038516.
0000 14204     OFFLINE CONTROL                                   (27
0000 14204     KEY(13)
0000 14204     END DATA                                          (0
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STATION NUMBER 1 64/07/29 PAGE 1

TIME	R	DR	EL	AZ	DEC	HA	C1	CC3	C3	RU
110000	.16754786 06	.15050839 01	47.774	136.409	1.709	332.381	1010789.32	1023069.48	1023069.48	001144227211
113000	.17027675 06	.15276002 01	51.738	146.322	1.851	339.905	1010961.87	1023414.55	1023414.55	001156211137
120000	.17304902 06	.15531298 01	54.750	157.878	1.986	347.439	1011157.52	1023805.83	1023805.83	001170314205
123000	.17586929 06	.15808013 01	56.542	170.873	2.117	354.980	1011369.58	1024229.95	1024229.95	001202551115
130000	.17874062 06	.16097161 01	56.911	184.619	2.242	2.522	1011591.17	1024673.13	1024673.13	001215145445
133000	.18166443 06	.16389676 01	55.813	198.099	2.362	10.062	1011815.34	1025121.47	1025121.47	001227704147
140000	.18464053 06	.16676600 01	53.386	210.424	2.477	17.597	1012035.23	1025561.24	1025561.24	001242604517
143000	.18766711 06	.16949262 01	49.881	221.162	2.587	25.123	1012244.18	1025979.16	1025979.16	001255643443
150000	.19074087 06	.17199454 01	45.568	230.310	2.693	32.637	1012435.91	1026362.62	1026362.62	001271032575
153000	.19385706 06	.17419581 01	40.674	238.093	2.795	40.136	1012604.59	1026699.98	1026699.98	001304341251
160000	.19700963 06	.17602795 01	35.374	244.791	2.893	47.618	1012744.95	1026980.73	1026980.73	001317753775
163000	.20019140 06	.17743108 01	29.796	250.665	2.988	55.082	1012852.41	1027195.68	1027195.68	001333455217
170000	.20339415 06	.17835493 01	24.034	255.933	3.081	62.524	1012923.06	1027337.02	1027337.02	001347225653
173000	.20660885 06	.17875998 01	18.158	260.770	3.174	69.941	1012953.80	1027398.52	1027398.52	001363024613
180000	.20982585 06	.17862029 01	12.216	265.317	3.264	77.338	1012942.27	1027375.51	1027375.51	001376627777
183000	.21303504 06	.17794119 01	6.325	269.694	3.396	84.652	1012886.99	1027264.98	1027264.98	001412414471
190000	.21622604 06	.17716328 01	.759	274.003	3.705	91.691	1012787.76	1027066.60	1027066.60	001426137161
				64/07/30						
070000	.27016126 06	.74354145 00	1.353	84.548	5.231	267.956	1004983.37	1011457.84	1011457.84	001733225267
073000	.27149878 06	.73915859 00	7.141	88.773	5.111	275.141	1004923.27	1011337.59	1011337.59	001740132761
080000	.27282795 06	.73808231 00	13.190	93.050	5.128	282.540	1004912.35	1011315.72	1011315.72	001745022735
083000	.27416031 06	.74313785 00	19.300	97.484	5.184	290.015	1004950.39	1011391.74	1011391.74	001751717675
090000	.27550723 06	.75433312 00	25.358	102.194	5.237	297.506	1005035.91	1011562.73	1011562.73	001756650015
093000	.27687959 06	.77140234 00	31.322	107.328	5.292	305.017	1005166.59	1011824.06	1011824.06	001763657613
100000	.27828764 06	.79394451 00	37.128	113.072	5.347	312.547	1005339.29	1012169.40	1012169.40	001770772225
103000	.27974081 06	.82144929 00	42.686	119.669	5.400	320.091	1005550.04	1012590.87	1012590.87	001776231171
110000	.28124751 06	.85330990 00	47.870	127.430	5.453	327.646	1005794.19	1013079.13	1013079.13	002003634236

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0000 142111    OFFLINE CONTROL                                   (27
0000 14211     TERMINATE JOB
0000 14211     END DATA                                          (0
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