

**Technical Memorandum No. 33-199**  
**SFPRO-Single Precision Cowell**  
**Trajectory Processor**

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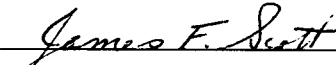
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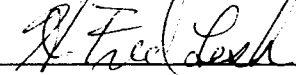
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**January 15, 1965**

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## ABSTRACT

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SFPRO, a Single Precision Cowell Trajectory Processor, is a link under the JPL IBSYS-SFOF-JPTRAJ monitor. SFPRO is a digital computer program written in the FAP language for the IBM 7094 computer. Created because of core limitations imposed by the SFOF system, SFPRO, in combination with SPACE, a Single Precision Cowell Trajectory Program, preserves the full output capability of the older JPL Space Trajectories Program. Given a spacecraft ephemeris tape generated by SPACE, SFPRO can perform tracking station view period calculations, and at specified intervals of time it can generate tracking station printouts, and printouts of spacecraft position and velocity and other quantities relative to the Earth, the Sun, and the target body, referenced to any of several planes. SFPRO can generate a binary SAVE tape, containing a time history of the position and velocity of the spacecraft with reference to the bodies of the integration scheme of SPACE, the orientation of the spacecraft with reference to as many as five tracking stations, and various auxiliary quantities. The spacecraft ephemeris contains all physical constants and other data which define the trajectory of a spacecraft. Therefore the trajectory cannot be modified by SFPRO. The program has all the output capabilities of SPACE, and in addition, the tracking station and SAVE tape options.

Herein presented are the general logic flow of SFPRO, definitions of input and output, hardware and software configurations, and interfaces of the program with the systems.

## I. INTRODUCTION

SFPRO, Single Precision Cowell Trajectory Processor, originated from a need to maintain capabilities previously available in the JPL Space Trajectories Program, described in Ref. 1 and 2 Section VIII, while producing a program which would operate under the IBSYS-SFOF-FPTRAJ monitor. The core storage requirements of such a program dictated that two separate links be written.

One link, SPACE, Single Precision Cowell Trajectory Program, would provide the trajectory integration and normal printing capability, and would

generate a chronologically ordered collection of data on magnetic tape, consisting of the results of integrating the equations of motion in SPACE, and other quantities generated by the integrator in performing its task. This collection of data is known as a spacecraft (or probe) ephemeris.

The spacecraft ephemeris becomes input data to SFPRO, which then produces printing as requested, computes epochs of tracking station view periods, and generates a trajectory SAVE tape on input request. A SAVE tape consists of records of fixed format containing position and velocity information for the spacecraft and the bodies of the integration scheme, as well as tracking station-related data and other quantities of engineering interest.

The JPL Double Precision Ephemeris System is used by SFPRO to determine planetary and lunar position and velocity when these quantities are required for output purposes.

SFPRO produces printed output with respect to the centers of the Earth, the Sun and the target body specified when the spacecraft ephemeris was generated by SPACE. The coordinate frames in which positions, velocities and angular quantities may be expressed are mean Earth equator and equinox of 1950.0, mean ecliptic and equinox of 1950.0, mean Earth equator and equinox of date, mean ecliptic and equinox of date, or true ecliptic and equinox of date. When Mars is the target selected and aerocentric output is requested, position and velocity of the spacecraft and the angular orientation of the Earth and Sun will be computed based on a Mars equator and equinox system assumed not to precess or nutate from its 1950.0 orientation. This coordinate system and its generation are described in subroutine 27 (Section VI). With the Moon as target, spacecraft position, velocity, and certain angular quantities are computed and printed with respect to a true lunar equator (selenographic-spherical) coordinate system whose formation is indicated in Section VI in subroutine 28.2.

Conic output may be called for; this expresses the osculating two-body orbit of the spacecraft with respect to the Earth, Sun or target in many sets of orbital elements referred to any of the above mentioned standard frames of reference, and in addition, to the plane of the orbit of the target body about its "parent" body, i. e. Earth-Moon or Sun-planet.

Tracking stations of the Deep Space Instrumentation Facility (DSIF) may be simulated using a topocentric spherical coordinate system, the positions of 15 DSIF stations being defined in SFPRO. The times of spacecraft rise,



extreme elevation and set with respect to the stations and the orientation of the spacecraft relative to the stations at these times can be computed and printed. This is the view period capability.

Simultaneously, these same quantities can be printed with the other blocks of output at the times specified for that output, during the duration of the spacecraft's visibility to a specific tracking station. This type of output is known as station prints.

Certain quantities computed relative to the stations are oriented toward the hardware configurations of the DSIF stations. In particular, equations for doppler frequency calculations are based on certain types of receiving and transmitting equipment. The antenna of a station may be mounted in the local horizontal plane, and is referred to as an azimuth-elevation (AZ-EL) station, or parallel to the Earth's equator, with the designation of hour angle-declination (HADEC). The DSIF stations are of both types, but the choice of computations may be made by input. The equations for tracking station quantities appear in subroutine 26 in Section VI.

Requests for type and density of printing are made to SFPRO by use of "phasing". In each phase, three printing intervals and two odd-time prints are available, and any of the standard output blocks described in Section VB may be printed at these times. View periods and station prints are also requested in the phasing portion of the input.

Phasing may also be utilized to print when the spacecraft reaches a given distance from a specified body or at the point of closest approach to an input body. A phase is terminated when the print end time of the last print interval of the phase is reached, or at the attainment of closest approach or the desired radius.

As many as eight phases may be used in processing a spacecraft ephemeris, the only constraint being that any SFPRO phase must request by input the same integration central body as used by SPACE in the generation of that portion of the spacecraft ephemeris.

Of significant importance is the generation of trajectory SAVE tapes. When requested by input, a binary tape is produced by SFPRO with records of fixed size, each containing position and velocity of the spacecraft relative to the seven bodies of SPACE, angles relating the spacecraft to the principle

bodies, and to any of the DSIF tracking stations, up to five in number. Section VA contains a complete description of the format of a SAVE tape. A record is produced after passage of time equal to an input multiple of the integration step size used by SPACE, a quantity found on the spacecraft ephemeris tape.

The SAVE tapes generated by SFPRO are used as input to several programs at the Jet Propulsion Laboratory. These include a Plotting Program, a Spacecraft Attitude Reference Program, a Star Identification Program, and a Communications Prediction Program, all of which were used in connection with the Mariner 1964 mission.

The spacecraft ephemeris tape provided by SPACE has one basic format, with two options available. In either option, the first record contains identification information sufficient to specify a unique trajectory. The second through the last record each contains the integrated position and velocity of the spacecraft at the end of a series of integration steps, usually six, and the finite differences computed in the integration process. Section VI, subroutine 31, Ref. 10 describes the integration process and defines the above-mentioned finite differences. One option produces a spacecraft ephemeris which contains the integration of the variational equations, and the associated finite differences, as well as the position and velocity data. Section VI, subroutine 43 of Ref. 10 indicates the formulation of the variational equations used in SPACE. The other option is as above, but without the variational equations and the corresponding finite differences. The variational equations are mentioned here because they effect the contents of the spacecraft ephemeris, but they are not utilized by SFPRO.

Because the leading record of a spacecraft ephemeris contains the values of all physical constants, initial conditions and other related data used in the integration of a trajectory by SPACE, there is no way in which the trajectory may be altered by SFPRO.

A spacecraft ephemeris need not be processed by SFPRO immediately after its generation by SPACE. In addition, the spacecraft ephemerides for several trajectories may be placed on one physical tape due to a serialization feature which identifies spacecraft ephemerides. The value of the serialization assembled in SFPRO and the method of modification is described in Section VI, subroutine 33, and a detailed description of spacecraft ephemeris record format appears in Section IVF.

## II. BASIC PROGRAM LOGIC

The operation of SFPRO can be separated into four logical segments. These are herein enumerated as initialization, phasing, end-of-step, and derivative box. Details of the latter three follow in Sections IIA, IIB, and IIC respectively.

In the initialization process, the identification record of the spacecraft ephemeris is read to obtain the data which defines the trajectory to be processed (see Section IVF for the spacecraft ephemeris tape identification record format). This data consists in part of the initial time and coordinates of the spacecraft as they were originally input to SPACE, the body to which these are referenced, and the target body name. The values of the physical constants used in SPACE and other data either defining the trajectory or which are necessary for processing the spacecraft ephemeris tape are also part of this identification record. The initial conditions and physical constants are printed at the beginning of each processed trajectory in the format specified in Section VB. Should the generation of a trajectory SAVE tape be requested by input, this process is initialized by subroutine 30, PLTSET, in Section VI.

The phasing, described in detail in Section IIA, is now examined to determine the frequency of printing to be used in the first phase of the processing. On this basis, triggers are set up which inform the spacecraft ephemeris interpolation subroutine 38, SPASM, in Section VI, of the times at which it is to interrupt its processing to allow printing to occur. In similar fashion, triggers are set up for the station view period option, which like print times, is requested in each phase. Section IVB indicates the type of input required to request printing and view period computation. Subroutine 26, LOOP, Section VI, describes in detail the calculations used in determining view periods.

At this point the derivative box (Section IIC) is entered once to bring the first integrated data record from the spacecraft ephemeris into the portion of storage known as the HBANK, which is explained in subroutine 38, SPASM, Section VI. This is the final step of the initialization process and SPASM, the spacecraft ephemeris interpolator, is now prepared to begin processing.

## A. PHASING

A method of segmenting a trajectory to provide a flexible output capability is utilized by SFPRO and is known as phasing. It is similar in many respects to that used by the program SPACE (Ref. 10), but not entirely the same. In SFPRO, phasing is used to control the times, frequencies, and types of printing desired. But unlike the phasing in SPACE, no means is available to control the integration of the trajectory in the phasing of SFPRO, as the integrated trajectory is indeed the primary input to SFPRO.

Internal to SFPRO, in subroutine 42.1, TRAJ (Section VI), are nominal sets of phasing for three prevalent cases, i. e., when the target is the Moon, Venus, or Mars. These "canned" phases are identical to their counterparts in SPACE, and provide a minimal amount of output suitable for the particular target body, and terminate processing at impact on or closest approach to the target. The canned phasing may be modified or completely overridden by input. In the event that a body other than those mentioned above is the target, phasing must be input which reflects this fact. Section IVB contains definitions of these and all other input parameters to SFPRO. Should a spacecraft ephemeris cover a shorter duration than the processing period requested in SFPRO, notice of this is given and processing is terminated. Conversely, a spacecraft ephemeris need not be processed to its full length, such processing to be terminated by the appropriate phasing input.

A phase ends when one of three possible conditions is satisfied, on the basis of whichever occurs first. If the final print time for a phase is reached, this causes termination of the phase. When the spacecraft reaches a distance from a body, both the distance and the body being inputs to the phasing, or when the spacecraft reaches closest approach with the target body, the phase is terminated. One must specify for each phase whether it is to be the last phase of the trajectory.

It is possible that the position of the spacecraft may not be known precisely enough beforehand for the user to ascertain in which phase to start processing, i. e., whether to start geocentric or selenocentric. If desired, for phasing which is identical or similar to that canned, the program will determine from the initial position of the spacecraft and the planetary ephemerides the phase in which to begin processing. This is referred to as "automatic phasing" and this mode is assumed by the program but may be overridden by input (again, see Section IVB).

## B. END-OF-STEP CALCULATIONS

The "end-of-step box" is that coding to which subroutine SPASM, the spacecraft ephemeris interpolator, transfers at the end of each integration step it processes. Subroutine 38 (Section VI) spells out the details of the linkage between SPASM and the end-of-step box, which is located in subroutine TRAJ, 42.1.

Upon completion of processing each step, certain quantities must be recomputed to reflect the changes in the position and velocity of the spacecraft over that step, and the change in time itself. The quantities involved are the positions and velocities of the n-bodies with respect to the integration central body, referenced to the mean Earth equator and equinox of 1950.0, and the magnitudes of the n-body--central body, and n-body--spacecraft position vectors. Also updated at this time are the current values of quantities which are dependent variables for the trigger logic of SPASM. Included in this group are topocentric quantities for view period triggers (see LOOP, subroutine 26) and quantities for shadow and back-up target impact triggers. Subroutine 30, PLLLT, Section VI, is called and will generate a trajectory SAVE tape record if one has been requested by input. The arc distance travelled by the spacecraft is updated by subroutine 29, PATH, Section VI, for use with the public information output described in Section VB. Control is always returned to SPASM.

## C. DERIVATIVE BOX

The "derivative box" logic in subroutine TRAJ is used by SPASM, and provides the latter with integrated data read from the spacecraft ephemeris by the subroutine 33, READN. When SPASM has processed all the data in its HBANK from the previous spacecraft ephemeris record, the next record is then read into the HBANK by READN. After a new record is read by READN the flag words in this record are examined in the derivative box and if they reflect a discontinuity in the integration an appropriate comment is written on SYSOUI. The trajectory is terminated by calling subroutine 1, ABORT, Section VI, if the last data record is passed, as a backup precaution. Hence a user should terminate a trajectory through the phasing capability and not allow SFPRO to run out of data. Unless the run is aborted, the derivative box returns control to SPASM.

III. MACHINE AND SYSTEM CONFIGURATION

There are two computer systems in use at the Jet Propulsion Laboratory. One is the standard IBM 7094 IBSYS job-shop system. It is used for daily checkout and production. The other system is the JPL SFOF system, which is used to process spacecraft data and to allow input, output, and control at remote user areas.

SFPRO, under JPTRAJ, satisfies all the requirements of both systems and can therefore be used in any of the various modes of operation. Core storage is allocated as follows:

Octal Locations	Contents
0-3777	IBSYS
4000-21077	SFOF
21100-22277	JPTRAJ
22300-77777	SFPRO

## IV. INPUT

## A. INPUT CAPABILITY

Data in the SFPRO link of a JPTRAJ source deck is input by JPTRAJ just prior to the execution of SFPRO. JPTRAJ does this with the aid of SFPRO's symbol table. In addition, data can come from other links in the JPTRAJ source deck by proper use of the JPTRAJ "WANT" and "USE" control cards. Here again, JPTRAJ uses SFPRO's symbol table. SFPRO has no input subroutine so that when JPTRAJ transfers control to SFPRO all input is completed (i.e., there is no on-line input capability in SFPRO). This restriction is circumvented by using "WANT" control cards and a link named TRIO (Ref. 11, Section VIII).

The binary tape-read subroutines EPHSET and EPHEM have been included in SFPRO for reading the n-body ephemeris tape.

Sense switches 4 and 6 on the 7094 console may be used to input a request to SFPRO for on-line output. Section V describes the output one may request and the setting of the switches.

B. INPUT DEFINITION



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SYMBOL	TYPE	EXPLANATION	UNITS	NOM. VALUE
PAGBCD	BCD	TWO LINES (40 WORDS) OF PAGE HEADING		BLANKS
FAZFLG	FIX	NON-ZERO=USE PHASING OF DOMINANT BODY		1
RUNID	BCD	RUN I.D. USED WITH SCDFRF=1 SAVE TAPE OPTION		TRAJ01
PLOTFQ	FIX	SAVE TAPE FLAG, INPUT N=SAVE EVERY NTH STEP		0
PLOTFQ+1	FIX	PHYSICAL FILE NO.		1
PLOTFQ+2	FLO	TIME INCREMENT ADDED TO TIME PAST INJ.	SEC	0.0
PLOTFQ+3	OCT	STATIONS 59 11 12 41 51 14 13 15 42 61 08 91		0
PLOTFQ+4	OCT	STATIONS 75 76 02 00 00 00 00 00 00 00 00 00 (MAXIMUM OF FIVE STATIONS)		0
		PUBLIC INFORMATION AND BOARD UNITS		
PUBLIC	FLO	ROTATION ANGLE	DEC	49.3
PUBLIC+1	FLO	SCALE FACTOR	BD UN/KM	.45E-7
PUBLIC+2	FLO	HORIZONTAL LOCATION OF SUN	BD UN	12.5
PUBLIC+3	FLO	VERTICAL LOCATION OF SUN	BD UN	8.0
CANSO	FLO	1950.0 UNIT CARTESIAN BODY-CANOPUS X		-.060340592
CANSO+1	FLO	1950.0 UNIT CARTESIAN BODY-CANOPUS Y		-.60342639
CANSO+2	FLO	1950.0 UNIT CARTESIAN BODY-CANOPUS Z		-.79513092
LAUNCH	SEG	LAUNCH EPOCH		0.0
TARGAD	FLO	ALTITUDE ABOVE TARGET TO END RUN VIEW PERIOD PRINTS		0.0
VPGROP	OCT	GROUP PRINT FLAG AT VIEW PERIODS		0
VPGROP+1	OCT	CONIC PRINT FLAG AT VIEW PERIODS		0
FLAG42	FIX	NON-ZERO PUTS OUTPUT IN SC-023 MODE		0
PRTSWK	FIX	PRINT SWITCH NON-ZERO=PRINT EVERY CASE		0
PRTSTP	FIX	NON-ZERO=PRINT EVERY END-OF-STEP		0
PRTSTP+1	OCT	PRINT GROUP AT EACH END-OF-STEP		0
PRTSTP+2	OCT	CONIC GROUP AT EACH END-OF-STEP		0
DEPOPT	FIX	0=NO DEP. VAR. 1=PRINT -1=END PHASE		0
DEPOPT+1	OCT	LOCATION OF DEPENDENT VARIABLE		0
DEPOPT+2	FLO	VALUE OF DEPENDENT VARIABLE		0.0
DPTSWT	FIX	ON-LINE OUTPUT CONTROL 0=NO REMOTE CONTROL, NO ON-LINE PRINT -1=REMOTE CNTROL.HANG FOR S.S. SETTING 5=FINE PRINT ON-LINE 1=MINIMUM PRINT ON-LINE		0

THE 40 PHASE PARAMETERS MUST BE INPUT INTO THE PROPER BUFFERS AS FOLLOWS

WHERE XXXXXX IS REPLACED BY  
MOOPH1 TO MOOPH8 FOR MOON  
VENPH1 TO VENPH8 FOR VENUS  
MARPH1 TO MARPH8 FOR MARS  
MOOPH1 TO MOOPH8 FOR ALL OTHER TARGET BODIES

SYMBOL	TYPE	EXPLANATION	UNITS	NOM. VALUE
XXXXXX+0	FIX	-=PRINT AT START OF PHASE + = DO NOT PRINT AT START OF PHASE SET TPRT=PHASE START USE OLD TPRT 0 PRINT AT END LAST PHASE 4 1 PRINT AT END NOT LAST PHASE 5 2 DO NOT PRINT AT END LAST PHASE 6 3 DO NOT PRINT AT END NOT LAST PHASE 7		
XXXXXX+1	BCD	BODY FROM WHICH TO COMPUTE K FOR R TEST		
XXXXXX+2	FLO	VALUE OF R TO END PHASE		
XXXXXX+3	BCD	BODY FROM WHICH TO COMPUTE R. FOR R.=0 TEST		
XXXXXX+4	FLO	VALUE OF R TO TURN ON R.=0 TEST + VALUE=TURN ON TEST WHEN (BODY-PROBE R) GR. THAN (+ VALUE) - VALUE=TURN ON TEST WHEN (BODY-PROBE R) LESS THAN -(+VALUE)		
XXXXXX+6	BCD	CENTRAL BODY FOR INTEGRATION		
XXXXXX+7	SEG	STEP SIZE		
XXXXXX+9	FIX	NO. OF STEPSIZE DOUBLES		
XXXXXX+10	BCD	BODY USED IN LOOKUP FOR STEPSIZE		
XXXXXX+11	SEG	PRINT END 1		
XXXXXX+13	SEG	PRINT DELTA 1		
XXXXXX+15	SEG	PRINT END 2		
XXXXXX+17	SEG	PRINT DELTA 2		
XXXXXX+19	SEG	PRINT END 3		
XXXXXX+21	SEG	PRINT DELTA 3		
XXXXXX+23	SEG	ODD PRINT 1		
XXXXXX+25	SEG	ODD PRINT 2		
XXXXXX+27	OCT	GROUP PRINT FLAGS WHERE THE FORMAT OF THE OCTAL WORD IS G GC H HC O T TC R O O O J WHERE G = GEOCENTRIC GC = GEOCENTRIC CONIC (PLANE INDEPENDENT) H = HELIOCENTRIC HC = HELIOCENTRIC CONIC (PLANE INDEPENDENT) T = TARGET TC = TARGET CONIC (PLANE INDEPENDENT) R = R DOT EQUAL ZERO U = VARIATIONAL EQUATIONS FLAG=1=EQUATORIAL 2=ECLIPTIC 4=ECLIPTIC AT START ONLY 5=EQUATORIAL AT START ONLY 6=ECLIPTIC AT END ONLY 7=EQUATORIAL AT END ONLY		
XXXXXX+28	OCT	STATION PRINTS (15 STATIONS IN TWO WORDS, MAX OF 5 AT A TIME) 12 STATIONS ARE FLAGGED IN FIRST WORD, 3 IN SECOND AS FOLLOWS 59 11 12 41 51 14 13 15 42 61 08 91, 75 76 02		

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XXXXXX+38 OCT CONIC PRINT FLAGS (PLANE DEPENDENT VARIABLES)  
 WHERE THE FORMAT OF THE OCTAL WORD IS  
 Q C O T Q C O T Q C O T  
 WHERE THE FIRST SET OF Q C O T IS USED IN THE GEO CONIC,  
 THE SECOND SET IS USED IN THE HELIO CONIC AND THE THIRD SET  
 IS USED IN THE TARGET CONIC AND WHERE  
 Q = EARTH EQUATORIAL PLANE  
 C = ECLIPTIC PLANE  
 O = ORBIT PLANE OF TARGET (K IS ALONG THE ASCENDING NODE  
 OF THE ORBIT PLANE OF THE TARGET ON THE TARGET  
 TRUE EQUATOR PLANE, IF THE TARGET TRUE EQUATOR  
 PLANE IS DEFINED. OTHERWISE, ON THE ECLIPTIC PLANE.)  
 T = TRUE TARGET EQUATOR PLANE (DEFINED FOR MOON AND MARS)  
 X IS DEFINED THE SAME AS FOR THE ORBIT PLANE  
 XXXXXX+30 OCT VIEW PERIODS I 15 STATIONS IN TWO WORDS, MAX OF 5 AT A TIME )  
 12 STATIONS ARE FLAGGED IN FIRST WORD, 3 IN SECOND AS FOLLOWS  
 .59 11 12 41 51 14 13 15 42 61 08 91, 75 76 02  
 XXXXXX+34 FIX SHADOW PARAMETER FLAG I=0M  
 XXXXXX+39 BCD OUTPUT EQUINOX I ) = TRUE-OF-DATE  
 (1950.0) = MEAN 1950.0

NOTE...THERE ARE NO INTEGRATION OR STEPSIZE CONTROL INPUTS TO SFPRO BUT  
 STORAGE HAS BEEN ALLOCATED FOR THEM. THIS ALLOWS ONE SET OF PHASING TO  
 SUFFICE FOR BOTH SPACE AND SFPRO VIA WANT CARDS, IF DESIRED

FRQ	FLO	A11	STATION FREQUENCY COEFFICIENTS	930.15E6
FRQ+1	FLO	A21		1.0
FRQ+2	FLO	A31		1.0
FRQ+3	FLO	A41		32.3595506
FRQ+4	FLO	A51		1E5
FRQ+5	FLO	A61		1.0
FRQ+6	FLO	A71		.455E6
FRQ+7	FLO	RF1		960.05E6
FRQ+8	FLO	RF2,K3		29.668212E5
FRQ+9	FLO	K1		32.4482
FRQ+10	FLO	K2		20.
FRQ+11	FLO	RFB,B5		960.05E6
FRQ+12	FLO	B6		1.0
FRQ+13	FLO	FA		960.05E6
FRQ+14	FLO	FI		30.434E6
FRQ+15	FLO	SLIT (SPEED OF LIGHT, KM/SEC)		299792.5
FRQ+16	FLO	SK1		23.5E6
FRQ+17	FLO	LSK1		23.5E6
FRQ+18	FLO	LSFT		2295.E6
FRQ+19	FLO	SFT		2295.E6
FRQ+20	FLO	FRQ1)		22.E6
HASPN	FLO	HOUR ANGLE CONSTRAINT FOR HA-DEC STATIONS DEG STATION COORDINATES, MAX. OF 15 STATIONS, FIVE WORDS EACH		90.0
STACRD	FLO	STATION LATITUDE		
STACRD+1	FLO	STATION LONGITUDE		
STACRD+2	FLO	RADIUS TO STATION		
STACRD+3	FIX	CODE WORD 0=A-Z,1=HA-DEC		
STACRD+4	FLO	STATION TRANSMITTER TYPE 0=L BAND 1=L-S BAND 2=S BAND		
STABCD,+3	BCD	STATION NAMES (MAX. OF 15 STATIONS, FOUR WORDS EACH)		

THERE ARE MANY MORE SYMBOLS IN THE SYMBOL  
 TABLE. THE FOLLOWING TABLE GIVES THE ADDITIONAL SYMBOLS,  
 WHERE I AND/OR O INDICATES WHETHER THE  
 DATA IS INPUT TO SFPRO OR OUTPUT FROM SFPRO.

SYMBOL	I/O	TYPE	EXPLANATION	UNITS
BTQ	O	FLO	B,T EARTH EQUATORIAL	KM
BRQ	O	FLO	B,R EARTH EQUATORIAL	KM
BTC	O	FLO	B,T ECLIPTIC	KM
BRC	O	FLO	B,R ECLIPTIC	KM
BTO	O	FLO	B,T, TARGET ORBITAL PLANE	KM
BRO	O	FLO	B,R, TARGET ORBITAL PLANE	KM
BTI	O	FLO	B,T, TARGET TRUE EQUATOR PLANE	KM
BRT	O	FLO	B,R, TARGET TRUE EQUATOR PLANE	KM
			ALL B,T, B,R VALUES IN THE BUFFERS ARE THE LAST ONES COMPUTED BY THE PROGRAM	
C3	O	FLO	TARGET CONIC ENERGY CONSTANT	KM2/SEC2
VH	O	FLO	TARGET CONIC HYPERBOLIC EXCESS VELOCITY	KM/SEC
TFD	O	FLO	TIME OF FLIGHT	DAYS
TFH	O	FLO	TIME OF FLIGHT	HOURS
TFM	O	FLO	TIME OF FLIGHT	MIN
TFLIND	O	FLO	LINEARIZED TIME OF FLIGHT	DAYS
TFLINH	O	FLO	LINEARIZED TIME OF FLIGHT	HOURS
TF1	O	FLO	TIME PAST INJECTION EPOCH	SEC
SELAT	O	FLO	SELENOGRAPHIC LATITUDE OF S/C	DEG
SELON	O	FLO	SELENOGRAPHIC LONGITUDE OF S/C	DEG
JULD	O	FLO	JULIAN DATE (2 WORDS) 1ST WORD INTEGER DAYS 2ND WORD FRACTIONAL PART OF A DAY	DAYS
LATIT	O	FLO	GEOCENTRIC LATITUDE OF S/C	DEG
LONGY	O	FLO	GEOCENTRIC LONGITUDE OF S/C	DEG
TZERO	O	FLO	INJECTION EPOCH SEC PAST 0 HR JAN 1, 1950	SEC
XDP	O	FLO	42-WORD BUFFER CONTAINING 7 RECTANGULAR POSITION VECTORS FOLLOWED BY 7 RECTANGULAR VELOCITY VECTORS THE ORDER OF THE VECTORS IS EARTH TO S/C MOON TO S/C SUN TO S/C VENUS TO S/C MARS TO S/C SATURN TO S/C JUPITER TO S/C THE COORDINATE SYSTEM IS EARTH CENTERED, EARTH EQUATORIAL, SPACE FIXED, WHERE THE EQUINOX IS DEFINED BY THE INPUT PARAMETER DEFINING THE OUTPUT EQUINOX	KM,KM/SEC
STATE	I	FIX	CONTAINS FLAGS FROM THE SEARCH PROGRAM	
TAPEX	I/O	FIX	EPHEMERIS TAPE INFORMATION (6 WORDS) WORD 1 PZE SYSUTB WORD 2 EMPTY WORD 3-4 J.D. OF MIN DATE ON TAPE WORD 5-6 J.D. OF MAX DATE ON TAPE	
T	O	FLO	CURRENT EPOCH SEC PAST 0 HR JAN 1, 1950	SEC

C. JPTRAJ RESTRICTIONS

SFPRO operates under the JPTRAJ monitor, which imposes three programming requirements. SFPRO satisfies these requirements by providing:

1. A four-word Program Control Block (PCB) located at entry ".....".
2. A Symbol Table, which immediately follows the PCB.
3. A zero (normal return via JEXIT) or a one (error return via ABORT) in the accumulator upon return to JPTRAJ.

A detailed description of the JPTRAJ programming requirements is found in Ref. 4 (Section VIII).

1. Program Control Block

..... BC1 1,SFPRO  
ZERO 1,,1  
ZERO LST  
TRA NS4

CLASS 1,,1 ERROR RETURN  
LENGTH OF SYMBOL TABLE

2. Symbol Table

```

*
BEGINNING OF SYMBOL TABLE
DRG EQU
SYM TZERO,I
SYM BTQ
SYM BTC
SYM BTD
SYM BTI
SYM BRQ
SYM BRC
SYM BRD
SYM BRT
SYM T,I
SYM C3,I
SYM VM,I
SYM TFD
SYM TFM
SYM TFLIMD
SYM TFLIMH
SYM TFI,I
SYM SELDM,I
SYM SELAT,I
SYM JULD
SYM LATIT,I
SYM LDMGY,I
SYM TARGAD
SYM PAGBCD
SYM TARBCD
SYM INJBCCD
SYM FAZFLLC
SYM INJTYP
SYM INJT
SYM INJX
SYM INJY
SYM INJZ
SYM INJDZ
SYM INJDY
SYM INJDX
SYM RMAX
SYM PHL
SYM INJTDI
SYM INJEQX
SYM MOOPH1
SYM MOOPH2
SYM MOOPH3
SYM MOOPH4
SYM MOOPH5
SYM MOOPH6
SYM MOOPH7
SYM MOOPH8
SYM VENPH1
SYM VENPH2
SYM VENPH3

SYM VENPH4
SYM VENPH5
SYM VENPH6
SYM VENPH7
SYM VENPH8
SYM MARPH1
SYM MARPH2
SYM MARPH3
SYM MARPH4
SYM MARPH5
SYM MARPH6
SYM MARPH7
SYM MARPH8
SYM STABCD
SYM STACRD
SYM FRQ
SYM XOP,I
SYM XOP,I
SYM TARAD
SYM LUNGRV
SYM SCALE1
SYM GRAV
SYM BRNDPT
SYM RADOPT
SYM DEFDPT
SYM VPGROP
SYM FLAG42,I
SYM RUNID,I
SYM PRTSWK,I
SYM STATE,I
SYM ABORT,I
SYM NEWBDD
SYM PLOTFO
SYM HASPAN
SYM TAPEX
SYM OPTSWT,I
SYM NUTEPH
SYM MNAET
SYM LAUNCH
SYM PUBLIC
SYM PRSTP
SYM CAN50
LST EQU **DRG
LENGTH OF SYMBOL TABLE

```

WHERE SYM IS DEFINED AS FOLLOWS

```

MACRO
Z SYM X,Y
BCI 1,X
RNT
IFF 1,Y
MZE SX
IFF 0,Y
PZE X
RMT
END

```

D. COMMON MAP AND LOAD MAP

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77152	COMMON	199	
77152	COMMON	COMMON	
77316	BFF23	COMMON+100	
77152	COM	COMMON	COMMON BLOCK
77151	PRTSWT	COMMON	PRINT SUPP. SWITCH, 0=SUPPRESS,NOM ZERO=NORMAL
77150	INPSWT	COMMON	
77147	OMEGA	COMMON	
77145	COMMON	1	
77143	COMMON	2	BUFFER FOR ,TIME,
77143	IT	COMMON	*
77141	COMMON	1	INJECTION EPOCH
77141	T(0)	COMMON	*
77136	COMMON	2	
77136	TARG	COMMON	
77135	LDMGA	COMMON	
77134	GHA(1)	COMMON	EARTH,S RATE IN RAD/SEC
77133	NUTRA	COMMON	GREENWICH HOUR ANGLE
77124	COMMON	6	NUTATION IN RIGHT ASCENSION
77124	YEAR	COMMON	
77123	MODE	COMMON	
77122	TARGET	COMMON	
77120	COMMON	1	
77120	GJH	COMMON	
77116	COMMON	1	
77116	RKH	COMMON	
77115	PHASE	COMMON	
77114	Q	COMMON	
77112	COMMON	1	
77111	COMMON	1	
77111	TBURN	COMMON	
77110	GR	COMMON	
77077	COMMON	8	
77077	AA	COMMON	EARTH,S MEAN EQUATOR TO 1950.0
77076	ET	COMMON	TRUE OBLIQUITY
77075	CENTER	COMMON	CENTRAL BODY MEMBER
77064	COMMON	8	*
77064	(MMA)	COMMON	MOON,S TRUE EQUATOR MATRIX TO 1950.0
77053	COMMON	8	*
77053	(NA)	COMMON	EARTH,S TRUE EQUATOR TO 1950.0
77042	COMMON	8	*
77042	MM	COMMON	MOON,S TRUE EQUATOR TO EARTH,S TRUE EQUATOR
77040	COMMON	1	
77040	TDB	COMMON	OBSERVATION TIME
77036	COMMON	1	
77036	TDR	COMMON	DRIVE TAPE TIME
77035	CODE	COMMON	
77034	MASS	COMMON	
77033	MASS-	COMMON	
77032	M(1)	COMMON	
77031	ACC	COMMON	
77030	RO	COMMON	
77027	R	COMMON	DISTANCE FROM CENTRAL BODY
77026	RB4P	COMMON	DISTANCE FROM NTH BODY TO PROBE
77025	RB5P	COMMON	*
77024	RB4P	COMMON	*
77023	RB3P	COMMON	*
77022	RB2P	COMMON	*
77021	RB1P	COMMON	*
77020	RB0P	COMMON	*
77017	RB6	COMMON	DISTANCE FROM NTH BODY TO CENTRAL BODY
77016	RB5	COMMON	*
77015	RB4	COMMON	*
77014	RB3	COMMON	*
77013	RB2	COMMON	*
77012	RB1	COMMON	*
77011	RB0	COMMON	*
00007	ESEP	SYN	RB0P-RB0
76764	COMMON	20	CARTESIAN VELOCITY COORDINATES
76764	XN-	COMMON	OF THE N BODIES 1950.0
76737	COMMON	20	CARTESIAN POSITION COORDINATES
76737	XN	COMMON	OF THE N BODIES 1950.0
76736	KB6	COMMON	
76735	KB5	COMMON	GRAVITY COEFFICIENTS OF THE N BODIES
76734	KB4	COMMON	*
76733	KB3	COMMON	*
76732	KB2	COMMON	*
76731	KB1	COMMON	*
76730	KB0	COMMON	*
00014	NTAB1	SYN	XN--XN-9
00044	NTAB2	SYN	3*NTAB1
00330	NTAB3	SYN	6*NTAB2
01122	NTAB4	SYN	NTAB3+378
00052	SEPP1	SYN	2*XN--2*XN
76727	JECAN	COMMON	
76726	MENAN	COMMON	BUFFERS FOR JEKYL, HYDE, ETAL
76725	HU	COMMON	*
76724	ECCEN	COMMON	*
76723	AVAL	COMMON	*
76722	PVAL	COMMON	*
76721	NORB	COMMON	*
76717	IMINE	COMMON	*
76716	FOFLG	COMMON	FREQUENCY FLAG, 0=OFF, OTHERWISE ON
76715	VAFGL	COMMON	VARIATIONAL EQUATIONS FLAG
00007	AMR	SYN	7
00064	AMN	SYN	52
00001	AME	SYN	1
00011	BAM	SYN	AMN+AME+1
74524	COMMON	3*AMN+AMN+BAM+AMN+BAM+AMN+AME	GENERAL BUFFER FOR MARK 1
74513	COMMON	9	DERIVATIVES FOR
74513	FRQ-	COMMON	FREQUENCY
74447	COMMON	35	DERIVATIVES FOR
74447	VAR-	COMMON	VARIATIONAL EQUATIONS,1950.0
74446	CZ--	COMMON	COMELL BUFFER 1950.0
74445	CY--	COMMON	COMELL BUFFER 1950.0
74444	CX--	COMMON	COMELL BUFFER 1950.0
74440	COMMON	3	DERIVATIVES FOR POSITIONS, 1950.0
74427	COMMON	9	
74427	FRQ	COMMON	
74363	COMMON	35	VARIATIONAL EQUATIONS, 1950.0
74363	VAR	COMMON	

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74362	CZ.	COMMON	1	COWELL BUFFER 1950.0
74361	CY.	COMMON	1	COWELL BUFFER 1950.0
74360	CX.	COMMON	1	COWELL BUFFER 1950.0
74357	CZ	COMMON	1	COWELL BUFFER 1950.0
74356	CY	COMMON	1	COWELL BUFFER 1950.0
74355	CX	COMMON	1	COWELL BUFFER 1950.0
74353		COMMON	1	CURRENT EPOCH
74353	T	COMMON	1	*
74351		COMMON	1	NUMBER OF EQUATIONS
74351	HBANK	COMMON	1	
74345		COMMON	3	
74335		COMMON	8	
74335	VARCFF	COMMON	1	
74271		COMMON	35	
74271	VARTRU	COMMON	1	VARIATIONAL EQUATIONS, TRUE EQUATOR
74266		COMMON	2	BUFFERS FOR THRUST
74266	CE	COMMON	1	*
74260		COMMON	5	MOON - FIXED POSITION 1950.0
74260	CD	COMMON	1	LUNAR OBLATENESS PERTURBATION 1950.0
74256		COMMON	1	EARTH OBLATENESS
74253		COMMON	3	POSITION WITH RESPECT TO EARTH 1950.0
74251		COMMON	2	POSITION WITH RESPECT TO EARTH MEAN OF DATE
74251	CC	COMMON	1	*
74246		COMMON	2	EARTH OBLATENESS PERTURBATION 1950.0
74246	CB	COMMON	1	*
74243		COMMON	2	N-BODY PERTURBATION 1950.0
74243	CA	COMMON	1	*
74240		COMMON	2	DIRECTION COSINES OF CANOPUS
74240	CANOP	COMMON	1	TRUE EQUATOR AND EQUINOX OF DATE
74235		COMMON	2	*
74235	S3	COMMON	1	*
74232		COMMON	2	*
74232	S2	COMMON	1	*
74227		COMMON	2	*
74227	S1	COMMON	1	*
74202		COMMON	20	TRUE EQUATOR AND EQUINOX OF DATE
74202	XOP.	COMMON	1	VELOCITY COORDINATES OF PROBE IN N BODY SYSTEMS
74155		COMMON	20	TRUE EQUATOR AND EQUINOX OF DATE
74155	XOP	COMMON	1	POSITION COORDINATES OF PROBE IN N BODY SYSTEMS
74130		COMMON	20	TRUE EQUATOR AND EQUINOX OF DATE
74130	XN.1	COMMON	1	VELOCITY COORDINATES OF NTH BODY
74103		COMMON	20	TRUE EQUATOR AND EQUINOX OF DATE
74103	XN1	COMMON	1	POSITION COORDINATES OF NTH BODY
74102	Z1.	COMMON	1	EARTH-FIXED CARTESIAN
74101	Y1.	COMMON	1	EARTH-FIXED CARTESIAN
74100	X1.	COMMON	1	EARTH-FIXED CARTESIAN
74077	ZJ	COMMON	1	EARTH-FIXED CARTESIAN
74076	YJ	COMMON	1	EARTH-FIXED CARTESIAN
74075	XJ	COMMON	1	EARTH-FIXED CARTESIAN
74074	SIGMA1	COMMON	1	EARTH-FIXED SPHERICAL
74073	GAMMA1	COMMON	1	EARTH-FIXED SPHERICAL
74072	V1	COMMON	1	EARTH-FIXED SPHERICAL
74071	THETA1	COMMON	1	EARTH-FIXED SPHERICAL
74070	PH11	COMMON	1	EARTH-FIXED SPHERICAL
74067	R1	COMMON	1	EARTH-FIXED SPHERICAL
74064		COMMON	2	BUFFER
74064	XEP.	COMMON	1	FOR ,,SPACE,,
74061		COMMON	2	FOR ,,SPACE,,
74061	XEP	COMMON	1	OUTPUT BUFFER
74060	Z.	COMMON	1	REFERENCED TO
74057	Y.	COMMON	1	TRUE EQUATOR
74056	X.	COMMON	1	AND EQUINOX OF DATE
74055	Z	COMMON	1	
74054	Y	COMMON	1	
74053	X	COMMON	1	
74050		COMMON	2	1950.0 EQUATOR
74050	CS3	COMMON	1	1950.0 EQUATOR
74045		COMMON	2	1950.0 EQUATOR TO EARTH
74045	CS2	COMMON	1	1950.0 EQUATOR TO EARTH
74042		COMMON	2	1950.0 EQUATOR TO SUN
74042	CS1	COMMON	1	1950.0 EQUATOR TO SUN
74041	QZ0.	COMMON	1	ENCKE BUFFER
74040	QY0.	COMMON	1	1950.0
74037	QX0.	COMMON	1	TWO-BODY SOLUTION, 1950.0
74036	QW0	COMMON	1	TWO-BODY SOLUTION, 1950.0
74035	QV0	COMMON	1	TWO-BODY SOLUTION, 1950.0
74034	QX0	COMMON	1	TRUE SOLUTION, 1950.0
74033	QZ.	COMMON	1	TRUE SOLUTION, 1950.0
74032	QY.	COMMON	1	TRUE SOLUTION, 1950.0
74031	QX.	COMMON	1	TRUE SOLUTION, 1950.0
74030	QZ	COMMON	1	TRUE SOLUTION, 1950.0
74027	QY	COMMON	1	TRUE SOLUTION, 1950.0
74026	QX	COMMON	1	TRUE SOLUTION, 1950.0
74012		COMMON	11	
74012	GRUPS	COMMON	1	
74007		COMMON	2	
74007	CR1	COMMON	1	
74004		COMMON	2	
74003		COMMON	1	
74003	CPT	COMMON	1	
74002	CPC	COMMON	1	
74001	CPM	COMMON	1	
74000	CPS	COMMON	1	
73777	CPE	COMMON	1	
73774		COMMON	2	
73774	EULER	COMMON	1	
73773	IAS	COMMON	1	
73772	INA	COMMON	1	
73771	ACCD	COMMON	1	
73770	DESS	COMMON	1	
73767	DEMS	COMMON	1	
73766	ALP	COMMON	1	
73765	EST4	COMMON	1	
73764	ST4	COMMON	1	
73763	SET4	COMMON	1	
73762	STP4	COMMON	1	
73761	TSP4	COMMON	1	
73760	TPS4	COMMON	1	
73757	TEP4	COMMON	1	
73756	ETP4	COMMON	1	
73755	EPT4	COMMON	1	
73754	ESM4	COMMON	1	



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73753 EMS4 COMMON 1  
 73752 SEM4 COMMON 1  
 73751 SMP4 COMMON 1  
 73750 MSP4 COMMON 1  
 73747 MPS4 COMMON 1  
 73746 MEP4 COMMON 1  
 73745 EMP4 COMMON 1  
 73744 EPM4 COMMON 1  
 73743 SEP4 COMMON 1  
 73742 ESP4 COMMON 1  
 73741 EPS4 COMMON 1  
 73740 TAL1 COMMON 1  
 73737 RAD COMMON 1  
 73736 RAA3 COMMON 1  
 73735 RAA2 COMMON 1  
 73734 RAA1 COMMON 1  
 73723 MVEC COMMON 8  
 73720 COMMON 2  
 73720 B3UV COMMON 1  
 73715 COMMON 2  
 73715 B2UV COMMON 1  
 73712 COMMON 2  
 73712 B1UV COMMON 1  
 73711 B3MAG COMMON 1  
 73710 B2MAG COMMON 1  
 73707 B1MAG COMMON 1  
 73706 MTA3 COMMON 1  
 73705 MTA2 COMMON 1  
 73704 MTA1 COMMON 1  
 73703 DAO COMMON 1  
 73702 DA3 COMMON 1  
 73701 DA2 COMMON 1  
 73700 DA1 COMMON 1  
 73677 SHATC COMMON 1  
 73671 COMMON 5  
 73671 SARA COMMON 1  
 73663 COMMON 5  
 73663 ERIF COMMON 1  
 73660 COMMON 2  
 73660 JOSHT COMMON 1  
 73654 COMMON 3  
 73654 SCUM COMMON 1  
 73653 SHA COMMON 1  
 73652 VT COMMON 1  
 73651 RT COMMON 1  
 73650 VM COMMON 1  
 73647 RM COMMON 1  
 73646 VS COMMON 1  
 73645 RS COMMON 1  
 73642 COMMON 2  
 73642 VOT COMMON 1  
 73637 COMMON 2  
 73637 ROT COMMON 1  
 73636 R.A.M COMMON 1  
 73633 COMMON 2

73633 VO1 COMMON 1  
 73630 COMMON 2  
 73630 RO1 COMMON 1  
 73627 R.A.S COMMON 1  
 73624 COMMON 2  
 73624 VO2 COMMON 1  
 73621 COMMON 2  
 73621 RO2 COMMON 1  
 73620 S1A COMMON 1  
 73617 RAWXR COMMON 1  
 73616 TSBP3 COMMON 1  
 73605 COMMON 8  
 73605 PEGM3 COMMON 1  
 73604 BAGE COMMON 1  
 73603 GARB COMMON 1  
 73564 COMMON 14  
 73564 GRUB8 COMMON 1  
 73545 COMMON 14  
 73545 GRUB6 COMMON 1  
 73533 COMMON 9  
 73533 GRUB5 COMMON 1  
 73523 COMMON 7  
 73523 GRAB6 COMMON 1  
 73515 COMMON 5  
 73515 GRAB5 COMMON 1  
 73513 COMMON 1  
 73513 MUSE3 COMMON 1  
 73505 COMMON 5  
 73505 TGSPPH COMMON 1  
 73477 COMMON 5  
 73477 ERSPPH COMMON 1  
 73476 MA3 COMMON 1  
 73475 EA3 COMMON 1  
 73474 TA3 COMMON 1  
 73473 SVL COMMON 1  
 73472 HNG COMMON 1  
 73471 HGE COMMON 1  
 73470 ADS COMMON 1  
 73467 DPT COMMON 1  
 73463 COMMON 3  
 73463 SCRUG COMMON 1  
 73462 DRT COMMON 1  
 73461 MA2 COMMON 1  
 73460 EA2 COMMON 1  
 73457 TA2 COMMON 1  
 73456 TSBP2 COMMON 1  
 73455 CRUD COMMON 1  
 73444 COMMON 8  
 73444 PEGM2 COMMON 1  
 73443 BOSH COMMON 1  
 73424 COMMON 14  
 73424 GRUB4 COMMON 1  
 73412 COMMON 9  
 73412 GRUB3 COMMON 1  
 73402 COMMON 7  
 73402 GRAB4 COMMON 1

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73374 COMMON 5  
 73374 GRAB3 COMMON 1  
 73372 COMMON 1  
 73372 MUSE2 COMMON 1  
 73370 COMMON 1  
 73367 COMMON 1  
 73362 COMMON 5  
 73362 JUICE COMMON 1  
 73350 COMMON 9  
 73350 SCMP. COMMON 1  
 73347 SCAMP COMMON 1  
 73335 COMMON 9  
 73335 MA1 COMMON 1  
 73334 EA1 COMMON 1  
 73333 TA1 COMMON 1  
 73332 DR COMMON 1  
 73331 ALT COMMON 1  
 73330 GED COMMON 1  
 73327 LONGS COMMON 1  
 73326 LONGM COMMON 1  
 73325 TSBP1 COMMON 1  
 73314 COMMON 8  
 73314 PEQM COMMON 1  
 73313 CRUMY COMMON 1  
 73312 CRUMB COMMON 1  
 73273 COMMON 14  
 73273 GRUB2 COMMON 1  
 73261 COMMON 9  
 73261 GRUB1 COMMON 1  
 73251 COMMON 7  
 73251 GRAB2 COMMON 1  
 73243 COMMON 5  
 73243 GRAB1 COMMON 1  
 73241 COMMON 1  
 73241 MUSE1 COMMON 1  
 73235 COMMON 3  
 73235 LTS COMMON 1  
 73234 ASD COMMON 1  
 73233 TIFJL COMMON 1  
 73232 SPN COMMON 1  
 73231 PRFLG COMMON 1  
 73227 COMMON 1  
 73227 37HED COMMON 1  
 \* SPECIAL PRINT ONLINE OR 3070 SS6  
 73226 SP1A COMMON 1 SINGLE SPACE  
 73225 SP2A COMMON 1 DOUBLE SPACE  
 73224 SP3A COMMON 1 SUPPRESS SPACE  
 73223 EJCTA COMMON 1 EJECT PAGE  
 \* FINE PRINT OFF LINE  
 73222 SP1B COMMON 1 SINGLE SPACE  
 73221 SP2B COMMON 1 DOUBLE SPACE  
 73220 SP3B COMMON 1 SUPPRESS SPACE  
 73217 EJCTB COMMON 1 EJECT PAGE  
 \* FINE PRINT ONLINE OR 3070 SS6,SS4  
 73216 SP1C COMMON 1 SINGLE SPACE  
 73215 SP2C COMMON 1 DOUBLE SPACE  
  
 73214 SP3C COMMON 1 SUPPRESS SPACE  
 73213 EJCTC COMMON 1 EJECT PAGE

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ENTRY POINTS TO REMINDBFLG	SUBROUTINES READB RESTKA	REQUESTED FROM LIBRARY SETHI REQIND	WRITEN PRCON	ENDFIL CKIND	BSREC CKACT	ENDOUT WRITEN	UNLOAD	OUTUS	ACTIND
THE NAME OF THIS PROGRAM IS *SFPRO *									
4/17/65									
ENTRY NAME	ENTRY ADD.	TRANSFER VECTORS	LOAD ADD.	OCTAL LENGTH	DECIMAL LENGTH	COMMON BREAK			
TL	22302	*NONE*	22300	00012					
DUMMY	22306								
DATCEL	22310								
CG	22303								
REGSAV	22300								
REGSTR	22301								
EXPORT	22307								
NARSMM	22322	SIN	22312	00240	00160				
NARSPC	22433	COS							
NARFIX	22446	CROSS							
PHAT	22533	UNIT							
PPHAT	22522	FIX							
MMA	22517	FLOAT							
CANCLK	23177	MATRIX	22552	01010	00520				
PLOTFO	23056	REMINDB							
PLLLT	22726	READB							
PLTSET	22572	STABCO							
FILEND	23057	PAGHCO							
RECNUM	23412	3LATZ							
		SAVLEIT							
		ABDRIT							
		LAUNCH							
		FLOTT							
		ADD							
		CWI							
		CHANGE							
		SIN							
		COS							
		GCE							
LOC10	23562	*NONE*	23562	00074	00060	77151			
LN	23566								
SQRT	23656	*NONE*	23656	00052	00042	77151			
SIN	23730	*NONE*	23730	00237	00159	77151			
COS	23733								
QSIN	23737								
QCOS	23741								
CROSS	24217	SQRT	24167	00103	00067	77151			
PROD	24170								
UNIT	24251								
ARTAN	24272	*NONE*	24272	00071	00057				
DAYS	24366	FIX	24363	00031	00025	77151			
		FLOAT							
		ADD							
		*NONE*							
ADD	24414	*NONE*	24414	00031	00025	77151			
FIXT	24446	FLOAT	24445	00257	00175				
FLOT	24551								
FIX	24724	*NONE*	24724	00012	00010				
FLOAT	24730								
CHANGE	24742	GRUP	24736	00035	00029				
		ORBETT							
		SPRAY							
		PRINTD							
ECLIP	24776	COS	24773	00056	00046				
		SIN							
		MATRIX							
RVIN	25060	COS	25051	00310	00200				
RYOUT	25203	SIN							
		MATRIX							
		PROD							
		ARTAN							
		UNIT							
		ARSIN							
GHA	25364	DAYS	25361	00105	00069				
		FIX							
		FLOAT							
GEDLAT	25470	SIN	25466	00056	00046	77151			
		SQRT							
GETTER	25546	PROD	25544	00046	00038				
		ARCOS							
SPACE	25616	COS	25612	00226	00150	77133			
EARTH	25716	SIN							
		RVOUT							
CLUCK	26044	RVIN	26040	00113	00075				
		UNIT							
		CROSS							
		PROD							
		ARTAN							
BCDNO	26156	PROD	26153	00045	00037				
MEMBEO	26201	ERPRIT							
		ABOHT							
ARSIN	26224	*NONE*	26220	00140	00096	77151			
ARCOS	26220								
MDLF	26366	DPRFLG	26360	00115	00077				
MACH	26473	PRSET							
TEM	26472	TIME1							
		PROUT							
		TIME							
		KERN1							
RDTEQ	26476	MNAET	26475	00154	00108				
DELTJD	26642								
DIST	26732	PROD	26651	00063	00051				
PATH	26652								
TIME1	26752	DPRFLG	26734	00446	00294	77123			
TIME2	26755	EQUNX1							
TIME3	26760	TARHCO							
LAUNCH	27364	INJEOX							
		DAYS							
		FIXT							
		ADD							
		FIX							
		FLOAT							
		GRUPPE							
		PROUT							
		FLOT							
		TL							
REA01	27452	SETHI	27402	00343	00227				
READN	27521	READB							
SCDATE	27653	RUNID							
SPAN	27614	REWIND							
READC	27537	FLGWRD							
		VARFLG							
		PROUT							
		ERPRIT							
		ABOHT							
		SPASH							
		SCFORF							
		SPGBCO							
		TARHCO							
		INJBCO							
		INJYTP							

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		INJX			
		INJDX			
		RMAX			
		RHL			
		INJTOT			
		INJEX			
		RRUPT			
		RRDUPT			
		GASUPT			
		NEWROU			
		TARAD			
		GRAV			
		LUNGRV			
		DOT			
		EGM			
		HARMN2			
		SCTIME			
		DELJJD			
		MNALT			
		NUT+PH			
		SCBEGT			
		SCENDT			
		KRPAI			
SAVEIT	27750	JJ			
FILE	30062	WRITEB	27745	00157	00111
		ENDFIL			
SEITE	40176	BSRLC			
CASE	40200	DATEL	30124	00201	00129
EJECT	30176	PROUT			
LINES	30201				
EJECT1	30177				
PAGGCD	30204				
SPGCD	30254				
GRUPPL	30330	EJECT1	30325	00016	00014
		LINES			
		SEITE			
EFFECT	30344	GRUPI	30343	00050	00040
SPRAY	30414	GRUP	30413	00013	00011
PRSET	30657	PROUT	30426	01255	00685
DPSET	31677	ENDOUT			73212
ERPRT	30566	OPRFLG			
JEXIT	31003	EXPGR			
ABORT	31002	KEAUC			
*****	31143	GRUPE			
TIME	30752	INJT			
PRTSWK	31660	INJTOT			
FLAG42	31653	INJGCD			
RUNID	31654	HRDUY			
		PLNTFQ			
		FILE			
		FILENG			
		RECNUM			
		FLUSH			
		BTQ			
		BTC			
		BTQ			
		BIT			
		BRQ			
		BRC			
		HRT			
		HRT			
		TFD			
		TFH			
		TFM			
		TFIND			
		TFLIM			
		JULD			
		TARUAD			
		PAGGCD			
		TARHCD			
		FAZ+LG			
		INJIYV			
		INJX			
		INJY			
		INJZ			
		INJDX			
		INJUY			
		INJGZ			
		RMAX			
		RHL			
		INJLOX			
		MOPRH1			
		MOPRH2			
		MOPRH3			
		MOPRH4			
		MOPRH5			
		MOPRH6			
		MOPRH7			
		MOPRH8			
		VENPH1			
		VENPH2			
		VENPH3			
		VENPH4			
		VENPH5			
		VENPH6			
		VENPH7			
		VENPH8			
		MARPH1			
		MARPH2			
		MARPH3			
		MARPH4			
		MARPH5			
		MARPH6			
		MARPH7			
		MARPH8			
		STACED			
		STALCD			
		FRO			
		TARAU			
		LUNGRV			
		SCALE1			
		GRAV			
		RRUPT			
		RRDUPT			
		DIPLPI			
		VRGKOP			
		NEWROU			
		HASPHN			
		TARFX			
		NUT+PH			
		MNALT			
		LALUNCH			
		PURHIC			
		PRTSTIP			
		CANCO			
		PRPLTA			
		PRDU1B			
		PRDU1C			
		PRDU1D			
		TMW			
		FODIUT			

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PHL	33224	LABEL				
RMAX	33225	TRAJ	31703	01330	00728	
ROD	33023	E-T				
NUTATE	32761	ROTEQ				
RESET	33202	MNA				
INTRAN	31730	GHA				
CANSO	33221	GRUPPE				
INJBCG	32357	EPHSET				
INJTYG	32360	GRAV				
INJX	32361	LUNGRV				
INJY	32362	RUNID				
INJZ	32363	SCALE1				
INJDX	32364	PROUT				
INJOY	32365	RADUPT				
INJZJ	32366	BRNOPT				
INJCKX	32367	TIME2				
HARMN2	32370	MNAE1				
GASCPT	32406	NUTMAT				
CENTRS	32535	MATKIX				
SCTIME	32440	INTK1				
		UNIT				
		EQUNX1				
BTB	36200	PXSET	33233	03067	01591	73234
LODP	33300	MATRIX				
CW1	33254	UNIT				
STABCD	35054	PROG				
STACCKD	35154	SIN				
STAI	35671	COS				
PETE	35150	ARSIN				
FRQ	36101	ARTAN				
SLIT	36120	ARCUS				
BLATZ	35305	CROSS				
HASPAN	36025	CLUCK				
		GETTER				
		LOGIG				
		GRAV				
		PLOTFG				
		GRUPPE				
		PROUT				
EPHSET	42431	NEWBCO	36322	04404	02308	
BNTR2	42431	FIX				
ANTR1	42513	TARAD				
INTK1	42513	CENTRS				
GRAV	42360	CENDES				
SCALE1	42354	DAYS				
DUT	42356	EPHEM				
E-T	42722	GRUPPE				
EGP	42352	PHOUT				
NEWBOC	42346	ERPR1				
NUTLOH	36562	ABOHT				
BODYTAB	42405	UNLOAD				
		TAPEX				
		EPTAPE				
EPHEM	42732	REMINU	42726	01456	00814	
TAPEX	44112	REAGR				
EPTAPE	44264	BSREC				
PROUT	44416	OUTUS	44404	02715	01485	
EODDLT	44571	ACTIND				
PRCNU	44507	BFLU				
PROUT2	44474	KFSIKA				
PROUT3	44500	REQIND				
TSXA	44641	PRCDM				
SPROUT	44416	CRIND				
LABEL	47251	CKACT				
TMWD	47252	WRITED				
FLUSH	47230					
PROUTA	46243					
PROUTB	46245					
PROUTC	47221					
PROUTD	47254					
MNA	47333	FIX	47321	01651	00937	77041
MNA1	47332	LOAD				
MNAMD	47363	CDS				
MNAMD1	47362	SIN				
MATRIX	50544	SORT				
NUTMAT	51034	ARTAN				
LUNGRV	50624	BODTAB				
NUTLCN	51032	ANTK1				
NUTDBL	51033	NUTLOB				
NUTEPH	51167					
MNAE1	51166					
SPASM	51172	*NONE*	51172	02527	01367	
HC	51364					
NI	51365					
TGLO	51372					
Y	51422					
YDDT	51423					
Y(2)	51424					
YO	51425					
YO(2)	51426					
BABTB	51566					
DELX	51472					
J	51366					
HD	51451					
ND	51433					
JJ	52472					
SET	52514					
CONIC	56601	SPRAY	53721	05404	02820	73212
USERV	57005	EFFECT				
PRINTD	54035	ROT				
TARAD	56215	PRSET				
CLAPP	60652	ORBETT				
SAC	56555	EQUNX1				
SAVA	56733	RESET				
IMPFLG	60653	TIME1				
PRINTD1	54034	DAYS				
GRDP1	56155	ARTAN				
BTQ	56560	PROD				
BTC	56561	ARSIN				
BTO	56562	GETTER				
BTI	56563	SIN				
BRQ	56564	SPACE				
BRC	56565	RVOUT				
BRO	56566	GEDLAT				
BRT	56567	HC				
TFD	56571	CANCLK				
TFH	56572	CLUCK				
TFM	56573	ECLIP				
TFLIND	56574	GRUPPE				
TFLINH	56575	GRAV				
JULD	56576	PROUT				
CENDES	54025	LODP				
PUBLIC	61250	UNIT				
GCE	56200	ARCOS				
		CROSS				
		MNA				
		MNAMD1				
		MATRIX				
		MARSMH				
		MARSPC				
		MARFIX				

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		MHA				
		INJFLG				
		NUTATE				
		ERPRT				
		ABORT				
		GRDP				
		COS				
		CANSO				
		JEKYL				
		CLASS				
		SPECL				
		ADD				
		TIME3				
		INJBCD				
		BCDNO				
		SQRT				
		LN				
		INJTYP				
		UIST				
		SQRT	61325	02313	01227	76716
		UNIT				
		CRINS				
		LN				
		ARTAN				
		ARCUS				
		SIN				
		HARMN2				
		INJTYP				
		SAVA				
		RMAX				
		READ1	63640	03627	01943	73212
		CASL				
		IMPFLG				
		CLAPP				
		BNTK2				
		BCDNO				
		PLTSET				
		EJECT				
		SEITE				
		FLOT				
		INJBCD				
		INTRAN				
		INTR1				
		PRDU				
		WOLF				
		CW1				
		BTR				
		SPRAY				
		STALRD				
		ADD				
		SET				
		SPAM				
		PRSET				
		PROUT				
		PRINTU				
		ERPRT				
		HC				
		ADORT				
		TIME1				
		GRUPPE				
		ROT				
		LOOP				
		CHANGE				
		TAKAD				
		PATN				
		PLLLT				
		PRNTD1				
		PLDTFO				
		BSREC				
		REGNUM				
		GETTER				
		ARSIN				
		READN				
		JJ				
		FLOTAT				
		GRAY				
CLAS1	62760					
SPEC1	63335					
JEKYL	61467					
FLQRH1	67331					
SCFORF	67451					
SCREGT	67452					
SCENDT	67454					
MOOPH1	66576					
MCOPH2	66646					
MCOPH3	66716					
MCOPH4	66766					
MCOPH5	67036					
MCOPH6	67106					
MCOPH7	67156					
MCOPHH	67226					
VENPH1	66716					
VENPH2	66766					
VENPH3	67036					
VENPH4	67106					
VENPH5	67156					
VENPH6	67226					
VENPH7	66576					
VENPHH	66646					
MARPH1	67106					
MARPH2	67156					
MARPH3	67226					
MARPH4	66576					
MARPH5	66646					
MARPH6	66716					
MARPH7	66766					
MARPHH	67036					
INJUT	67303					
TARHC1	67364					
RADOPT	67372					
LAST	67401					
REND	67402					
REND1	67404					
MODE1	67406					
KERN1	67407					
GJHO	67410					
RKHO	67412					
HBOOY	67413					
PRT0	67414					
OPRT0	67416					
OPRT	67430					
GRDP	67434					
CCDE1	67435					
VIEN	67437					
PASH	67443					
CRBET1	67447					
EGUNK1	67450					
OPRFLG	67455					
BRNOP1	67441					
DEPOP1	67333					
VPKOP	65205					
INJFLG	67330					
TRAJ	63722					
TARN	67332					
TARGAD	67323					
FAZ1LG	67370					
INJ1	67366					
FLOTT	65326					
VANFLG	67400					
DOT	66301					
PR1STP	67336					
READD	67470	(ICU)	67467	00365	00245	
READB	67472					
WRITEU	67475					
WRITEB	67477					
BSREC	67706					
BSFILE	67711					
REWINO	67714					
UNLODU	67717					
ENDFIL	67722					
SETLDA	67700					
SETHI	67703					
(UNIT)	70051					
TAP1D	70051					
(ICU)	70057					
OUTUS	70106	*NONE*	70054	00030	00024	
BFLG	70142	RUGSAV	70104	02320	01232	
ENCOUT	70473	RUGSTR				
CKIND	72335					
CKACT	72400					
REQIND	72334					
ACTIND	72333					
RESTRK	72331					
PLICCN	72414					
PL2CON	72415					
PL3CON	72416					
PRLCN	72417					

\*SFPRO \* JUST LOADED.

UNUSED LOC. LIES FROM 72424 THROUGH 73212, LEAVING 00567 OCTAL OR 00375 DECIMAL LOCATIONS.

E. INPUT FORMS

JPL SFPRØ SPECIAL OUTPUT CONTROL		Name	DATE
ID NAME	VALUE	EXPLANATION	12-1-64
PAGBCD+11=		PAGE HEADING	
PAGBCD+3V=		(A SECOND LINE OF PAGE HEADING IS AVAILABLE BY INPUT INTOØ	
PAGBCD+6V=		PAGBCD+20 THROUGH PAGBCD+39)	
PAGBCD+9V=			
PAGBCD+12=			
PAGBCD+15=			
PAGBCD+18=			
FAZFLG=		NØN-ZERØ = AUTØMATIC PHASING	
RUNID = ( )		RUN I.D.	
PLØTFQ =		SAVE TAPE FLAG AND FREQ. BY STEP	
PLØTFQ+1=		PHYSICAL FILE NØ.	
PLØTFQ+2=		TIME INCREMENT ADDED TO TIME PAST INJ. SEC	
PLØTFQ+3=		STATIONS (MAXIMUM OF FIVE)	
PUBLIC =		Ω ROTATION ANGLE DEG	
PUBLIC+1=		S SCALE FACTØR BØARD UNITS/KM	
PUBLIC+2=		US LØC. SUN-HØRIZØNTAL BØARD UNITS	
PUBLIC+3=		VS LØC. SUN-VERTICAL BØARD UNITS	
CAN50=		BØDY-CANØPUS UNIT 1950.0 POSITION (-060340592	
LAUNCH=		LAUNCH EPØCH .60342839	
TARGAD=		ALT. ABØVE TARGET TO END RUN KM	
VPGRØP=		PRINT GRØUP CØNIC FLAGS USED AT VIEW PERIØDS	
FLAG42=		NØN-ZERØ PUTS ØUTPUT IN SC4020 MØDE	
PRTSWX=		NØN-ZERØ = PRINT EVERY CASE	
PRSTP =		NØN-ZERØ = PRINT EVERY END ØF STEP	
PRSTP+1=		PRINT GRØUP CØNIC FLAGS USED AT END ØF STEP	
DEPØPT =		O=NØ DEP.VAR. 1=PRINT -1=END PHASE	
DEPØPT+1=		LØCATION ØF DEPENDENT VARIABLE	
DEPØPT+2=		VALUE OF DEPENDENT VARIABLE	
ØPTSWT =		ØN-LINE ØUTPUT CØNTROL -1=EXTERNAL SET	
		O=NØ ØN-LINE PRINT 5=FINE 1=MINIMUM	





JPL SFPRØ STATION CONSTANTS		Name	DATE
ID NAME	VALUE	EXPLANATION	12-1-64
FRQ+1V=	FLØ 950.15E6	A1I	
FRQ+2V=	FLØ 1.0	A2I	
FRQ+3V=	FLØ 1.0	A3I	
FRQ+4V=	FLØ 32.3595506	A4I	
FRQ+5V=	FLØ 1E5	A5I	
FRQ+6V=	FLØ 1.0	A6I	
FRQ+7V=	FLØ .455E6	A7I	
FRQ+8V=	FLØ 960.05E6	RF1	
FRQ+9V=	FLØ 22.6822E6	RF2, K3	
FRQ+10=	FLØ 32.4402	K1	
FRQ+11=	FLØ 20.	K2	
FRQ+12=	FLØ 960.05E6	RFB, B5	
FRQ+13=	FLØ 1.0	B6	
FRQ+14=	FLØ 960.05E6	FA	
FRQ+15=	FLØ 30.434E6	FI	
FRQ+16=	FLØ 29792.5	SLIT	
FRQ+17=	FLØ 23.5E6	SK1	
FRQ+18=	FLØ 23.5E6	LSK1	
FRQ+19=	FLØ 2295.E6	LSFT	
FRQ+20=	FLØ 2295.E6	SFT	
HASPN=	FLØ 22.E6	FRQ))	
HASPN=	FLØ 90.	HØUR ANGLE CONSTRAINT FOR HA-DEC STATIONS, DEG	
STACRD-4=	FLØ -10.0	ELEV. ANGLE TO START STATION PRINTS	
STACRD-3=	FLØ 5E-4	ELEV. TOLERANCE FOR VIEW PERIODS	
STACRD-2=	FLØ 5E-6	ELEV. RATE TOLERANCE FOR VIEW PERIODS	
STACRD-1=	FLØ 5.0	ELEV. ANGLE TO START, END VIEW PERIODS	
STABCD+C	BCD	STATION A NAME: FØUR BCD WØRDS	
STACRD+C	FLØ	STATION A CØRD: LAT., LØNG., R., CØDE, DUMMY CØDE=0=AZ - EL; 1=HA-DEC	
STABCD+0	BCD	STATION B NAME	
STACRD+0	FLØ	STATION B CØRD.	
STABCD+0	BCD	STATION C NAME	
STACRD+0	FLØ	STATION C CØRD.	
STABCD+0	BCD	STATION D NAME	
STACRD+0	FLØ	STATION D CØRD.	

F. SPACECRAFT EPHEMERIS TAPE FORMAT

JPL TECHNICAL MEMORANDUM NO. 33-199

TAPE ID RECORD

BUFFER NAME	NUMBER OF PARAMETERS	DESCRIPTION
RUNID	1	BCD S/C EPHEMERIS IDENTIFICATION
FLGWRD	1	CURRENT STATUS FLAG WORD
SCFORF	1	DATA RECORD FORMAT FLAG
PAGBCD	40	SPACE PAGE HEADING
TARBCD	1	BCD TARGET NAME
INJBOD	1	BCD INJECTION CENTRAL BODY NAME
INJTYP	1	TYPE OF INJECTION CONDITIONS
INJT	2	SEXAGESIMAL INJECTION EPOCH
INJX	3	INJECTION CONDITIONS
INJDX	3	
RMAX	1	
PHL	1	
INJTDI	1	DELTA TIME ADDED TO INJT
INJEQX	1	INJECTION EQUINOX
BRNDPT	18	MOTOR BURN INPUT PARAMETERS
RADOPT	6	RADIATION PRESSURE INPUT PARAMETERS
GASOPT	17	GAS JETS INPUT PARAMETERS
NEWBOD	4	BODY TO REPLACE SATURN OPTION
TARAD	7	TABLE OF BODY RADII
GRAY	7	N-BODY GM'S
LUNGRV	4	LUNAR POTENTIAL CONSTANTS
OMEGAO	1	ROTATION RATE OF THE EARTH
DUT	1	DIFFERENCE=ET-UT
EGM	4	GM'S USED FOR EPHEMERIS
HARMN2	14	OBLATENESS CONSTANTS FOR EARTH AND MARS
VARFLG	1	VARIATIONAL EQUATIONS FLAG
TIM	1	TIME OF DAY OF S/C EPHEMERIS GENERATION
MACH	1	MACHINE USED IN S/C EPHEMERIS GENERATION
SYSDAT	1	DATE OF S/C EPHEMERIS GENERATION
DELTJD	2	JD 1950.0 - JD 0 HR JAN 1, 1950
MNAET	1	FLAG TO DESIGNATE FREQ OF COMPUTATION OF MATRICES
MUTEPM	1	FLAG TO DESIGNATE WHERE TO GET NUTATIONS
SCBEGT	2	EPOCH TO START WRITING S/C EPHEMERIS
SCENDT	2	EPOCH TO STOP WRITING S/C EPHEMERIS
CX	6	INJECTION CONDITIONS MEAN 1950.0 EARTH EQ.

TAPE DATA RECORD

BUFFER NAME	NUMBER OF PARAMETERS	DESCRIPTION
RUNID	1	BCD S/C EPHEMERIS IDENTIFICATION
FLGWRD	1	CURRENT STATUS FLAG WORD
KERN1	1	BCD CENTRAL BODY NAME
JJJJJ	1	DIFFERENCE COUNT
HC	1	STEP SIZE FOR RECORD
TTTTT	2	END TIME FOR RECORD
JJ	1	NUMBER OF INTEGRATION STEPS TAKEN
DISTIM	2	DISCONTINUITY TIME IN RECORD
HBANK+4	6/42	POSITION
HBANK+108	6/42	VELOCITY
HBANK+264	6/42	DELTA 0
HBANK+316	6/42	DELTA 1
HBANK+368	6/42	DELTA 2
HBANK+420	6/42	DELTA 3
HBANK+472	6/42	DELTA 4
HBANK+524	6/42	DELTA 5
HBANK+576	6/42	DELTA 6

V. OUTPUT

A. SAVE TAPE FORMAT

JPL TECHNICAL MEMORANDUM NO. 33-199

VARIABLES STORED ON THE TRAJECTORY SAVE TAPE ARE REFERENCED TO A S/C,GEO,HELIO,OR TARGETCENTRIC COORDINATE SYSTEM. ALL UNITS ARE MADE UP OF KM,SEC,DEGREES UNLESS STATED

VAR.NO. DESCRIPTION

- 1-2 DOUBLE PRECISION TIME IN SECONDS PAST 1950.0
- 3 TIME IN SECONDS PAST INJECTION
- 4 CENTRAL BODY NUMBER
- 5 TARGET BODY NUMBER
- 6-8 GEOCENTRIC EARTH-PROBE POSITION VECTOR
- 9-11 GEOCENTRIC EARTH-PROBE VELOCITY VECTOR
- 12 GEOCENTRIC LATITUDE OF THE PROBE
- 13 GEOCENTRIC LONGITUDE OF THE PROBE
- 14 GEOCENTRIC EARTH-PROBE POSITION VECTOR MAGNITUDE
- 15 DECLINATION OF THE PROBE
- 16 RIGHT ASCENSION OF THE PROBE
- 17 GEOCENTRIC EARTH-PROBE VELOCITY VECTOR MAGNITUDE
- 18 INERTIAL PATH ANGLE
- 19 INERTIAL AZIMUTH ANGLE
- 20 ALTITUDE OF PROBE ABOVE EARTH
- 21 RT. ASCENSION OF THE EARTH IN THE S/C COORDINATE SYSTEM
- 22 DECLINATION OF THE TARGET IN THE S/C COORDINATE SYSTEM
- 23 RT. ASCENSION OF THE TARGET IN THE S/C COORDINATE SYSTEM
- 24 HELIOCENTRIC SUN-PROBE POSITION VECTOR MAGNITUDE
- 25 HELIOCENTRIC LATITUDE OF THE PROBE
- 26 HELIOCENTRIC LONGITUDE OF PROBE
- 27 ALTITUDE OF PROBE ABOVE ECLIPTIC PLANE
- 28 (HELIO. SUN-PROBE R MAG.)(SIN (HELIO. LONG. OF PROBE))
- 29 (HELIO. SUN-PROBE R MAG.)(COS (HELIO. LONG. OF PROBE))
- 30 EARTH-PROBE-SUN ANGLE
- 31 EARTH-PROBE-TARGET ANGLE
- 32 EARTH-PROBE-NEAR LIMB OF TARGET ANGLE
- 33 SUN-EARTH-PROBE ANGLE
- 34 SUN-PROBE-NEAR LIMB OF EARTH ANGLE
- 35 SUN-TARGET-PROBE ANGLE
- 36 MOON-EARTH-PROBE ANGLE
- 37 MOON-PROBE-SUN ANGLE
- 38 EARTH-PROBE-MOON ANGLE
- 39 TARGET-PROBE-SUN ANGLE
- 40 CANOPUS CLOCK ANGLE EARTH CENTER
- 41 MOON CLOCK ANGLE EARTH CENTER
- 42 TARGET CLOCK ANGLE EARTH CENTER
- 43 TARGETCENTRIC TARGET-PROBE POSITION VECTOR MAGNITUDE
- 44 TARGETCENTRIC TARGET-PROBE VELOCITY VECTOR MAGNITUDE
- 45 ALTITUDE OF PROBE ABOVE TARGET
- 46 ANGULAR SEMI DIAMETER OF TARGET
- 47-49 SELENOCENTRIC MOON-PROBE POSITION VECTOR
- 50-52 HELIOCENTRIC SUN-PROBE POSITION VECTOR
- 53-55 APHRODIOCENTRIC VENUS-PROBE POSITION VECTOR
- 56-58 AREOCENTRIC MARS-PROBE POSITION VECTOR
- 59-61 CRONOCENTRIC SATURN-PROBE POSITION VECTOR
- 62-64 ZEOCENTRIC JUPITER-PROBE POSITION VECTOR
- 65 TIME PAST LAUNCH (ZERO IF NO LAUNCH EPOCH IS GIVEN)
- 66 DAYS PAST MIDNIGHT OF LAUNCH (ZERO IF NO LAUNCH EPOCH IS GIVEN)
- 67 EARTH CLOCK ANGLE
- 68 CANOPUS-PROBE-EARTH ANGLE
- 69 CANOPUS-PROBE-SUN ANGLE
- 70-72 ZERO

VARIABLES STORED ON THE TRAJECTORY SAVE TAPE REFERENCED TO A TOPOCENTRIC COORDINATE SYSTEM AT A VIEWING STATION (MAXIMUM OF FIVE STATIONS)

STAT. 1	STAT. 2	STAT. 3	STAT. 4	STAT. 5	VARIABLE
73-76	109-112	145-148	181-184	217-220	1-4 STATION NAME, BCD
77	113	149	185	221	5 AZIMUTH ANGLE
78	114	150	186	222	6 ELEVATION ANGLE
79	115	151	187	223	7 HOUR ANGLE
80	116	152	188	224	8 DECLINATION
81	117	153	189	225	9 SLANT RANGE
82	118	154	190	226	10 AZIMUTH RATE
83	119	155	191	227	11 ELEVATION RATE
84	120	156	192	228	12 HOUR ANGLE RATE
85	121	157	193	229	13 DECLINATION RATE
86	122	158	194	230	14 SLANT RANGE RATE
87	123	159	195	231	15 SLANT RANGE ACCEL.
88	124	160	196	232	16 PROBE RIGHT ASCENSION
89	125	161	197	233	17 F1 CPS
90	126	162	198	234	18 F2 CPS
91	127	163	199	235	19 1-WAY DOPPLER RATE CPS**2
92	128	164	200	236	20 2-WAY DOPPLER RATE CPS**2
93	129	165	201	237	21 BEACON FREQUENCY CPS
94	130	166	202	238	22
95	131	167	203	239	23
96	132	168	204	240	24
97	133	169	205	241	25
98	134	170	206	242	26
99	135	171	207	243	27 TRANSMITTER REF. CPS
100	136	172	208	244	28 DOPPLER RATE CPS**2
101	137	173	209	245	29 SPACE LOSS DB
102	138	174	210	246	30 POLARIZATION ANGLE
103	139	175	211	247	31 PROBE-STATION-SUN ANGLE
104	140	176	212	248	32 PROBE-STATION-MOON ANGLE
105	141	177	213	249	33 STATION-PROBE-SUN ANGLE
106	142	178	214	250	34 CANOPUS CLOCK ANGLE
107	143	179	215	251	35 MOON CLOCK ANGLE
108	144	180	216	252	36 TARGET CLOCK ANGLE

B. PRINTED OUTPUT FORMAT AND DEFINITIONS

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CONSTANTS

LINE A  
CASE (NO.) IBSYS-JPTRAJ-SFPRO (DATE) (PAGE NO.)

LINE B  
(FIRST LINE OF PAGE HEADING FROM SPACE )

LINE C  
(SECOND LINE OF PAGE HEADING FROM SPACE )

LINE D  
(THIRD LINE OF PAGE HEADING FROM SFPRO )

LINE E  
(FOURTH LINE OF PAGE HEADING FROM SFPRO )

LINE F  
DOUBLE PRECISION EPHEMERIS TAPE - EPHEM1

LINE G  
S/C EPHEMERIS WRITTEN (TIME) (DATE) RUNID=( )

LINE H  
GM GRAVITATIONAL COEFFICIENT FOR THE EARTH IN KM<sup>3</sup>/SEC<sup>2</sup>  
J COEFFICIENT OF THE SECOND HARMONIC IN EARTHS OBLATENESS  
H COEFFICIENT OF THE THIRD HARMONIC IN EARTHS OBLATENESS  
D COEFFICIENT OF THE FOURTH HARMONIC IN EARTHS OBLATENESS  
RE EARTH RADIUS TO BE USED IN THE EARTHS OBLATE POTENTIAL, KM  
REM EARTH RADIUS TO CONVERT LUNAR EPHEMERIS TO KM

LINE I  
G UNIVERSAL GRAVITATIONAL CONSTANT FOR LUNAR OBLATENESS, KM<sup>3</sup>/SEC<sup>2</sup>-KG  
A MOMENTS OF INERTIA OF MOON FOR LUNAR OBLATE POTENTIAL,KG-KM<sup>2</sup>  
B  
C  
OME ROTATION RATE OF THE EARTH IN DEG/SEC  
AU ASTRONOMICAL UNIT TO CONVERT PLANETARY EPHEMERIDES TO KM

LINE J  
GM GRAVITATIONAL COEFFICIENT FOR THE MOON IN KM<sup>3</sup>/SEC<sup>2</sup>  
GMS GRAVITATIONAL COEFFICIENT FOR THE SUN IN KM<sup>3</sup>/SEC<sup>2</sup>  
GMV GRAVITATIONAL COEFFICIENT FOR VENUS IN KM<sup>3</sup>/SEC<sup>2</sup>  
GMA GRAVITATIONAL COEFFICIENT FOR MARS IN KM<sup>3</sup>/SEC<sup>2</sup>  
GMC GRAVITATIONAL COEFFICIENT FOR SATURN IN KM<sup>3</sup>/SEC<sup>2</sup>  
GMJ GRAVITATIONAL COEFFICIENT FOR JUPITER IN KM<sup>3</sup>/SEC<sup>2</sup>

LINE K  
EGM EARTHS GM, USED WITH EPHEMERIDES, NOT PERTURBATIONS, KM<sup>3</sup>/SEC<sup>2</sup>  
MGM MOONS GM, USED WITH EPHEMERIDES, NOT PERTURBATIONS, KM<sup>3</sup>/SEC<sup>2</sup>  
JA COEFFICIENT OF THE SECOND HARMONIC IN MARS OBLATENESS  
HA COEFFICIENT OF THE THIRD HARMONIC IN MARS OBLATENESS  
DA COEFFICIENT OF THE FOURTH HARMONIC IN MARS OBLATENESS  
RA MARS RADIUS TO BE USED IN THE MARS OBLATE POTENTIAL, KM

ACCELERATIONS

LINE I (IF SOLAR RADIATION PRESSURE IS REQUESTED)  
RADIATION PRESSURE INPUT

LINE J (IF SOLAR RADIATION PRESSURE IS REQUESTED)  
ARA AREA OF SPACECRAFT, SQUARE METERS  
GB MULTIPLE OF PERCENT OF REFLECTED RADIANT ENERGY  
MAS MASS OF SPACECRAFT,KG  
GB1 CONSTANT COEFFICIENT OF POLYNOMIAL, RADIAN-SQUARE METERS  
GB2 LINEAR COEFFICIENT OF POLYNOMIAL,RADIANS-SQUARE METERS/DEG  
SC SOLAR RADIATION CONSTANT, (KG-KM/SQUARE SEC)<sup>1-6</sup>

LINE K (IF GAS JETS ARE REQUESTED)  
ATTITUDE CONTROL INPUT

LINE L (IF GAS JETS ARE REQUESTED)  
GAS FLAG  
GRB REFERENCE BODY  
GS1 START TIME SEG. YMMDDHH  
GS2 MMSFFF  
GDT DELTA T ADDED TO START TIME,SEC

LINE M (IF GAS JETS ARE REQUESTED)  
GE1 END TIME SEG. YMMDDHH  
GE2 MMSFFF  
GMS MASS,KG  
GAD FA POLYNOMIAL QUADRATIC TERM  
GAI LINEAR TERM  
GA2 CONSTANT TERM

LINE N (IF GAS JETS ARE REQUESTED)  
GBO FB POLYNOMIAL QUADRATIC TERM  
GB1 LINEAR TERM  
GB2 CONSTANT TERM  
GCO FC POLYNOMIAL QUADRATIC TERM  
GCI LINEAR TERM  
GC2 CONSTANT TERM

LINE O (IF MOTOR BURN IS REQUESTED)  
MOTOR BURN INPUT

LINE P (IF MOTOR BURN IS REQUESTED)  
BRN FLAG FOR BURN IF ZERO NO BURN  
BT1 START TIME IN SEG. YMMDDHH  
BT2 MMSFFF  
BDT DURATION OF BURN,SEC  
BC3 VALUE OF ENERGY FOR SHUT OFF, KM<sup>2</sup>/SEC<sup>2</sup>  
BMU BIAS ANGLE,DEG

LINE Q (IF MOTOR BURN IS REQUESTED)  
BCF GUIDANCE FLAG  
BOD BODY FROM WHICH TO MEASURE ALTITUDE TO START BURN  
BAL ALTITUDE ABOVE BODY TO START BURN,KM  
BWT WEIGHT OF VEHICLE,POUNDS  
BW. FLOW RATE,POUNDS/SEC  
BTH THRUST,POUNDS FORCE

LINE R (IF MOTOR BURN IS REQUESTED)  
BPG PRINT GROUPS DURING BURN  
BPC CONIC GROUPS DURING BURN  
BCK X COMPONENT OF C VECTOR,KM  
BCY Y  
BCZ Z



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INJECTION CONDITIONS

LINE A  
INJECTION CONDITIONS (EQUINOX) (TARGET) (DP SEC PAST 1950) (JD) (CALENDAR DATE)

LINE B (INCLUDES ONE OF THE \* LINES BELOW)  
(CENTRAL BODY)

\*IF COORDINATES ARE INERTIAL CARTESIAN  
X0 VERNAL EQUINOX CARTESIAN POSITION, KM  
Y0  
Z0  
DX0 VERNAL EQUINOX CARTESIAN VELOCITY, KM/SEC  
DY0  
DZ0

\*IF COORDINATES ARE SPHERICAL INERTIAL  
RAD RADIUS, KM  
DEC DECLINATION, DEG  
RA RIGHT ASCENSION, DEG  
V VELOCITY, KM/SEC  
PTH PATH ANGLE, DEG  
AZI AZIMUTH ANGLE, DEG

\*IF COORDINATES ARE EARTH-FIXED OR SELENOGRAPHIC  
RAD RADIUS, KM  
LAT LATITUDE, DEG  
LON LONGITUDE, DEG  
VE VELOCITY RELATIVE TO ROTATING COORDINATE SYSTEM, KM/SEC  
PTR PATH ANGLE RELATIVE TO ROTATING COORDINATE SYSTEM, DEG  
AZR AZIMUTH ANGLE RELATIVE TO ROTATING COORDINATE SYSTEM, DEG

\*IF COORDINATES ARE ENERGY-ASYMPTOTE  
AZL AZIMUTH AT LAUNCH SITE, DEG  
RAD RADIUS, KM  
PTH PATH ANGLE, DEG  
C3 ENERGY CONSTANT FROM VIS VIVA INTEGRAL, KM<sup>2</sup>/SEC  
DAD DECLINATION OF OUTGOING ASYMPTOTE, DEG  
RAD RIGHT ASCENSION OF OUTGOING ASYMPTOTE, DEG

LINE C  
(TYPE) (CARTESIAN, SPHERICAL, EARTH FIXED, SELENOGRAPHIC, ENERGY-ASYMPTOTE, PSEUDO-ASYMPTOTE)  
TO SECONDS PAST MIDNIGHT OF INJECTION TIME, SEC  
GHA GREENWICH HOUR ANGLE OF VERNAL EQUINOX AT INJECTION EPDCH, DEG  
GHD GREENWICH HOUR ANGLE OF VERNAL EQUINOX AT PREVIOUS MIDNIGHT, DEG  
(ECLIPTIC) IS PRINTED IF APPLICABLE)

LINE D  
(DATE AND TIME OF RUN) (CENTRAL BODY) (EQUATION OF MOTION)

GEOCENTRIC

(TIME PAST INJECTION) (EQUINOX) (DP SEC PAST 1950) (JD) (CALENDAR DATE)  
GEOCENTRIC (COORDINATE PLANE)

LINE A  
X VERNAL EQUINOX CARTESIAN POSITION, KM  
Y  
Z  
DX VERNAL EQUINOX CARTESIAN VELOCITY, KM/SEC  
DY  
DZ

LINE B  
R RADIUS, KM  
DEC DECLINATION, DEG  
RA RIGHT ASCENSION, DEG  
V INERTIAL SPEED, KM/SEC  
PTH INERTIAL PATH ANGLE, DEG  
AZ INERTIAL AZIMUTH ANGLE, DEG

LINE C  
R RADIUS, KM  
LAT GEOCENTRIC LATITUDE, DEG  
LON EARTH-FIXED LONGITUDE, DEG  
VE EARTH-FIXED SPEED, KM/SEC  
PTE EARTH-FIXED PATH ANGLE, DEG  
AZE EARTH-FIXED AZIMUTH ANGLE, DEG

LINE D  
XS THE GEOCENTRIC POSITION OF THE SUN, KM  
YS  
ZS  
DXS THE GEOCENTRIC VELOCITY OF THE SUN, KM/SEC  
DYS  
DZS

LINE E  
XM THE GEOCENTRIC POSITION OF THE MOON, KM  
YM  
ZM  
DXM THE GEOCENTRIC VELOCITY OF THE MOON, KM/SEC  
DYM  
DZM

LINE F  
XT THE GEOCENTRIC POSITION OF THE TARGET BODY, KM  
YT  
ZT  
DXT THE GEOCENTRIC VELOCITY OF THE TARGET BODY, KM/SEC  
DYT  
DZT

LINE G  
RS EARTH-SUN DISTANCE, KM  
VS GEOCENTRIC SPEED OF SUN, KM/SEC  
RM EARTH-MOON DISTANCE, KM  
VM GEOCENTRIC SPEED OF MOON, KM/SEC  
RT EARTH-TARGET DISTANCE, KM  
VT GEOCENTRIC SPEED OF TARGET, KM/SEC

CONTINUED ON NEXT PAGE

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LINE H  
 GED GEODETIC LATITUDE, DEG  
 ALT ALTITUDE ABOVE THE EARTH'S SURFACE, KM  
 LOS LONGITUDE OF SUN, DEG  
 RAS RIGHT ASCENSION OF SUN, DEG  
 RAM RIGHT ASCENSION OF MOON, DEG  
 LOM LONGITUDE OF MOON, DEG

LINE I  
 OUT EPHEMERIS TIME MINUS UNIVERSAL TIME, SEC  
 DT ADAMS-MOULTON STEP SIZE, SEC  
 DR GEOCENTRIC RADIAL SPEED OF PROBE, KM/SEC  
 SHA SUN SHADOW PARAMETER, KM  
 DES DECLINATION OF THE SUN, DEG  
 DEM DECLINATION OF THE MOON, DEG

LINE J  
 CCL CANOPUS CLOCK ANGLE, DEG  
 MCL MOON CLOCK ANGLE, DEG  
 TCL TARGET CLOCK ANGLE, DEG

HELIOCENTRIC

HELIOCENTRIC (COORDINATE PLANE)

LINE A  
 X VERNAL EQUINOX CARTESIAN POSITION, KM  
 Y  
 Z  
 DX VERNAL EQUINOX CARTESIAN VELOCITY, KM/SEC  
 DY  
 DZ

LINE B  
 R SUN-PROBE RADIUS, KM  
 LAT CELESTIAL LATITUDE - OR DECLINATION - OF THE PROBE, DEG  
 LON CELESTIAL LONGITUDE - OR RIGHT ASCENSION - OF THE PROBE, DEG  
 V INERTIAL SPEED, KM/SEC  
 PTH PATH ANGLE, DEG  
 AZ AZIMUTH ANGLE, DEG

LINE C  
 XE HELIOCENTRIC POSITION OF THE EARTH, KM  
 YE  
 ZE  
 DXE HELIOCENTRIC VELOCITY OF THE EARTH, KM/SEC  
 DYE  
 DZE

LINE D  
 XT HELIOCENTRIC POSITION OF THE TARGET, KM  
 YT  
 ZT  
 DXT HELIOCENTRIC VELOCITY OF THE TARGET, KM/SEC  
 DYT  
 DZT

LINE E  
 LTE CELESTIAL LATITUDE - OR DECLINATION - OF THE EARTH, DEG  
 LOE CELESTIAL LONGITUDE - OR RIGHT ASCENSION - OF THE EARTH, DEG  
 LTY CELESTIAL LATITUDE - OR DECLINATION - OF THE TARGET, DEG  
 LOT CELESTIAL LONGITUDE - OR RIGHT ASCENSION - OF THE TARGET, DEG  
 RST DISTANCE OF THE TARGET FROM THE SUN, KM  
 VST SPEED OF THE TARGET WITH RESPECT TO THE SUN, KM/SEC

LINE F  
 EPS EARTH-PROBE-SUN ANGLE, DEG  
 ESP EARTH-SUN-PROBE ANGLE, DEG  
 SEP SUN-EARTH-PROBE ANGLE, DEG  
 EPM EARTH-PROBE-MOON ANGLE, DEG  
 EMP EARTH-MOON-PROBE ANGLE, DEG  
 MEP MOON-EARTH-PROBE ANGLE, DEG

LINE G  
 MPS MOON-PROBE-SUN ANGLE, DEG  
 MSP MOON-SUN-PROBE ANGLE, DEG  
 SMP SUN-MOON-PROBE ANGLE, DEG  
 SEM SUN-EARTH-MOON ANGLE, DEG  
 EMS EARTH-MOON-SUN ANGLE, DEG  
 ESM EARTH-SUN-MOON ANGLE, DEG

LINE H (NOT PRINTED IF TARGET=MOON)  
 EPT EARTH-PROBE-TARGET ANGLE, DEG  
 ETP EARTH-TARGET-PROBE ANGLE, DEG  
 TEP TARGET-EARTH-PROBE ANGLE, DEG  
 TPS TARGET-PROBE-SUN ANGLE, DEG  
 TSP TARGET-SUN-PROBE ANGLE, DEG  
 STP SUN-TARGET-PROBE ANGLE, DEG

LINE I (ONLY RPM AND SPN ARE PRINTED IF TARGET=MOON)  
 SET SUN-EARTH-TARGET ANGLE, DEG  
 STE SUN-TARGET-EARTH ANGLE, DEG  
 EST EARTH-SUN-TARGET ANGLE, DEG  
 RPM PROBE-MOON DISTANCE, KM  
 RPT PROBE-TARGET DISTANCE, KM  
 SPN SUN-PROBE-NEAR LIMB OF EARTH ANGLE, DEG

LINE J  
 GCE CLOCK ANGLE OF EARTH, DEG  
 GCT CLOCK ANGLE OF TARGET, DEG  
 SIP SUN-PROBE-NEAR LIMB OF TARGET ANGLE, DEG  
 CPT CANOPUS-PROBE-TARGET ANGLE, DEG  
 SIN CANOPUS-PROBE-NEAR LIMB OF TARGET ANGLE, DEG

LINE K  
 REP EARTH PROBE DISTANCE, KM  
 VEP VELOCITY OF THE PROBE WITH RESPECT TO EARTH, KM/SEC  
 CPE CANOPUS-PROBE-EARTH ANGLE, DEG  
 CPS CANOPUS-PROBE-SUN ANGLE, DEG

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(TARGET)CENTRIC

(TARGET)CENTRIC (COORDINATE PLANE)

LINE A  
 X TARGET-CENTERED VERNAL EQUINOX POSITION, KM  
 Y  
 Z  
 DX TARGET-CENTERED VERNAL EQUINOX VELOCITY, KM/SEC  
 DY  
 DZ

LINE B  
 R RADIUS FROM TARGET CENTER, KM  
 DEC DECLINATION - OR CELESTIAL LATITUDE, DEG  
 RA RIGHT ASCENSION - OR CELESTIAL LONGITUDE, DEG  
 V SPEED RELATIVE TO THE TARGET, KM/SEC  
 PTH TARGET-BODY PATH ANGLE, DEG  
 AZ TARGET-BODY AZIMUTH ANGLE, DEG

LINE C (PRINTED ONLY IF TARGET=MOON)  
 R RADIUS FROM TARGET CENTER, KM  
 LAT TARGET-CENTERED LATITUDE, DEG  
 LON TARGET-CENTERED LONGITUDE, DEG  
 VP SPEED RELATIVE TO THE ROTATING TARGET, KM/SEC  
 PTP ROTATING TARGET-BODY PATH ANGLE, DEG  
 AZP ROTATING TARGET-BODY AZIMUTH ANGLE, DEG

LINE D (PRINTED ONLY IF TARGET=MOON)  
 LTS SELENOGRAPHIC LATITUDE OF THE SUN, DEG  
 LNS SELENOGRAPHIC LONGITUDE OF THE SUN, DEG  
 LTE SELENOGRAPHIC LATITUDE OF THE EARTH, DEG  
 LNE SELENOGRAPHIC LONGITUDE OF THE EARTH, DEG

LINE E  
 ALT ALTITUDE ABOVE THE TARGET BODYS SURFACE, KM  
 SHA SUNS SHADOW PARAMETER, KM  
 SHA = -ABS(RTP X IRTS)+SGN(RTP DOT RTS)  
 ALP ILLUMINATED CRESCENT ORIENTATION VIEWING ANGLE, DEG  
 ALP = ARCCOS(A DOT V) WHERE  $S_3 = IRTP$   $W = 1(S_3 X S_4)$   $V = WXS_3$   
 $S_4 = IRTS$   $U = (D, D, 1)$   $A = 1(UXS_3)$   
 DR RADIAL RATE, KM/SEC  
 DP TRANSVERSE ANGULAR VELOCITY, DEG/SEC  
 ASD ANGULAR SEMIDIAMETER OF TARGET AS SEEN FROM S/C, DEG

LINE F  
 HGE RIGHT ASCENSION OF EARTH IN SPACECRAFT COORDINATE SYSTEM, DEG  
 SVL DECLINATION OF TARGET IN SPACECRAFT COORDINATE SYSTEM, DEG  
 HNG RIGHT ASCENSION OF TARGET IN SPACECRAFT COORDINATE SYSTEM, DEG  
 SIA EARTH-PROBE-NEAR LIMB OF TARGET ANGLE, DEG

THE FOLLOWING ADDITIONAL LINES ARE PRINTED  
 IF MARS IS THE TARGET. ALL VARIABLES ARE  
 REFERENCED TO A MARS EQUATORIAL INERTIAL COORDINATE  
 SYSTEM OR TO A MARS FIXED COORDINATE SYSTEM

LINE H AREOCENTRIC EQUATORIAL COORDINATES

LINE I  
 X MARS EQUATORIAL, MARS-PROBE POSITION, KM  
 Y  
 Z  
 DX MARS EQUATORIAL, MARS-PROBE VELOCITY, KM/SEC  
 DY  
 DZ

LINE J  
 R RADIUS FROM MARS CENTER, KM  
 DEC DECLINATION, DEG  
 RA RIGHT ASCENSION, DEG  
 V SPEED RELATIVE TO MARS, KM/SEC  
 PTH PATH ANGLE, DEG  
 AZ AZIMUTH ANGLE, DEG

LINE K  
 R RADIUS FROM MARS CENTER, KM  
 LAT MARS-CENTERED LATITUDE, DEG  
 LON MARS-FIXED LONGITUDE, DEG  
 VP SPEED RELATIVE TO ROTATING MARS, KM/SEC  
 PTP PATH ANGLE RELATIVE TO ROTATING MARS, DEG  
 AZP AZIMUTH ANGLE RELATIVE TO ROTATING MARS, DEG

LINE L  
 RAE RIGHT ASCENSION OF THE EARTH, DEG  
 DEE DECLINATION OF THE EARTH, DEG  
 RAS RIGHT ASCENSION OF THE SUN, DEG  
 DES DECLINATION OF THE SUN, DEG  
 LDE LONGITUDE OF THE EARTH, DEG  
 LOS LONGITUDE OF THE SUN, DEG

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GEO DR HELIO OR TARGET CONIC

GROUP A

(BODY) CONIC

EPOCH OF PERICENTER PASSAGE (OP SEC PAST 1950) (JD) (CALENDAR DATE)

LINE A  
 SMA SEMIMAJOR AXIS,KM  
 ECC ECCENTRICITY,UNITLESS  
 B MAGNITUDE OF B VECTOR,KM  
 SLR SEMILATUS RECTUM,KM  
 APO APOCENTER DISTANCE,KM  
 RCA CLOSEST APPROACH DISTANCE,KM

LINE B  
 VH HYPERBOLIC EXCESS SPEED,VELOCITY AT APOGEE FOR ELLIPSE,KM/SEC  
 C3 TWICE TOTAL ENERGY PER UNIT MASS OR VIS VIVA INTEGRAL,KM<sup>2</sup>/SEC<sup>2</sup>  
 C1 ANGULAR MOMENTUM,KM<sup>2</sup>/SEC  
 TFP TIME FROM PERICENTER PASSAGE,SEC  
 TF TIME FROM INJ TO PERICENTER PASSAGE IN HRS FOR EARTH-MOON TRAJ,  
 IN DAYS OTHERWISE

PER PERIOD, MIN EXCEPT DAYS IF HELIO, PRINTED ONLY IF C3 IS -  
 LTF LINEARIZED TIME-OF-FLIGHT IN HRS FOR EARTH-MOON TRAJ, IN DAYS  
 OTHERWISE PRINTED ONLY IF C3 IS + IN PLACE OF PER

LINE C  
 TA TRUE ANOMALY,DEG  
 MTA MAXIMUM TRUE ANOMALY,DEG  
 EA ECCENTRIC ANOMALY,DEG  
 MA MEAN ANOMALY,DEG  
 C3 JACOBI CONSTANT, KM<sup>2</sup>/SEC<sup>2</sup>, PRINTED IN GEO AND SELENO CONICS ONLY  
 C1 TIME FROM INJECTION IN HRS FOR EARTH-MOON TRAJ, IN DAYS OTHERWISE  
 (PRINTED ONLY IF C3 IS + AND IF CONIC IS TARGET CONIC)

LINE D  
 ZAE ANGLE BETWEEN IN. ASYMPOTTE AT TARG AND TARG-EARTH VECTOR,DEG  
 ZAP ANGLE BETWEEN IN. ASYMPOTTE AT TARG AND TARG-SUN VECTOR,DEG  
 ZAC ANGLE BETWEEN IN. ASYMPOTTE AT TARG AND TARG-CANOPUS VECTOR,DEG  
 DEF ANGLE BETWEEN INCOMING AND OUTGOING ASYMPOTTES,DEG  
 IR IMPACT RADIUS,KM  
 GP ANGLE BETWEEN IN. ASYMPOTTE AND ITS PROJ. ON ORB. PLANE OF TARG,DEG

GROUPS B,C,D

ALL VECTORS REFERENCED TO ( ) PLANE

LINE A  
 X BODY-PROBE POSITION VECTOR IN COORD. SYSTEM GIVEN ABOVE,KM  
 Y  
 Z  
 DX BODY-PROBE VELOCITY VECTOR IN COORD. SYSTEM GIVEN ABOVE, KM/SEC  
 DY  
 DZ

LINE B  
 INC INCLINATION OF PROBE ORBIT PLANE TO PLANE GIVEN ABOVE,DEG  
 LAN LONGITUDE OR RIGHT ASCENSION OF ASCENDING NODE,DEG  
 APF ARGUMENT OF PERICENTER,DEG  
 MX UNIT M VECTOR M = W X IR0  
 MY  
 MZ

LINE C  
 WX UNIT W VECTOR  
 WY  
 WZ  
 PX UNIT P VECTOR  
 PY  
 PZ

LINE D  
 QX UNIT Q VECTOR  
 QY  
 QZ  
 RX UNIT R VECTOR  
 RY  
 RZ

LINE E  
 BX UNIT B VECTOR  
 BY  
 BZ  
 TX UNIT T VECTOR T = R X S  
 TY  
 TZ

LINE F  
 (PRINTED ONLY IF C3 IS +)  
 SXI UNIT INCOMING ASYMPOTTE VECTOR  
 SYI  
 SZI  
 DAI DECLINATION OR LATITUDE OF INCOMING ASYMPOTTE,DEG  
 RAI RIGHT ASCENSION OR LONGITUDE OF INCOMING ASYMPOTTE,DEG

LINE G  
 (PRINTED ONLY IF C3 IS +)  
 SXO UNIT OUTGOING ASYMPOTTE VECTOR  
 SYO  
 SZO  
 DAO DECLINATION OR LATITUDE OF OUTGOING ASYMPOTTE,DEG  
 RAO RIGHT ASCENSION OR LONGITUDE OF OUTGOING ASYMPOTTE,DEG

LINE H  
 (PRINTED ONLY IF C3 IS + AND IF CONIC IS TARGET CONIC)  
 ETE ANGLE BETWEEN T AND PROJ. OF EARTH-TARG VECTOR ON R-T PLANE,DEG  
 ETS ANGLE BETWEEN T AND PROJ. OF SUN-TARG VECTOR ON R-T PLANE,DEG  
 ETC ANGLE BETWEEN T AND PROJ. OF CANOPUS-TARG VECTOR ON R-T PLANE,DEG

LINE I  
 (PRINTED ONLY IF C3 IS -)  
 DAP DECLINATION OF ASYMPOTTE,DEG  
 RAP RT. ASCENSION OF ASYMPOTTE,DEG

LINE J  
 BTX T COMPONENT OF B,KM WHERE X=Q FOR EARTH EQU., X=C FOR ECLIPTIC  
 BRX B COMPONENT OF B,KM X=D FOR TARG ORBIT, X=T FOR TARG EQU  
 R MAGNITUDE OF B,KM  
 THA DIRECTION ANGLE OF IMPACT PARAMETER IN R-T PLANE MEASURED + FROM T  
 T VECTOR IN ( ) PLANE

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---

OUTPUT DESIGNATING BEGINNING OF TRAJECTORY BURN

LINE A  
(TIME PAST INJECTION) (EQUINDX) (DP SEC PAST 1950) (JD) (CALENDAR DATE)  
LINE B  
START BURN

OUTPUT DESIGNATING END OF TRAJECTORY BURN

LINE A  
(TIME PAST INJECTION) (EQUINDX) (DP SEC PAST 1950) (JD) (CALENDAR DATE)  
LINE B  
END BURN

OUTPUT DESIGNATING BEGINNING OF GAS JET COMPUTATION

LINE A  
(TIME PAST INJECTION) (EQUINDX) (DP SEC PAST 1950) (JD) (CALENDAR DATE)  
LINE B  
START GAS JETS

OUTPUT DESIGNATING END OF GAS JET COMPUTATION

LINE A  
(TIME PAST INJECTION) (EQUINDX) (DP SEC PAST 1950) (JD) (CALENDAR DATE)  
LINE B  
END GAS JETS

SHADOW PARAMETERS

\* WHEN PROBE ENTERS, LEAVES, IS IN, OR OUT OF A BODY'S SHADOW  
ONE OF THE FOLLOWING SET OF TWO LINES WILL BE OUTPUT

LINE A  
(TIME PAST INJECTION) (EQUINDX) (DP SEC PAST 1950) (JD) (CALENDAR DATE)  
LINE B  
PROBE IS ENTERING (BODY) SHADOW

LINE A  
(TIME PAST INJECTION) (EQUINDX) (DP SEC PAST 1950) (JD) (CALENDAR DATE)  
LINE B  
PROBE IS LEAVING (BODY) SHADOW

LINE A  
(TIME PAST INJECTION) (EQUINDX) (DP SEC PAST 1950) (JD) (CALENDAR DATE)  
LINE B  
PROBE IS IN (BODY) SHADOW

LINE A \*  
(TIME PAST INJECTION) (EQUINDX) (DP SEC PAST 1950) (JD) (CALENDAR DATE)  
LINE B  
PROBE IS OUT OF (BODY) SHADOW

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IF PUBLIC INFORMATION IS REQUESTED THE FOLLOWING FIVE LINES ARE PRINTED

LINE A  
PUBLIC INFORMATION

LINE B  
EAL ALTITUDE OF PROBE ABOVE EARTH ST. MILES  
TAL ALTITUDE OF PROBE ABOVE TARGET ST. MILES  
RPE EARTH PROBE DISTANCE ST. MILES  
RPT TARGET PROBE DISTANCE ST. MILES  
RPS SUN PROBE DISTANCE ST. MILES  
ARC DISTANCE ALONG PATH OF THE TRAJECTORY ST. MILES

LINE C  
VGC GEOCENTRIC INERTIAL SPEED OF PROBE ST. MILES/HR.  
VTC TARGETCENTRIC INERTIAL SPEED OF PROBE ST. MILES/HR.  
VSC HELIOCENTRIC INERTIAL SPEED OF PROBE ST. MILES/HR.  
LAT GEOCENTRIC LATITUDE OF PROBE DEG.  
LON GEOCENTRIC LONGITUDE OF PROBE DEG.

LINE D  
BOARD UNITS

LINE E  
UP HORIZONTAL POSITION OF PROBE BOARD UNITS  
VP VERTICAL POSITION OF PROBE BOARD UNITS  
UE HORIZONTAL POSITION OF EARTH BOARD UNITS  
VE VERTICAL POSITION OF EARTH BOARD UNITS  
UT HORIZONTAL POSITION OF TARGET BOARD UNITS  
VT VERTICAL POSITION OF TARGET BOARD UNITS

STATION PRINTS

(TIME PAST INJECTION) (EQUINOX) (DP SEC PAST 1950) (JD) (CALENDAR DATE)

(STATION NAME) (AZEL OR HADEC)

LINE A  
R GEO. RADIUS MAG. OF PROBE, KM  
LAT GEO. LATITUDE, DEG.  
LON GEO. LONGITUDE, DEG.

LINE B  
MIN MINUTES FROM INJECTION  
HA LOCAL HOUR ANGLE OF PROBE, DEG  
DEC LOCAL DECLINATION OF PROBE, DEG  
ELE ELEVATION ANGLE OF PROBE, DEG  
AZI NORTH AZIMUTH OF PROBE, DEG

LINE C  
CKC CLOCK ANGLE OF CANOPUS, DEG.  
CKM CLOCK ANGLE OF MOON, DEG.  
CKT CLOCK ANGLE OF TARGET, DEG.  
PSS PROBE-STATION-SUN ANGLE, DEG  
PSM PROBE-STATION-MOON ANGLE, DEG.

LINE D  
UT TIME CORRECTION FOR FREQUENCIES, HOURS  
DHA HOUR-ANGLE RATE, DEG/SEC  
ODE DECLINATION RATE, DEG/SEC  
DEL ELEVATION RATE, DEG/SEC  
DAZ AZIMUTH RATE, DEG/SEC

LINE E  
ET EPHEMERIS TIME CORRECTOR, HOURS  
RGE SLANT RANGE OF PROBE, KM  
DRG SLANT-RANGE RATE, KM/SEC  
DDR RATE OF THE SLANT-RANGE RATE, KM/SEC<sup>2</sup> (ZERO IF CENTER NOT EARTH)  
SLS SPACE LOSS, DB

LINE F  
RDI RADIUS OF THE STATION, KM  
PHI NORTH GEOCENTRIC LATITUDE OF THE STATION, DEG  
THI EAST LONGITUDE OF THE STATION, DEG  
SPS STATION-PROBE-SUN ANGLE, DEG  
POL POLARIZATION ANGLE, DEG.

LINE G  
DT TIME FOR LIGHT TO TRAVEL FROM STATION TO PROBE (SEC.)  
RFB REFERENCE BEACON FREQUENCY, CPS  
RF1 ONE WAY REFERENCE FREQUENCY, CPS  
RF2 TWO WAY REFERENCE FREQUENCY, CPS  
FA TRANSPONDER RECEIVER FREQUENCY, CPS

LINE H  
BF1 BEACON FREQUENCY, CPS  
F1 ONE WAY DOPPLER FREQUENCY, CPS  
F2 TWO WAY DOPPLER FREQUENCY, CPS  
XA GROUND TRANSMITTER FREQUENCY, CPS  
PRA PROBE RIGHT ASCENSION, DEG.

LINE I  
D1 ONE WAY DOPPLER DETECTOR FREQUENCY, CPS  
D2 TWO WAY DOPPLER DETECTOR FREQUENCY, CPS  
DDP DOPPLER RATE, SQUARE CPS  
DF1 ONE WAY DOPPLER FREQUENCY RATE, SQUARE CPS (ONLY IF CENTER = EARTH)  
DF2 TWO WAY DOPPLER FREQUENCY RATE, SQUARE CPS (ONLY IF CENTER = EARTH)

C. JOB-SHOP OUTPUT CAPABILITY

1. In the job-shop mode of operation, printed output is put on tape SYSOU1. Or, by proper use of input parameter FLAG42, the output is put on low density tape SYSPL1. The latter tape can be processed by the S-C 4020 High-Speed Microfilm Recorder. Subroutine PROUT is utilized to produce the line images for SYSOU1 or SYSPL1.
2. Output also appears on the 7094 on-line printer. The progress of the trajectory and the occurrence of errors are noted. Subroutine ERPRT is utilized to produce the on-line print. Additional on-line print capability is available by proper use of the 7094 console sense switches or by input. A minimum on-line print (defined as on-line printing of injection conditions, phase changes and encounter conditions) is obtained by depressing sense switch 6. A detailed or fine on-line print (defined as the duplication, on-line, of all output on SYSOU1 or SYSPL1) is obtained by depressing sense switches 4 and 6. The sense switches, hence the on-line print request, may be changed at will during the computation of the trajectory. If desired, input parameter OPTSWT may be used to preset the on-line print request in the source deck.
3. The trajectory SAVE tape may be put on high density binary tape SYSCK2. Input parameters located at PLOTfq control the generation of the SAVE tape.
4. Debugging output (SNAP) may be used (Ref. 4, Section VIII). SFPRO's FILE control card must have the following format:

	Column	
1	8	16
\$	FILE	147

#### D. SFOF OUTPUT CAPABILITY

The SFOF output capability is similar to the job-shop output capability. The normal output is put on SYSOU1. The on-line output control and printing are done at remote user area 5, instead of at the 7094 console and printer. The progress of the trajectory and the occurrence of errors are printed on the remote administrative printer. The minimum or fine print of the trajectory is printed on the remote SC-3070 printer. This minimum or fine on-line SC-3070 print is controlled by the remote console option switches 33 and 35 (corresponding to sense switches 4 and 6). If desired, input parameter OPTSWT may be used to preset the on-line print request in the source deck.

The spacecraft ephemerides are treated the same as in the job-shop mode but the debugging output capability (SNAP) does not exist.



## VI. SUBROUTINES

SFPRO is made up of 43 closed subroutines, some of which have more than one entry and perform more than one function. Many subroutines have not changed in function from Ref. 1 (Section VIII) but the documentation was repeated in this Technical Memorandum (TM 33-199) for completeness. All subroutines were documented according to the following specifications:

### IDENTIFICATION

Entry name(s)

Programmer(s)

Coding language

Date

### PURPOSE

Defines the task performed by this subroutine.

### RESTRICTIONS

Cites the error conditions, external buffers used, COMMON used, subroutines used, etc., (COMMON names and subroutine names are capitalized).

### METHOD

Gives a detailed description of how the subroutine accomplishes its task.

Includes a flow chart when applicable.

### USE

Defines all calling sequences, including the definition and use of input and output parameters.

### CODING INFORMATION

Gives the decimal and octal sizes of the subroutine excluding COMMON storage or external buffer storage.

### REFERENCES

Gives Requests for Programming (RFP) number, Inter-Office Memoranda (IOM's) and technical references if applicable.

IDENTIFICATION

1-1 of 2

ABORT/ERPRT/JEXIT/PRSET/...../TIME

Nicholas S. Newhall, JPL

IBM 7094 Fap

December 2, 1964

PURPOSE

To handle communication between SFPRO and the various systems, I/O devices, switches, flags and subroutines.

RESTRICTIONS

- a. Entries RUNID, PRTSWX, FLAG42, COMTRJ, COMTRK and COMFLG are provided for those input parameters.
- b. The on-line printer is sensed to obtain the date and time-of-day if the parameter EXPORT is zero.
- c. The print flags are in COMMON locations SP1A, ..., SP3C, EJCTA, EJCTB, EJCTC, 37HED, PRFLG and PRTSWT.
- d. Subroutines TYPWRT and PROUT are used for on-line printing.

METHOD

- a. PRSET examines the input flags, the 7094 sense-switches, the SFOF mode cell SFMODE, and user area option switches in order to set the appropriate COMMON print flags for PROUT.
- b. ERPRT prints the on-line messages. The 7094 on-line printer or the remote user area administrative printer will print the message, depending on the contents of parameter SFMODE.
- c. TIME provides the user with the BCD time-of-day in the AC and the computer code letter A, B or C left adjusted in the MQ and followed by blanks.
- d. JEXIT prints "END TRAJECTORY (SFPRO)", closes the output files used by PROUT and returns control to JPTRAJ with a zero in the accumulator, designating a normal return.
- e. ABORT prints "END TRAJECTORY (SFPRO)", closes the output files used by PROUT and returns control to JPTRAJ with a one in the accumulator, designating the error return.
- f. .... is the location of the Program Control Block (PCB) and contains the information JPTRAJ needs to set up for and transfer control to SFPRO.

USE

1-2 of 2

Calling sequences:

a. CALL PRSET

return

b. TSX §ERPRT, 4, N

PZE A, , B

return

where

A, ..., A+(B-1) contain BCD text

B is the number of words of text,  $B \leq 12$

N = 0 means message not printed off-line

= 2 means message printed off-line after a double space

= 3 means message printed off-line after a page eject.

c. CALL TIME

return

d. CALL JEXIT

(transfers control to JPTRAJ)

e. CALL ABORT

(transfers control to JPTRAJ)

CODING INFORMATION

Length of subroutine is 757(10) or 1365(8) words.

IDENTIFICATION

2

ADD  
 JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

PURPOSE

To perform double precision addition of two double precision floating point numbers.

RESTRICTIONS

- a. If the numbers involved are sufficiently large so as to cause overflow, erroneous results will be obtained.
- b. Uses COMMON to COMMON + 3.

METHOD

The contents of the AC-MQ registers and/or the contents of specified cells in core storage (see USE) are added using the DFAD machine instruction. The high order part of the result is placed in the AC and the low order part in the MQ.

USE

Calling sequences:

- a. CALL ADD  
 return

Enter with one of the double precision numbers in the AC-MQ and the other number in COMMON and COMMON + 1. Exit with the result in the AC-MQ.

- b. CALL ADD or CALL ADD, YI, 0  
 TSX YI, 0  
 TSX 0, 0  
 return

Enter with one of the double precision numbers in the AC-MQ and the other number in YI and YI + 1. Exit with the result in the AC-MQ.

- c. CALL ADD or CALL ADD, YI, ZI  
 TSX YI, 0  
 TSX ZI, 0  
 return

Enter with one of the double precision numbers in YI and YI + 1 and the other number in ZI and ZI + 1. Exit with the result in the AC-MQ.

CODING INFORMATION

Length of the subroutine is 25(10) or 31(8) words.

IDENTIFICATION

3

ARCOS/ARSIN  
 JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

PURPOSE

To compute arcsine x or arccosine x for a floating point, single precision x, in degrees.

RESTRICTIONS

If  $|x| > 1.0$  the result will be  $\pm 90.0$  for the arcsine, taking the same sign as the argument, and will be 180.0 for the arccosine for a negative argument and 0.0 for the arccosine for a positive argument.

METHOD

$$\sin^{-1} x = \pi/2 - \sqrt{1-x} F(x), \quad \cos^{-1} x = \sqrt{1-x} F(x)$$

where  $F(x) = \sum_{i=0}^7 C_i x^i$ , and

$C_0 = 1.570796327$	$C_4 = 0.0308918810$
$C_1 = -0.2145988016$	$C_5 = -0.0170881256$
$C_2 = 0.0889789874$	$C_6 = 0.0066700901$
$C_3 = -0.0501743046$	$C_7 = -0.0012624911$

Accuracy: 7 significant decimal digits.

USE

Enter with the argument in the accumulator. Exit with the result in the accumulator in degrees.

Calling sequences:

for arccosine:	for arcsine:
CLA X	CLA X
CALL ARCOS	CALL ARSIN
return	return

CODING INFORMATION

Length of subroutine is 96(10) or 140(8) words.

## IDENTIFICATION

ARTAN  
 JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

## PURPOSE

To compute arctangent (y/x) in degrees for floating point, single precision x and y.

## RESTRICTIONS

Uses COMMON to COMMON + 4.

## METHOD

The following Rand approximating polynomial is used:

$$\text{Arctan } (y/x) = \text{Arctan } D = \pi/4 + \sum_{i=0}^7 C_{2i+1} \left( \frac{D-1}{D+1} \right)^{2i+1}$$

where:

$C_1 = 0.9999993329$	$C_9 = 0.0964200441$
$C_3 = -0.3332985605$	$C_{11} = -0.0559098861$
$C_5 = 0.1994653599$	$C_{13} = 0.0218612288$
$C_7 = -0.1390853351$	$C_{15} = -0.0040540580$

Accuracy: 7 significant figures.

## USE

Enter with y in the accumulator and x in the MQ. Exit with Arctan (y/x) in the accumulator in degrees normalized to lie in the range 0 to 360.

Calling sequence:

```
CLA    Y
LDQ    X
CALL   ARTAN
return
```

## CODING INFORMATION

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

IDENTIFICATION

BCDNO/NEWBCD  
 JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

PURPOSE

To replace a BCD word (the name of a celestial body) in the accumulator with a fixed point number scaled 35. This number will be used as a reference number in locating data pertinent to that body.

RESTRICTIONS

- a. An error is possible if the BCD word is not recognized (see USE), in which case a comment to this effect is printed and control is given to ABORT.
- b. ERPRT, PROUT and ABORT may be called.
- c. NEWBCD is provided so that SATURN may be replaced by some other body name.

METHOD

The accumulator is compared with each of seven BCD words until equality occurs. Each comparison is counted and, at equality, this count, in fixed point scaled 35, replaces the accumulator.

USE

Calling sequence:

CAL L(BCD word)  
 CALL BCDNO  
 return

If (BCD word) = EARTH	return with accumulator = 0
MOON	= 1
SUN	= 2
VENUS	= 3
MARS	= 4
SATURN	= 5
JUPITE	= 6

CODING INFORMATION

Length of subroutine is 36(10) or 44(8) words.

IDENTIFICATION

6

CHANGE

Peter S. Fisher, JPL  
IBM 7094 Fap  
December 2, 1964

PURPOSE

To call PRINTD with special group and conic print flags.

RESTRICTIONS

The subroutines SPRAY and PRINTD are called, and GROP and ORBETT are referenced indirectly.

METHOD

The current group and conic print flags are saved and the desired replacements are substituted. SPRAY is called to prepare the GROPS flags for PRINTD and then PRINTD is called. Then the group and conic flags are reset and SPRAY is again called to restore the GROPS flags.

USE

Calling sequence:

```
CALL  CHANGE
OCT   A
OCT   B
return
```

where A is one word of twelve octal digits (designating the desired group options) and B is one word of twelve octal digits (designating the desired conic options).

CODING INFORMATION

Length of subroutine is 28(10) or 34(8) words.



IDENTIFICATION

7.1-1 of 4

CLASS

JPL Staff

IBM 7094 Fap

December 2, 1964

PURPOSE

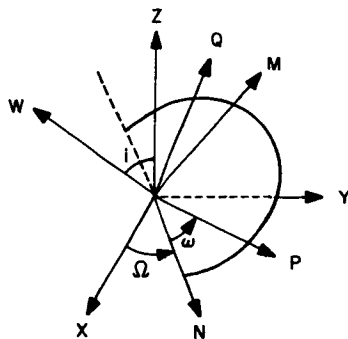
To calculate conic orbital elements.

RESTRICTIONS

- a. CLASS is a subset of a rectangular-to-orbital elements package and uses other subroutines in the package.
- b. COMMON through COMMON+3 are used.
- c. An error can occur if the input value of  $c_3$  is zero.
- d. Subroutines SQRT, ARCOS and SIN are called.
- e. Location HARMN is referenced indirectly to obtain the Earth's oblateness constants.

METHOD

The following sketch illustrates the relationship between the orbital elements and the reference  $\hat{P}$ ,  $\hat{Q}$ ,  $\hat{W}$  and  $\bar{X}$ ,  $\bar{Y}$ ,  $\bar{Z}$  frames:



Hence,  $i = \cos^{-1} W_z$ , where  $0 \leq i \leq 180$  deg for the inclination

$$\left\{ \begin{array}{l} \sin \Omega = \frac{W_x}{\sin i} \\ \cos \Omega = \frac{-W_y}{\sin i} \end{array} \right.$$

where  $0 \leq \Omega < 360$  deg for the right ascension of the ascending node

$$\left\{ \begin{array}{l} \sin \omega = \frac{P_z}{\sin i} \\ \cos \omega = \frac{Q_z}{\sin i} \end{array} \right.$$

where  $0 \leq \omega < 360$  deg for the argument of the pericenter.

The formulas for  $\Omega$  may be derived by constructing the unit vector  $\hat{N}$  at the ascending node:

$$\hat{N} = \frac{\hat{U} \times \hat{W}}{|\hat{U} \times \hat{W}|}$$

where  $\hat{U} = (0, 0, 1)$  and  $\sin i = |\hat{U} \times \hat{W}|$ .  $\hat{N}$  is then projected onto the X and Y axes to give the formulas for the cosine and the sine.

Next, the auxiliary unit vector  $\hat{M} = \hat{W} \times \hat{N}$  is constructed so that  $\omega$  is given by:

$$\left\{ \begin{array}{l} \sin \omega = \hat{P} \cdot \hat{M} = \hat{P} \cdot (\hat{W} \times \hat{N}) = -\hat{N} \cdot (\hat{W} \times \hat{P}) = -\hat{N} \cdot \hat{Q} \\ \cos \omega = \hat{P} \cdot \hat{N} \end{array} \right.$$

The conic parameters are given by the standard formulas for  $c_1 \neq 0$ :

$$q = \frac{p}{1 + \epsilon} \quad \text{the closest approach distance}$$

$$V_p = \frac{\mu(1 + \epsilon)}{c_1} \quad \text{the velocity at closest approach}$$

$$V_a = \frac{\mu(1 - \epsilon)}{c_1} \quad \text{velocity at farthest departure} (c_3 < 0)$$

$$V_h = \sqrt{c_3} \quad \text{hyperbolic excess velocity} (c_3 > 0)$$

$$q_2 = a(1 + \epsilon) \quad \text{farthest departure distance} (c_3 < 0)$$

$$p = \frac{2\pi}{n} \quad \text{the period}$$

For an Earth satellite, the quantities  $\dot{\omega}$  and  $\dot{\Omega}$  are also computed:

$$\dot{\omega} = \frac{nJ_a^2}{p^2} \left( 2 - \frac{5}{2} \sin^2 i \right)$$

$$\dot{\Omega} = \frac{-nJ_a^2}{p^2} \cos i$$

where

7.1-3 of 4

- J is the coefficient of the second harmonic in the Earth's oblateness expression
- $a_{\oplus}$  is the Earth radius, km
- n is the mean motion, rad/sec
- p is the semilatus rectum, km

so that  $\dot{\omega}$  and  $\dot{\Omega}$  may be converted to deg/day for output.

USE

Calling sequence:

```
CALL CLASS
PZE A, B
PZE C
NOP
error return
normal return
```

where

- A, ..., A+8 contain the input vectors  $\hat{P}$ ,  $\hat{Q}$ ,  $\hat{W}$ .
- B, ..., B+7 contain the input parameters  $c_1$ ,  $c_3$ ,  $\mu$ ,  $\epsilon$ ,  $1 - \epsilon$ , a, p and n, respectively, as computed by JEKYL.
- C, ..., C+9 contain the output parameters:
  - i, inclination, radians
  - $\Omega$ , right ascension of the ascending node, radians
  - $\omega$ , argument of pericenter, radians
  - q, closest approach distance, km
  - $V_p$ , velocity at closest approach, km/sec
  - $V_a$ , (or  $V_h$  if  $c_3 > 0$ ), velocity at farthest departure (or hyperbolic excess velocity), km/sec
  - $q_2$ , (or zero if  $c_3 > 0$ ), farthest departure distance, km
  - P, period, sec
  - $\dot{\omega}$ , derivative of  $\omega$ , deg/day
  - $\dot{\Omega}$ , derivative of  $\Omega$ , deg/day

The error exit will be taken if the input  $c_3$  is zero.

CODING INFORMATION

Length of subroutine (includes CLASS as a subset) is 1226 (10) or 2312 (8) words.

REFERENCE

7.1-4 of 4

Holdridge, D. B., Space Trajectories Program for the IBM 7090 Computer, Technical Report No. 32-223, Revision No. 1, Jet Propulsion Laboratory, Pasadena, California, September 1, 1962.

IDENTIFICATION

7.2-1 of 4

JEKYL  
 JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

PURPOSE

To compute the  $\hat{P}$ ,  $\hat{Q}$  and  $\hat{W}$  vectors, the epoch of closest approach, and  $c_1$  and  $c_3$  from cartesian position and velocity vectors.

RESTRICTIONS

- a. COMMON through COMMON+14 are used.
- b. An error can occur if the logarithm or square root of a negative number is attempted.
- c. Subroutines SQRT, UNIT, CROSS and LN are called.
- d. JEKYL is a subset of a rectangular-to-orbital-elements package and uses several other subroutines in the package.
- e. COMMON locations ECCEN, IMINE, AVAL, PVAL, NORB, NU, JECAN and MENAN are used.

METHOD

Given the cartesian position and velocity vectors  $\bar{R}$  and  $\bar{V}$  compute:

$$p = \frac{R^2 V^2 - (R\dot{R})^2}{\mu} \quad \text{the semilatus rectum}$$

where

$$R\dot{R} = \bar{R} \cdot \bar{V}$$

$$c_1 = \sqrt{R^2 V^2 - (R\dot{R})^2} \quad \text{the angular momentum}$$

$$\frac{1}{a} = \frac{2\mu - RV^2}{R\mu}$$

$$c_3 = -\frac{\mu}{a} \quad \text{the "energy" or vis viva integral}$$

At this point a test is made with the help of the I. D. input to determine whether or not  $a$  is an acceptable parameter.  $a^*$  is defined by

$$a^* = \begin{cases} 10^{10} \text{ km for the planets} \\ 10^9 \text{ km for the Sun} \\ 10^{12} \text{ km for the Moon} \end{cases}$$

The motion is considered parabolic and  $c_3$  is set to zero whenever  $|a| > a^*$ .

$$1 - \epsilon^2 = \frac{p}{a}$$

$$\epsilon = \sqrt{1 - (1 - \epsilon^2)}$$

the eccentricity

$$\begin{cases} \cos \nu = \frac{p - R}{\epsilon R} \\ \sin \nu = \frac{\dot{R}}{\epsilon} \sqrt{\frac{p}{\mu}} \end{cases}$$

true anomaly

$$q = \frac{p}{1 + \epsilon}$$

closest approach distance

$$\hat{W} = \frac{\bar{R} \times \bar{V}}{c_1}$$

unit angular momentum vector

$$\hat{U}_1 = \frac{\bar{R}}{R}$$

$$\hat{V}_1 = \frac{R}{c_1} \bar{V} - \frac{\dot{R}}{c_1} \bar{R}$$

$$\hat{P} = \cos \nu \bar{U}_1 - \sin \nu \bar{V}_1$$

$$\hat{Q} = \sin \nu \bar{U}_1 + \cos \nu \bar{V}_1$$

If  $c_3 \neq 0$ ,  $T - T_p$  is computed from Kepler's equation according to the sign of  $a$ :

If  $a > 0$ :

$$\begin{cases} \cos E = \frac{R}{p} (\cos \nu + \epsilon) \\ \sin E = \frac{R}{p} \sqrt{1 - \epsilon^2} \sin \nu \end{cases}$$

$$M = E - \epsilon \sin E$$

7.2-3 of 4

if  $1 - \epsilon > 0.1$  or if  $1 - \epsilon \leq 0.1$  and  $|\sin E| > 0.1$

$$M = (1 - \epsilon) \sin E + \left( \frac{\sin^3 E}{6} + \frac{3 \sin^5 E}{40} \right)$$

if  $1 - \epsilon \leq 0.1$  and  $\cos E > 0$ ,  $|\sin E| \leq 0.1$

$$M = n(T - T_p)$$

where

$$n = \sqrt{\mu a}^{-3/2}$$

if  $a < 0$ :

$$\sinh F = \frac{R\dot{R}}{\epsilon \sqrt{\mu |a|}}$$

$$M = \epsilon \sinh F - F$$

if  $\epsilon - 1 > 0.1$  or if  $\epsilon - 1 \leq 0.1$  and  $|\sinh F| > 0.1$

$$M = (\epsilon - 1) \sinh F - \left( \frac{3 \sinh^5 F}{40} - \frac{\sinh^3 F}{6} \right)$$

if  $\epsilon - 1 \leq 0.1$  and  $|\sinh F| \leq 0.1$

$$M = n(T - T_p)$$

where

$$n = \sqrt{\mu |a|}^{-3/2}$$

If  $c_3 = 0$ , the formula for the parabola is used:

$$M = \sqrt{\mu}(T - T_p) = qD + \frac{1}{6} D^3$$

where

$$D = R\dot{R}/\sqrt{\mu} = \sqrt{2q} \tan \nu/2$$

USE

Calling sequence:

CALL JEKYL

PZE 0, , A

PZE B, , C

PZE D  
PZE E, , F  
PZE G  
error return  
normal return

where

- A contains the  $\mu$  (gravitational coefficient) of the body from which the input position and velocity vectors are measured.
- A+1 contains an integer I. D. used in the parabola test: 0 = planets  
1 = Moon  
2 = Sun
- B, B+1, B+2 contain the input cartesian position vector,  $\bar{R}$ .
- C, C+1, C+2 contain the input cartesian velocity vector,  $\bar{V}$ .
- D, ..., D+8 contain the output unit vectors  $\hat{P}$ ,  $\hat{Q}$ ,  $\hat{W}$ .
- E contains the input epoch T.
- F contains the output epoch of closest approach,  $T_p$ .
- G, G+1, G+2 contain the output  $\Delta T = T - T_p$ , the angular momentum,  $c_1$ , and the energy or vis viva integral,  $c_3$ .

In addition, the following quantities are computed and stored in the COMMON locations given:

Location	Symbol	Description
ECCEN	$\epsilon$	eccentricity
IMINE	$1-\epsilon$	1 minus eccentricity
AVAL	a	semimajor axis
PVAL	p	semilatus rectum
NORB	n	mean motion
NU	$\nu$	true anomaly
JECAN	E(or F)	eccentric anomaly
MENAN	M	mean anomaly

The error exit is taken if a negative square root is attempted or if the logarithm of a negative number is attempted.

CODING INFORMATION

Length of subroutine (includes JEKYL as a subset) is 714(10) or 2312(8) words.

REFERENCE

Holdridge, D. B., Space Trajectories Program for the IBM 7090 Computer, Technical Report No. 32-223, Revision 1, Jet Propulsion Laboratory, Pasadena, California, September 1, 1962.



IDENTIFICATION

7.3-1 of 2

SPECL

JPL Staff

IBM 7094 Fap

December 2, 1964

PURPOSE

To compute the reference unit vectors  $\hat{R}$ ,  $\hat{S}$ ,  $\hat{T}$ , and  $\bar{B}$  and the impact parameters  $B \cdot T$ ,  $B \cdot R$ .

RESTRICTIONS

- a. COMMON through COMMON+3 are used.
- b. Subroutines SQRT, ARCOS and SIN are called.
- c. COMMON location PVAL and ECCEN are used.
- d. SPECL is a subset of a rectangular-to-orbital-elements package and uses several other subroutines in the package.
- e. External locations SAVA, INJTYP and RMAX are referenced indirectly.
- f. An error will occur if a negative square root is attempted.

METHOD

The computation of the  $\hat{S}$  and  $\bar{B}$  vectors depends on the value of the eccentricity,  $\epsilon$ :

- a.  $\epsilon \geq 1$ , the hyperbolic case with  $a < 0$ :

$$\hat{S} = \begin{cases} \frac{1}{\epsilon} \hat{P} + \frac{\sqrt{\epsilon^2 - 1}}{\epsilon} \hat{Q} & \text{for the incoming asymptote} \\ \frac{-1}{\epsilon} \hat{P} + \frac{\sqrt{\epsilon^2 - 1}}{\epsilon} \hat{Q} & \text{for the outgoing asymptote} \end{cases}$$

$$\bar{B} = \begin{cases} \frac{|a|(\epsilon^2 - 1)}{\epsilon} \hat{P} - \frac{|a|\sqrt{\epsilon^2 - 1}}{\epsilon} \hat{Q} & \text{for the incoming asymptote} \\ \frac{|a|(\epsilon^2 - 1)}{\epsilon} \hat{P} + \frac{|a|\sqrt{\epsilon^2 - 1}}{\epsilon} \hat{Q} & \text{for the outgoing asymptote} \end{cases}$$

b.  $\epsilon < 1$ , the elliptic case with  $a > 0$

7.3-2 of 2

$$\left. \begin{aligned} \hat{S} &= \hat{P} \\ \bar{B} &= a \sqrt{|\epsilon^2 - 1|} \hat{Q} \end{aligned} \right\} \text{for both the incoming and outgoing asymptote options}$$

The remaining two reference vectors  $\hat{T}$  and  $\hat{R}$  are given in either the hyperbolic or elliptic case by

$$\hat{T} = \left( \frac{S_y}{\sqrt{S_x^2 + S_y^2}}, \frac{-S_x}{\sqrt{S_x^2 + S_y^2}}, 0 \right)$$

$$\hat{R} = \hat{S} \times \hat{T}$$

USE

Calling sequence:

```
CALL  SPECL
PZE   A, , B
PZE   C
error return
normal return
```

Enter with the semimajor axis,  $a$ , in the AC and the eccentricity,  $\epsilon$ , in the MQ.

Where

- A, ..., A+8 contain the input vectors  $\hat{P}$ ,  $\hat{Q}$ ,  $\hat{W}$ .
- B contains zero for reference to an incoming asymptote and 1 for reference to an outgoing asymptote.
- C, ..., C+14 contain the output  $B \cdot T$ ,  $B \cdot R$  and vectors  $\hat{S}$ ,  $\bar{B}$ ,  $\hat{T}$  and  $\hat{R}$ , respectively.

The error return is taken if a negative square root is attempted.

CODING INFORMATION

Length of subroutine (includes SPECL as a subset) is 714(10) or 2312(8) words.

REFERENCE

Holdridge, D. B., Space Trajectories Program for the IBM 7090 Computer, Technical Report No. 32-223, Revision 1, Jet Propulsion Laboratory, Pasadena, California, September 1, 1962.

IDENTIFICATION

8

CLUCK

Peter S. Fisher, JPL

IBM 7094 Fap

December 2, 1964

PURPOSE

To compute the Canopus clock angle, Moon clock angle, and target clock angle.

RESTRICTIONS

The subroutines UNIT, CROSS, PROD, and ARTAN are called.

METHOD

$$\text{Clock } \star \triangleq \text{Tan}^{-1} \left( \frac{-\bar{A} \cdot \bar{C}}{\bar{B} \cdot \bar{C}} \right)$$

where:

$$\bar{A} = \frac{\bar{R}_{sp} \times \bar{R}_{ip}}{|\bar{R}_{sp} \times \bar{R}_{ip}|}$$

$$\bar{B} = \frac{\bar{A} \times \bar{R}_{sp}}{|\bar{A} \times \bar{R}_{sp}|}$$

$$\bar{C} = \frac{(\bar{N} \times \bar{R}_{sp}) \times \bar{R}_{sp}}{|(\bar{N} \times \bar{R}_{sp}) \times \bar{R}_{sp}|}$$

$\bar{R}_{sp} \triangleq$  True of-date Sun-probe position vector

$\bar{R}_{ip} \triangleq$  True of-date observation point-probe position vector

$\bar{N} \left\{ \begin{array}{l} \triangleq \text{True of-date probe-Canopus position vector for the Canopus clock angle} \\ \triangleq \text{True of-date Moon-probe position vector for the Moon clock angle} \\ \triangleq \text{True of-date target-probe position vector for the target clock angle} \end{array} \right.$

USE

Calling sequence:

Call CLUCK

PZE A, , B

return

where A is the location of the input  $\bar{R}_{ip}$  vector and where B is the location where the three output clock angles will be stored.

CODING INFORMATION

Length of subroutine is 72(10) or 110(8) words

IDENTIFICATION

9

COS/SIN/QCOS/QSIN

JPL Staff

IBM 7094 Fap

December 2, 1964

PURPOSE

To compute sin x or cos x for a floating point, single precision x (x in radians or degrees).

RESTRICTIONS

- a. Loops for large argument or small unnormalized argument.
- b. Uses COMMOM to COMMON +2.

METHOD

The argument is reduced to a first quadrant equivalent and then a thirteenth order polynomial approximation, employing fixed point arithmetic, is used.

The cosine is computed by first adding  $\pi/2$  to the argument.

USE

Enter with the argument in the accumulator.

Exit with the result in the accumulator.

Calling sequences:

for COS X		for SIN X	
X in radians	X in degrees	X in radians	X in degrees
CLA X	CLA X	CLA X	CLA X
CALL QCOS	CALL COS	CALL QSIN	CALL SIN
return	return	return	return

CODING INFORMATION

Length of subroutine is 159(10) or 237(8) words.

IDENTIFICATION

10-1 of 2

CROSS/PROD/UNIT

JPL Staff

IBM 7094 Fap

December 2, 1964

PURPOSE

To compute: (1) the cross product of two vectors; or (2) the dot product of two vectors, or the magnitude and magnitude squared of one vector; or (3) a unit vector.

RESTRICTIONS

- a. All vectors must be stored BES 3.
- b. In the calling sequences to the CROSS and UNIT option the location given for the output vector may be the same as the location given for an input vector.

METHOD

The vector operations of vector product and scalar product and the multiplication of a vector by a scalar ( $1/|v|$  to obtain a unit vector) are performed in a manner indicated by their definitions.

USE

Calling sequences:

- a. To compute the vector product of two vectors  $\vec{C} = \vec{A} \times \vec{B}$ :

CALL CROSS

PZE A, , B

PZE C

return

- b. To compute the scalar product of two vectors  $\vec{A} \cdot \vec{B}$ :

CALL PROD

MZE A, , B

return

Exit with the result in the accumulator.

- c. To compute the magnitude and magnitude squared of a vector  $\vec{A}$ :

CALL PROD

PZE A

return

Exit with the magnitude in the AC and the magnitude squared in the MQ.

d. To obtain a unit vector  $\bar{B} = \bar{A}/|\bar{A}|$ ;  
CALL UNIT  
PZE A, , B  
return

10-2 of 2

CODING INFORMATION

Length of subroutine is 66(10) or 102(8) words.

IDENTIFICATION

11

DAYS

JPL Staff

IBM 7094 Fap

December 2, 1964

PURPOSE

To convert the double precision floating point seconds located in the AC and MQ to single precision integer days and residual seconds.

RESTRICTIONS

- a. A double precision number is assumed to be two floating point words.
- b. Subroutines FIX, FLOAT, and ADD are called.
- c. Uses COMMON to COMMON +5.

METHOD

The double precision seconds are divided by 86,400 and the integral part of the result in single precision replaces the MQ. The residual seconds replace the AC.

USE

Enter with the seconds in the AC and MQ in double precision floating point. Exit with the residual seconds in floating point in the AC and the integral days in floating point in the MQ.

Calling sequence:

CLA L(SECONDS A)

LDQ L(SECONDS B)

CALL DAYS

return

CODING INFORMATION

Length of subroutine is 25(10) or 31(8) words.

IDENTIFICATION

12

DUMMY/EOS/CANCLK/DATCEL/RGGSAV/RGGSTR/EXPORT

JPL Staff

IBM 7094 Fap

December 2, 1964

PURPOSE

To allow certain parameters to be defined at program load time, and to provide storage and definition of miscellaneous quantities.

METHOD

EOS, RGGSAV and RGGSTR are defined. CANCLK is a three-word buffer for clock angles. DUMMY is provided for name only. DATCEL contains the BCD date of loading of the program in a format as follows: YYMMDD. EXPORT is a flag which controls the sensing of the 7094 on-line printer to read the JPL printer board and clock. If EXPORT is non-zero, no sensing of the on-line printer is made by the program. This is to allow non-JPL installations to use the program even if their printer board or clock hardware is different.

USE

This subroutine is always left symbolic and is the first physical subroutine in the deck. This allows for the word DATCEL and other parameters to be updated at load time, if necessary.

CODING INFORMATION

Length of subroutine is 9(10) or 11(8) words.



IDENTIFICATION

13-1 of 3

EARTH/SPACE  
 JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

PURPOSE

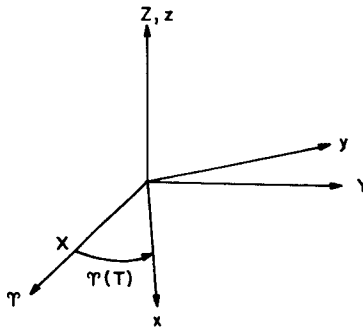
To rotate from space-fixed cartesian coordinates to Earth-fixed sphericals, and vice versa.

RESTRICTIONS

- a. Subroutines COS, SIN, RVIN, RVOU and MATRIX are called.
- b. COMMON through COMMON+11 are used.
- c. The COMMON locations GHA(T) and LOMEGA are assumed to contain the Greenwich hour angle in degrees and the Earth's rotation rate in radians/sec, respectively.

METHOD

At the epoch T a "space-fixed" cartesian coordinate system is defined, centered at the Earth with the X - Y plane the equator, the X axis the direction of the vernal equinox, and the Z axis the spin axis of the Earth. The "Earth-fixed" frame is obtained from the space-fixed by rotating about the Z axis by an angle  $\tau(T)$ , the Greenwich hour angle of the vernal equinox, to bring the x axis in coincidence with the Greenwich meridian as shown in the following sketch:



The coordinates are then related by

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} \cos \tau(T) & \sin \tau(T) \\ -\sin \tau(T) & \cos \tau(T) \end{pmatrix} \begin{pmatrix} X \\ Y \end{pmatrix}$$

$$z = Z,$$

and

13-2 of 3

$$\begin{pmatrix} \dot{x} \\ \dot{y} \end{pmatrix} = \begin{pmatrix} \cos \varphi(T) & \sin \varphi(T) \\ -\sin \varphi(T) & \cos \varphi(T) \end{pmatrix} \begin{pmatrix} \dot{X} \\ \dot{Y} \end{pmatrix} + \omega \begin{pmatrix} -\sin \varphi(T) & \cos \varphi(T) \\ -\cos \varphi(T) & -\sin \varphi(T) \end{pmatrix} \begin{pmatrix} X \\ Y \end{pmatrix}$$

$$\dot{z} = \dot{Z},$$

where  $\omega$  is the rotation rate of the Earth.

The inverse transformation is

$$\begin{pmatrix} X \\ Y \end{pmatrix} = \begin{pmatrix} \cos \varphi(T) & -\sin \varphi(T) \\ \sin \varphi(T) & \cos \varphi(T) \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

$$Z = z$$

and

$$\begin{pmatrix} \dot{X} \\ \dot{Y} \end{pmatrix} = \begin{pmatrix} \cos \varphi(T) & -\sin \varphi(T) \\ \sin \varphi(T) & \cos \varphi(T) \end{pmatrix} \begin{pmatrix} \dot{x} \\ \dot{y} \end{pmatrix} + \omega \begin{pmatrix} -\sin \varphi(T) & -\cos \varphi(T) \\ \cos \varphi(T) & -\sin \varphi(T) \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

$$\dot{Z} = \dot{z}$$

SPACE performs the rotation from space-fixed cartesian to Earth-fixed cartesian and then calls subroutine RVOUT to obtain the Earth-fixed spherical set.

EARTH calls subroutine RVIN to make the transformation from Earth-fixed spherical to Earth-fixed cartesian and then performs the rotation from Earth-fixed cartesian to space-fixed cartesian.

#### USE

Calling sequences:

- a. To rotate from space-fixed cartesian coordinates to Earth-fixed sphericals:

CALL SPACE

PZE A, , B

PZE C, , D

where A, A+1, A+2 contain the input space-fixed cartesian position.

B, B+1, B+2 contain the input space-fixed cartesian velocity.

C, ... , C+5 contain the output Earth-fixed spherical set  $r, \phi, \theta, v, \gamma, \sigma$ .

D, ... , D+5 contain the output Earth-fixed cartesian set  $x, y, z, \dot{x}, \dot{y}, \dot{z}$ .

b. To rotate from Earth-fixed sphericals to space-fixed cartesian coordinates:

CALL EARTH

PZE A

PZE B,,C

where A, ..., A+5 contain the input Earth-fixed spherical set  $r, \phi, \theta, v, \gamma, \sigma$ .

B, B+1, B+2 contain the output space-fixed cartesian position coordinates  $X, Y, Z$ .

C, C+1, C+2 contain the output space-fixed cartesian velocity coordinates  $\dot{X}, \dot{Y}, \dot{Z}$ .

and where both entries assume that COMMON location GHA(T) and LOMEGA contain the Greenwich hour angle in degrees and the Earth's rotation rate in radians/sec, respectively.

#### CODING INFORMATION

Length of subroutine is 112(10) or 160(8) words.

#### REFERENCE

Holdridge, D. B., Space Trajectories Program for the IBM 7090 Computer, Technical Report No. 32-223, Revision No. 1, Jet Propulsion Laboratory, Pasadena, California, September 1, 1962.

IDENTIFICATION

14-1 of 2

ECLIP

JPL Staff

IBM 7094 Fap

December 2, 1964

PURPOSE

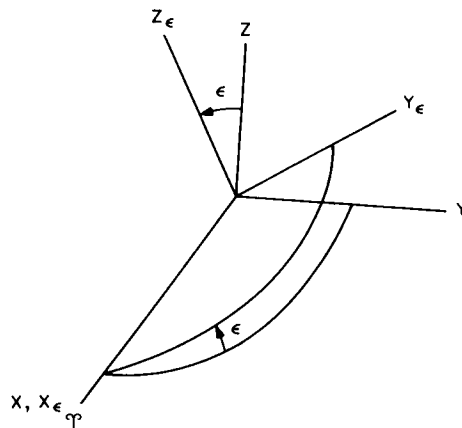
To rotate Earth equatorial coordinates to ecliptic and vice versa.

RESTRICTIONS

- a. Subroutines SIN, COS and MATRIX are called.
- b. COMMON+10 through COMMON+12 are used.
- c. The cell ET in COMMON is assumed to contain the mean or true obliquity of the ecliptic.

METHOD

The ecliptic plane is characterized by its inclination to the Earth's equator,  $\epsilon$ , the obliquity of the ecliptic, and its ascending node on the Earth's equator, the vernal equinox, as shown in the following sketch:



where X, Y, Z is the Earth equatorial frame and  $X_\epsilon$ ,  $Y_\epsilon$ ,  $Z_\epsilon$  is the ecliptic. The coordinates are related by

$$\begin{pmatrix} X_\epsilon \\ Y_\epsilon \\ Z_\epsilon \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\epsilon & \sin\epsilon \\ 0 & -\sin\epsilon & \cos\epsilon \end{pmatrix} \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}$$

where  $\epsilon$  can be the mean or true obliquity.

USE

14-2 of 2

Calling sequence:

```
CALL ECLIP
   PFX  X,, Y
   return
```

where

X-3, X-2, X-1 contain the input vector.

Y-3, Y-2, Y-1 contain the output vector.

PFX = PZE assumes equatorial input and rotates to ecliptic.

PFX = MZE assumes ecliptic input and rotates to equatorial.

X = Y is permitted.

And where the COMMON location ET contains the input true of-date obliquity or the mean 1950.0 obliquity.

#### CODING INFORMATION

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

#### REFERENCE

Holdridge, D. B., Space Trajectories Program for the IBM 7090 Computer, Technical Report No. 32-223, Revision No. 1, Jet Propulsion Laboratory, Pasadena, California, September 1, 1962.

IDENTIFICATION

15

EFFECT

JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

PURPOSE

To replace each of the output flags GROPS to GROPS +11 with a 0, 2, or 4 for the suppression, ecliptic, or equatorial output option, respectively.

RESTRICTIONS

- a. It is assumed that subroutine SPRAY has previously been called so that GROPS to GROPS +11 contain the group output flags.
- b. PHASE, GROPS and CODE, in COMMON, are used and GROPI is referenced indirectly.

METHOD

The value of PHASE is found to be 0, 1 or >1 according as the start-of-phase, normal, or end-of-phase print condition has been met at the print epoch. At the same time each flag will be a one digit octal integer. Each of the resulting 24 possible combinations is considered and each branch replaces the flag with 0, 2, or 4 scaled 35.

The following table summarizes the combinations and results:

Initial value of octal flag	Resulting value of octal flag
0	0 for all values of PHASE
1	4 for all values of PHASE
2	2 for all values of PHASE
3	0 for all values of PHASE
4	2 for PHASE = 0, 0 otherwise
5	4 for PHASE = 0, 0 otherwise
6	2 for PHASE > 1, 0 otherwise
7	4 for PHASE > 1, 0 otherwise

USE

Calling sequence:  
 CALL EFFECT  
 return

CODING INFORMATION

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

IDENTIFICATION

16-1 of 6

EPHEM  
 JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

PURPOSE

The ephemeris interpolation routine EPHEM is designed to read a JPL Ephemeris Tape and to interpolate for the position and/or velocity of any subset of the planets and Moon at any Julian date within the time interval spanned by the tape.

The ephemeris data carried on tape are in heliocentric coordinates for the planets and geocentric coordinates for the Moon. EPHEM, however, may be used to obtain coordinates referenced to any of the bodies as center. In particular, data are furnished for the Earth-Moon barycenter rather than for the Earth, and EPHEM performs the necessary calculations for obtaining geocentric coordinates of the planets and Sun.

The data on the ephemeris tape and the results of the interpolation are expressed in the coordinate system of the mean Earth equator and equinox of 1950.0.

RESTRICTIONS

- a. Subroutines READB, BSREC, REWIND are called.
- b. A buffer of 1862 cells must be provided by the user for storage of the raw ephemeris from the tape. Buffers of 36, 13, and 150 cells are also required by EPHEM, as described in USE.
- c. EPHEM makes extensive use of 7094 double precision instructions, hence all tables must start in even core locations.
- d. The ephemeris tape must be in the format described in Appendix A of Ref. 1.

METHOD

Everett's formula

$$\begin{aligned}
 x(T_j) = & ux_0 + tx_1 + \frac{u(u^2 - 1)}{3!} \Delta_m^2 x_0 + \frac{t(t^2 - 1)}{3!} \Delta_m^2 x_1 \\
 & + \frac{u(u^2 - 1)(u^2 - 4)}{5!} \Delta_m^4 x_1 + \frac{t(t^2 - 1)(t^2 - 4)}{5!} \Delta_m^4 x_1
 \end{aligned}$$

is used for interpolation, where

$T_j$  = the desired Julian date,  $T \leq T_j < T + h$

$h$  = step size of data

$T$  = point in time at which data are tabulated

$$t = (T_j - T)/h, 0 \leq t \leq 1$$

16-2 of 6

$$u = 1 - t$$

$$x_0 = x(T)$$

$$x_1 = x(T + h)$$

$$\Delta_m^n = n^{\text{th}} \text{ modified difference}$$

It is assumed that the Julian date specified by the user as the epoch for which data are requested is in Universal Time. Since the ephemerides are tabulated in Ephemeris Time, the specified epoch is modified by

$$ET = UT + \Delta t$$

to convert to Ephemeris Time.

Planetary coordinates for centers other than the Sun are obtained by the vector subtraction

$$\bar{P} = \bar{P}_0 - \bar{C}$$

where

$$\bar{P} = \text{planetary coordinates referred to the desired center}$$

$$\bar{P}_0 = \text{planetary coordinates referred to the Sun}$$

$$\bar{C} = \text{heliocentric coordinates of the desired center}$$

A similar vector subtraction is performed for velocity vectors.

Calculation of the heliocentric coordinates of the Earth and/or Moon or the geocentric or selenocentric coordinates of the Sun and planets requires additional manipulations.

Heliocentric lunar and Earth coordinates are obtained as

$$\bar{M} = \bar{B} + \mu_m \bar{L}$$

$$\bar{E} = \bar{B} - \mu_e \bar{L}$$

where

$$\bar{M} = \text{heliocentric coordinates of the Moon}$$

$$\bar{E} = \text{heliocentric coordinates of the Earth}$$

$$\bar{B} = \text{heliocentric coordinates of the Earth-Moon barycenter}$$

$$\bar{L} = \text{geocentric coordinates of the Moon}$$

$$\mu_m = \frac{\mu_E}{\mu_E + \mu_M}$$

$$\mu_e = \frac{\mu_M}{\mu_E + \mu_M}$$



$\mu_E$  = the GM of the Earth

16-3 of 6

$\mu_M$  = the GM of the Moon

Both  $\mu_E$  and  $\mu_M$  are obtained from TAB1, as described in the next section.

## USE

The subroutine EPHEM may be used by either the FORTRAN II or the FAP programs.

The calling sequence for a FORTRAN II program is

CALL EPHEM (JD, CENT, TAB1, TAB2, TAB3, TAB4, NTAPE)

and for the FAP program is

CALL EPHEM, JD, CENT, TAB1, TAB2, TAB3, TAB4, NTAPE

The arguments in the calling sequence are interpreted as follows:

JD = double-precision floating point Julian date  $T_j$ , assumed to be in Universal Time, at which data are required.

CENT = control-word floating point integer identifying the desired center of the coordinate system according to the scheme given in Table 1.

TAB1 = 36-word table of physical constants with the structure given in Table 2.

TAB2 = 13 floating point integers that control the data output for each body according to the scheme given in Table 3. The control-word sequence is given in Table 4.

TAB3 = 1862-word buffer used by EPHEM to store a record of ephemeris data as it is read from the ephemeris tape.

TAB4 = 150-word block of storage containing the output information listed in Table 5. The control-word integer in TAB4 is interpreted as shown in Table 6.

NTAPE = location of word containing a fixed-point number designating the logical tape unit on which the JPL Ephemeris Tape is mounted.

The nutations and nutation rates are always in units of radians and radians/day. The units of the planetary and lunar data are determined by the value of the output control word found in location TAB1 +34. If this single precision word is zero the output will be in kilometers and kilometers/sec; if this word is 1.0 the planetary data will be in AU and AU/day and the lunar data will be in "Earth-radii" and "Earth-radii"/day.

The output is always cartesian, referenced to the mean Earth equator and equinox of 1950.0.

## CODING INFORMATION

- a. When the routine is part of a new core load it will automatically rewind the ephemeris tape the first time called to allow it to retrieve the data in the identification records. This data defines the time span of data on the tape. The criterion for this rewind is comparison of the current tape unit designation with that of the previous call. Only if they are the same will a rewind not be issued. To prevent rewinds when chain type jobs

are run, the entry TAPEX is provided. The six quantities starting at TAPEX may be "wanted" (see Ref. 2) from link to link in any compatible fashion to prevent rewinding. To deliberately cause a rewind, the entry EPTAPE is provided. If a zero is stored in this cell, the ephemeris tape will rewind the next time EPHEM is called.

b. Length of subroutine is 813(10) or 1455(8) words.

Table 1. Central body identification

Body	Control integer	Body	Control integer
Mercury	1.0	Neptune	8.0
Venus	2.0	Pluto	9.0
Earth	3.0	Sun	10.0
Mars	4.0	Moon	11.0
Jupiter	5.0	Earth-Moon	
Saturn	6.0	barycenter	12.0
Uranus	7.0		

Table 2. TAB1 structure


Word in record	Physical constant and unit	Word format
TAB1	k = universal gravitational constant, AU <sup>3/2</sup> /day	Double-precision floating point 
TAB1+2	GM of Mercury, km <sup>3</sup> /sec <sup>2</sup>	
+4	GM of Venus, km <sup>3</sup> /sec <sup>2</sup>	
+6	GM of Earth, km <sup>3</sup> /sec <sup>2</sup>	
+8	GM of Mars, km <sup>3</sup> /sec <sup>2</sup>	
+10	GM of Jupiter, km <sup>3</sup> /sec <sup>2</sup>	
+12	GM of Saturn, km <sup>3</sup> /sec <sup>2</sup>	
+14	GM of Uranus, km <sup>3</sup> /sec <sup>2</sup>	
+16	GM of Neptune, km <sup>3</sup> /sec <sup>2</sup>	
+18	GM of Pluto, km <sup>3</sup> /sec <sup>2</sup>	
+20	GM of Sun, km <sup>3</sup> /sec <sup>2</sup>	
+22	GM of Moon, km <sup>3</sup> /sec <sup>2</sup>	
+24	Astronomical unit, km	
+26	Earth radius for lunar ephemeris conversion, km	
+28	Speed of light, km/sec	

Table 2 (Cont'd)

16-5 of 6

Word in record	Physical constant and unit	Word format
TAB1+30	Solar-flux constant, lb-force/m <sup>2</sup>	Double-precision floating point
+32	Seconds per mean solar day	Double-precision floating point
+34	Output-unit control word	Single-precision floating point
+35	$\Delta t = ET - UT, \text{ sec}$	Single-precision floating point

Table 3. TAB2 output control interpretation

Control word	Meaning
0.0	No data, this body
1.0	Position data only, this body
2.0	Velocity data only, this body
3.0	Both position and velocity data, this body

Table 4. TAB2 structure

Word position	Body controlled	Word position	Body controlled
TAB2	Mercury	TAB2+7	Neptune
TAB2+1	Venus	+8	Pluto
+2	Earth	+9	Sun
+3	Mars	+10	Moon
+4	Jupiter	+11	Earth-Moon barycenter
+5	Saturn		
+6	Uranus	+12	Nutations

Table 5. TAB4 structure

16-6 of 6

Word position	Contents
TAB4	Floating point control-word integer indicating type of error, if any
TAB4+1	Zero cell for double-precision compatibility
+2	Mercury position and velocity in double-precision floating point
+14	11 more sub-blocks of position and velocity data for each of the other bodies in double-precision floating point, each sub-block consisting of 12 words, in the same order as given in TAB2
+146	Nutation in longitude and nutation in latitude in single-precision floating point
+148	Nutation rates in single-precision floating point

Table 6. TAB4 error code interpretation

Control word	Meaning
0.0	Successful return
1.0	Specified date $T_j$ smaller than starting date of data available
2.0	$T_j$ greater than final date of data available
3.0	Reading error (redundancy)
4.0	A TAB2 control word is negative or greater than 3
5.0	CENTER control word is in error

REFERENCES

1. Peabody, P. R., Scott, J. F., Orozco, E. G., User's Description of JPL Ephemeris Tapes, Technical Report No. 32-580, Jet Propulsion Laboratory, Pasadena, California, March 2, 1964.
2. Newhall, N. S., User's Guide for JPTRAJ (JPL Trajectory Monitor), Engineering Document No. 199, Jet Propulsion Laboratory, Pasadena, California, January 4, 1964.

IDENTIFICATION

17-1 of 2

EPHSET/E. T./INTR1

Alan D. Rosenberg, JPL

IBM 7094 Fap

December 2, 1964

PURPOSE

- a. EPHSET performs initialization of the calling sequence to the subroutine EPHEM.
- b. INTR1 obtains positions and velocities of the Moon, Sun, and planets at a given epoch from the double precision JPL Ephemeris Tape and arranges this information in a manner compatible with the program SPACE. Results are referenced to the mean Earth equator and equinox of 1950.0.
- c. E. T. converts a given universal time epoch to the corresponding ephemeris time epoch.

RESTRICTIONS

- a. FIX, DAYS, EPHEM, GRUPPE, PROUT, ERPRT, ABORT and UNLOAD are called.
- b. NEWBCD, TARAD, CENTR5, CENTE5, TAPEX and EPTAPE are external cells which are referenced.
- c. Subroutine INTR1 has the following error conditions:
  1. Unknown central body reference for EPHEM: (CENTER).
  2. Unknown control word for EPHEM: (CONTRL).
  3. Redundancy reading ephemeris tape: (REDUN).
  4. Input epoch earlier than data on ephemeris tape: (EARLY).
  5. Input epoch later than data on ephemeris tape: (LATE).

The word in parenthesis above is printed in the error message: PLANETARY EPHEMERIS ERROR = (error word) on a device appropriate to the mode of SFOF operation and always on the off-line output.

Conditions 1. and 2. cause CALL ABORT in SFOF mode 4 and non-SFOF mode of operation, and TSX ENDSYS, 4 in SFOF mode 2. Conditions 3., 4., and 5. allow one re-try in mode 4 and non-SFOF mode by pressing START, then CALL ABORT in case of a second failure. In SFOF mode 2, TSX ENDSYS, 4 occurs and a comment TURN ON-----AFTER OPERATOR ACTION is printed, where the name of the program currently operating is inserted above.

- d. The ephemeris tape is assumed to be mounted on SYSUT8, which corresponds to FORTRAN logical tape 12 and physical unit B6.
- e. The COMMON cells T, KB0, XN, XN., CENTER, TARG, PRFLG, 37HED, SP1A, SP2A, SP3A, EJCTA, SP1B, SP2B, SP3B, EJCTB, SP1C, SP2C, EJCTC are referenced.

- f. The system low-core cells (PAUSE, ENDSYS, SFMODE and JPTRAJ) are referenced.
- g. The buffer NEWBOD through NEWBOD +3 and entry BODTAB are provided to allow substitution of any of the normally unused planets, i. e. Mercury, Neptune, Uranus and Pluto, in place of Saturn.
- h. The buffers EGM, SCALE1, DUT and GRAV contain physical constants which may be modified by input. Entry NUTLOB has been provided so the computed nutations are accessible.

## METHOD

- a. INTR1 takes the double precision seconds past 0<sup>h</sup> January 1, 1950 U. T. which it assumes to be in T and T+1, converts it to double precision Julian date and calls EPHEM; upon return, the double precision positions and velocities of the bodies are rounded off and stored in the XN and XN. buffers in COMMON. The nutation in longitude and obliquity and their rates in radians and radians/day are placed in NUTOBL through NUTOBL +3.
- b. E. T. adds T, the double precision seconds past 0<sup>h</sup> January 1, 1950 U. T. to  $\Delta T$ , the difference between Universal and Ephemeris time, and returns with the results in the AC-MQ.

## USE

- a. CALL EPHSET  
return
- b. CALL INTR1  
return

Assumption is that T and T+1 contain the double precision seconds past 0<sup>h</sup> January 1, 1950 U. T., and CENTER contains a fixed point integer scaled 35, of value 0 through 6, corresponding to the names EARTH, MOON, SUN, VENUS, MARS, SATURN, JUPITE, respectively.

- c. CALL E. T.  
return

Assumption is as above for cells T and T+1. Results are double precision seconds past 0<sup>h</sup> January 1, 1950 E. T. in the AC-MQ.

## CODING INFORMATION

Length of subroutine is 2308(10) or 4404(8) words.

## REFERENCE

Cary, C.; Inter-Office Memorandum 312. 3-176, Physical Constants and Other Parameters to be used in MA-C Computations-Updated Version, October 30, 1964.

IDENTIFICATION

18

FIX/FLOAT  
JPL Staff  
IBM 7094 Fap  
December 2, 1964

PURPOSE

To convert a single precision floating point number to a fixed point integer scaled 35 or vice versa.

RESTRICTIONS

Conversion will be made mod  $2^{27}$ .

METHOD

The unnormalized add and floating point add instructions are used with masks.

USE

Enter with the number to be converted in the accumulator. Exit with the result in the accumulator.

Calling sequences:

To float a fixed point integer:

CLA L(INTEGER)

CALL FLOAT

return

To fix a floating point number:

CLA L(NUMBER)

CALL FIX

return

CODING INFORMATION

Length of subroutine is 9(10) or 11(8) words.

IDENTIFICATION

19-1 of 2

FIXT/FLOT  
JPL Staff  
IBM 7094 Fap  
December 2, 1964

PURPOSE

To compute the number of seconds that have elapsed since 0<sup>h</sup> January 1, 1950, given a Greenwich Mean Time (GMT) between the years 1950 and 2000 or vice versa.

RESTRICTIONS

- a. The locations YEAR to YEAR +6, in COMMON, are used in the FIXT option.
- b. A double precision number is considered to be two floating point words.

METHOD

The double precision floating point number is decoded into the various lengths of time and vice versa, taking into account leap years and leap centuries.

USE

- a. GMT to seconds: on entrance the AC must contain YYMM0DDHH and the MQ must contain NNSSFFF, where

YY = last two digits of the year  
MM = month of the year, January being 1  
0 = zero  
DD = days  
HH = hours  
NN = minutes  
SS = seconds  
FFF = milliseconds

Exit with the double precision floating point seconds past 0<sup>h</sup>, January 1, 1950, in the AC and MQ. If YY = MM = 0, then (AC - MQ) is converted to an interval in double precision seconds.

Calling sequence:

CLA L(YYMM0DDHH)  
LDQ L(NNSSFFF)  
CALL FLOT  
return



b. Seconds to GMT: on entrance the AC and MQ must contain the double precision floating point seconds past 0<sup>h</sup>, January 1, 1950. Exit with the GMT in location YEAR to YEAR +6, where

YEAR = YY = last two digits of year  
+1 = MM = month, January being 1  
+2 = DD = days  
+3 = HH = hours  
+4 = NN = minutes  
+5 = SS = seconds  
+6 = FFF = milliseconds

YEAR through YEAR +5 are fixed point integers scaled 35. YEAR +6 is fixed point scaled 0.

Calling sequence:

```
CLA    L(SECONDS A)
LDQ    L(SECONDS B)
CALL   FIXT
return
```

#### CODING INFORMATION

Length of subroutine is 175(10) or 257(8) words.

## IDENTIFICATION

20-1 of 2

GEDLAT  
 JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

## PURPOSE

To compute  $\phi'$ , the geodetic latitude of the probe, and  $\rho'$ , the distance from the geocenter to the point on the surface of the Earth lying on the Earth-probe line.

## RESTRICTIONS

- a. Subroutines SIN and SQRT are called.
- b. COMMOM through COMMON+9 are used.

## METHOD

- a.  $\phi'$  is given by:

$$\phi' = \phi + b_1 \sin 2\phi + b_2 \sin 4\phi + b_3 \sin 6\phi$$

where  $\phi$  is the input geocentric latitude of the probe,

$$b_1 = 0.19456624 \text{ deg}$$

$$b_2 = 0.00033036 \text{ deg}$$

$$b_3 = 0.00000075 \text{ deg.}$$

- b.  $\rho'$  is given by:

$$\rho' = a \sqrt{1 - \epsilon^2 \sin^2 \phi}$$

where  $\phi$  is the input geocentric latitude of the probe,

$$\epsilon^2 = 0.006768657997, \text{ eccentricity squared,}$$

$$a = 6378.2064, \text{ equatorial radius, kilometers.}$$

## USE

Calling sequence:

CALL GEDLAT

20-2 of 2

Enter with the geocentric latitude of the probe,  $\phi$ , in the accumulator in degrees.

Exit with the geodetic latitude of the probe,  $\phi'$ , in the AC in degrees and the radius,  $\rho'$ , in the MQ in kilometers.

#### CODING INFORMATION

Length of subroutine is 46(10) or 56(8) words.

#### REFERENCE

Holdridge, D. B., Space Trajectories Program for the IBM 7090 Computer, Technical Report 32-223, Revision 1, Jet Propulsion Laboratory, Pasadena, California, September 1, 1962.

## IDENTIFICATION

21

GETTER  
 JPL Staff  
 IBM 7094 Fap

## PURPOSE

To compute, in floating point, the angle, in degrees, between two vectors, where each vector is the difference of two other vectors.

## RESTRICTIONS

- a. All vectors must be stored BES 3.
- b. Subroutines ARCOS and PROD are called.
- c. The formula used to compute the angle does not hold, in general, for unit vectors since

$$\frac{\bar{A} - \bar{B}}{|\bar{A} - \bar{B}|} \neq \frac{\hat{A} - \hat{B}}{|\hat{A} - \hat{B}|}$$

for all  $\bar{A}, \bar{B}$  where  $\hat{\phantom{x}}$  signifies a unit vector.

## METHOD

The desired angle is computed using the following formula:

$$\text{ANGLE} = \text{ARCOS} \left[ \frac{(\bar{A} - \bar{B}) \cdot (\bar{C} - \bar{B})}{|\bar{A} - \bar{B}| |\bar{C} - \bar{B}|} \right]$$

Note: For  $\bar{B} = \bar{0}$ , either  $\bar{A}$  or  $\bar{C}$  may be unit vectors and give a correct result.

## USE

Calling sequence:

```
CALL  GETTER
PZE   A, , C
PZE   B, , D
return
```

The angle between the vectors  $\bar{A} - \bar{B}$  and  $\bar{C} - \bar{B}$  is computed in degrees and stored in D.

## CODING INFORMATION

Length of subroutine is 37(10) or 45(8) words.

IDENTIFICATION

22-1 of 2

GHA  
 JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

PURPOSE

To compute the Earth's rotation rate and the Greenwich hour angle of the vernal equinox.

RESTRICTIONS

- a. COMMON locations T, T+1, NUTRA, LOMEGA, OMEGA and GHA(T) contain input and output quantities.
- b. COMMON through COMMON+6 are used.
- c. Subroutines DAYS, FIX and FLOAT are called.

METHOD

The mean value of the Greenwich hour angle is computed as follows:

$$\tau_m(T) = 100.07554260 + 0.9856473460 d + (2.9015) 10^{-13} d^2 + \omega t \pmod{360 \text{ deg}}$$

$$0 \leq \tau_m(T) < 360 \text{ deg}$$

where

- T is the epoch under consideration in U. T.
- d is integer days past 0 hr January 1, 1950
- t is seconds past 0 hr of epoch T
- $\omega$  is the Earth's rotation rate and is given by:

$$\omega = \frac{0.00417807417}{1 + (5.21) 10^{-13} d} \text{ deg/sec.}$$

Given the nutation in right ascension,  $\delta\alpha$ , the true value of the hour angle is:

$$\tau(T) = \tau_m(T) + \delta\alpha$$

USE

Calling sequence:

```
CALL  GHA
      return
```

where

- T, T+1 contain the input double precision seconds past 0 hr January 1, 1950 U. T.
- NUTRA contains  $\delta\alpha$ , the input nutation in right ascension in degrees.
- OMEGA contains the output Earth's rotation rate in deg/sec.

LOMEGA contains the output Earth's rotation rate in rad/sec.

GHA(T) contains the output true Greenwich hour angle in degrees.

CODING INFORMATION

Length of subroutine is 68(10) or 104(8) words.

IDENTIFICATION

23

GRUPPE  
JPL Staff  
IBM 7094 Fap  
December 2, 1964

PURPOSE

To maintain a count of the number of lines of output made on a page and to use this count to control page ejects.

RESTRICTIONS

Subroutine SEITE is called to give the page eject and page heading.

METHOD

If the print suppress flag indicates no printing, the subroutine exits.  $N$ , the number of lines of output that are going to be printed in the following group, is added to the current line count  $C$ . If  $N + C > 63$  subroutine SEITE is called to get a page eject and page heading. If  $N + C \leq 63$ ,  $N + C$  becomes the new line count  $C$ .

USE

Calling sequence:

```
CALL  GRUPPE  
PZE  N
```

where  $N$  is the number of lines of output that will be requested before the next CALL GRUPPE.

CODING INFORMATION

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

IDENTIFICATION

24.1

INTRAN  
JPL Staff  
IBM 7094 Fap  
December 2, 1964

PURPOSE

To print the initial conditions found in the identification record of the spacecraft ephemeris tape as the heading information for the trajectory to be processed.

RESTRICTIONS

- a. Subroutines DAYS, E. T., ROTEQ, MNA, GHA, GRUPPE, TIME2 and PROUT are used.
- b. Entries PHL, RMAX, INJBCD, INJTYP, INJX, INJY, INJZ, INJDX, INJDY, INJDZ, INJEQX, HARMN2, GASOPT and CENTR5 are provided for storage of data from the spacecraft ephemeris identification record.
- c. GRAV, LUNGRV, SCALE1, RADOPT, BRNOPT, RUNID and EPHSET are referenced indirectly to locate quantities for printing.

METHOD

INTRAN prints the physical constants, injection conditions and other quantities which determine the trajectory integrated by SPACE. This information comes to SFPRO in the identification record of the spacecraft ephemeris.

USE

Calling sequence:  
CALL INTRAN  
return

CODING INFORMATION

Length of subroutine (includes INTRAN as a subset) is 728(10) or 1330(8) words.



IDENTIFICATION

24.2

NUTATE  
 JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

PURPOSE

To update the precession A and nutation N matrices and apply the product matrix NA to the Earth-probe vector.

RESTRICTIONS

- a. NUTATE is a subset of a rotation package and uses other parameters in the package.
- b. MNAET is tested to determine if the .1 day delta-time option is to be used in computing the N matrix. A zero MNAET forces recomputation of N.
- c. Locations XEP, CC, (NA), AA and TARG (epoch in days past 0 hr January 1 1950), in COMMON, are referenced.
- d. Subroutines ROTEQ, MNA and MATRIX are called.
- e. COMMON through COMMON+2 are used.
- f. NUTMAT, the location of the nutation matrix, is referenced indirectly.

METHOD

Subroutine ROTEQ is called to update the A matrix. The N matrix is updated if MNAET = 0 or if MNAET is non-zero and time has increased by .1 day since the last computation. N is updated by calling subroutine MNA. Then subroutine MATRIX is called to form the product NA. The CC+3 vector is then multiplied by NA to give the Earth-probe position vector in the space fixed Earth true equator and equinox of date coordinate system (XEP).

USE

Calling sequence:

```
CALL  NUTATE
      return
```

CODING INFORMATION

Length of subroutine (includes NUTATE as a subset) is 728(10) or 1330(8) words.

IDENTIFICATION

24.3

RESET

JPL Staff

IBM 7094 Fap

December 2, 1964

PURPOSE

To set the obliquity of the ecliptic to the 1950.0 value and to set the NA matrix to unity.

RESTRICTIONS

- a. RESET is a subset of a rotation package and uses other parameters in the package.
- b. COMMON locations ET and (NA) are used.

METHOD

The mean obliquity of 1950.0 is put into ET and the (NA) matrix is set to unity so any use of these quantities will cause the results to be in the mean 1950.0 coordinate system.

USE

Calling sequence:

CALL RESET

return

CODING INFORMATION

Length of subroutine (includes RESET as a subset) is 728(10) or 1330(8) words.

IDENTIFICATION

24.4

ROT

JPL Staff

IBM 7094 Fap

December 2, 1964

PURPOSE

To update the planetary ephemerides, the Greenwich hour angle and the (n-body)-probe vector and to rotate several sets of vectors to the output coordinate system.

RESTRICTIONS

- a. ROT is a subset of a rotation package and uses other subroutines in the package.
- b. Subroutines INTR1, GHA, UNIT, MATRIX, RESET and NUTATE are called.
- c. Location EQUINX1 is referenced indirectly.
- d. CX, CX., QX, QX., XN, XN., CS2, (NA), XEP, XEP., X, X., S2, CANOP, XN1, XN.1, X0P, X0P. and VAFLG, in COMMON, are used.

METHOD

- a. The planetary ephemerides are updated by calling subroutine INTR1.
- b. Subroutine NUTATE is called (which calls MNA to update the nutation in rt. ascension and the M and N matrices) and then GHA is called to compute the current value of the true Greenwich hour angle.
- c. The true of-date Earth-probe position and velocity vector are computed and stored in XEP and XEP. .
- d. RESET is called if the output equinox is 1950.0.
- e. The X, X., S1, S2, CANOP, and the variational coefficients are rotated to the desired output reference system, determined by the contents of location EQUINX1.
- f. The Earth-(n-body) position and velocity vectors are formed.
- g. The N and A matrices are recomputed, if RESET was called earlier.

USE

Calling sequence:

```
CALL ROT
return
```

CODING INFORMATION

Length of subroutine (includes ROT as a subset) is 728(10) or 1330(8) words.

IDENTIFICATION

25

LN/LOG10  
 JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

PURPOSE

To compute  $\log_{10} x$  or  $\log_e x$  for a floating point, single precision  $x$ .

RESTRICTIONS

- a. An error will occur if  $x \leq 0$ .
- b. Uses COMMON to COMMON +3.

METHOD

Represent  $x$  as  $2^k F$  where  $1/2 \leq F < 1$ .

Therefore,  $\log_e x = \log_e (2^k F) = k \log_e 2 + \log_e F$ .

The following continued fraction is used to compute  $\log_e F$ :

$$\log_e F = \log_e \left( 0.725 + \frac{r}{0.725 + \frac{r}{2 + \frac{r}{2.175 + \frac{r}{1 + \frac{r}{3.625 + \frac{r}{\frac{2}{3} + \frac{r}{5.075 + \frac{r}{0.5}}}}}}}} \right)$$

where  $r = (F - 0.725)$ .

$\log_{10} x$  is computed by obtaining  $\log_e x$ , using the above approximation, and then using the relation:

$$\log_{10} x = (\log_e x) (\log_{10} e)$$

Accuracy: This method gives 26 significant binary digits except near  $x = 1$ , where the result is accurate to 26 binary places.

USE

Enter with a floating point argument in the accumulator, exit with the floating point logarithm in the accumulator.

Calling sequences:

For $\log_e x$ :	CLA	X	For $\log_{10} x$ :	CLA	X
	CALL	LN		CALL	LOG10
	error return			error return	
	normal return			normal return	

CODING INFORMATION

Length of subroutine is 59(10) or 73(8) words.

IDENTIFICATION

26-1 of 12

LOOP

Alan D. Rosenberg, JPL

IBM 7094 Fap

December 2, 1964

PURPOSE

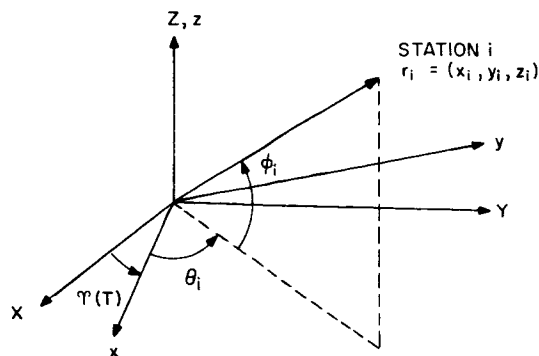
To make calculations for view periods and station prints for designated stations, and to print the results of these calculations.

RESTRICTIONS

- a. Subroutines called are PRSET, MATRIX, UNIT, PROD, CROSS, SIN, COS, ARSIN, ARCOS, CLUCK, GETTER, LOG10, GRUPPE, PROUT.
- b. Cells referred to indirectly are GRAV and PLOTFO.
- c. The COMMON region is used including cells from COM through COM+199, and X0P, CX., SP1B, SP1C, SP2B, SP2C, SP3B, SP3C, T(0), OMEGA, PRFLG, CENTER, GHA(T), and LOMEGA.

METHOD

Let the space-fixed geocentric cartesian coordinates of the probe referenced to the true equator and equinox of date be given as  $(X, Y, Z)$ , and the corresponding velocity vector as  $(\dot{X}, \dot{Y}, \dot{Z})$ . For a station with coordinates  $(r_i, \phi_i, \theta_i)$  the program computes the topocentric quantities to be described herein. Sketch 1 illustrates the basic coordinate systems.



Sketch 1. Earth - fixed station coordinates

$\gamma(T)$  is the right ascension of the Greenwich meridian at epoch T.  $r_i$  is the distance from the geocenter to the station,  $\phi_i$  is the geocentric north latitude, and  $\theta_i$  is the east longitude.

The subroutine LOOP, in its arithmetic calculations, first sets up the matrix shown below:

$$\begin{bmatrix} \cos \gamma(T) & \sin \gamma(T) & 0 \\ -\sin \gamma(T) & \cos \gamma(T) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

This matrix is stored in locations SIMLAR +40, through SIMLAR +48, where  $\gamma(T)$  is the right ascension of the Greenwich meridian at epoch T. The Earth-fixed cartesian coordinates of the probe (x, y, z) are found below:

$$\begin{Bmatrix} x \\ y \\ z \end{Bmatrix} = \begin{bmatrix} \cos \gamma(T) & \sin \gamma(T) & 0 \\ -\sin \gamma(T) & \cos \gamma(T) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} X \\ Y \\ Z \end{Bmatrix}$$

(X, Y, Z) are the geocentric true-of-date space fixed cartesian coordinates of the probe and are located in locations CAPX, CAPY, CAPZ, respectively.

The corresponding Earth-fixed velocity components ( $\dot{x}$ ,  $\dot{y}$ ,  $\dot{z}$ ) are computed by the following operations:

$$\begin{Bmatrix} \dot{x} \\ \dot{y} \\ \dot{z} \end{Bmatrix} = \begin{bmatrix} \cos \gamma(T) & \sin \gamma(T) & 0 \\ -\sin \gamma(T) & \cos \gamma(T) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} \omega Y + \dot{X} \\ -\omega X + \dot{Y} \\ \dot{Z} \end{Bmatrix}$$

where  $\omega$  is the rotation rate of the Earth.

The coordinates are stored in X) through X)+2. The velocities are stored in X). through X).+2

The Earth-fixed cartesian coordinates of the station are:

$$x_i = r_i \cos \phi_i \cos \theta_i$$

$$y_i = r_i \cos \phi_i \sin \theta_i$$

$$z_i = r_i \sin \phi_i$$

The storage is arranged as follows:

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SIMLAR+3  $\phi_i$   
 SIMLAR+4  $\theta_i$   
 SIMLAR+5  $r_i$   
 SIMLAR+11  $\sin \phi_i$   
 SIMLAR+12  $\cos \phi_i$   
 SIMLAR+13  $\sin \theta_i$   
 SIMLAR+14  $\cos \theta_i$

where the sines and cosines of  $\phi_i$  and  $\theta_i$  are computed in LOOP.

The values of  $(x_i, y_i, z_i)$  are placed in SIMLAR+18  $\rightarrow x_i$   
 +19  $\rightarrow y_i$   
 +20  $\rightarrow z_i$

The topocentric coordinates of the probe are  $(x_{ip}, y_{ip}, z_{ip})$  where

$$\begin{aligned} x_{ip} &= x - x_i \rightarrow \text{SIMLAR+15} \\ y_{ip} &= y - y_i \rightarrow \text{SIMLAR+16} \\ z_{ip} &= z - z_i \rightarrow \text{SIMLAR+17} \end{aligned}$$

The magnitude of the slant range vector  $\vec{r}_{ip}$  is found by

$$\rho = \sqrt{[x_{ip}^2 + y_{ip}^2 + z_{ip}^2]}$$

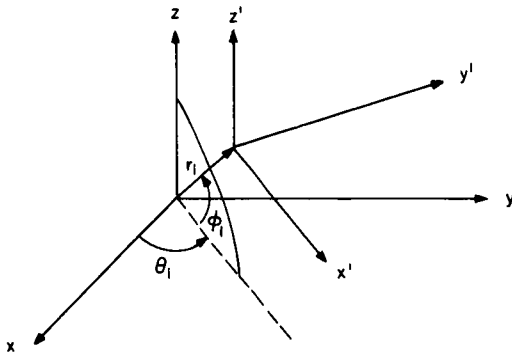
and is stored in RAD.

The slant range rate is stored in RDT and computed by the following equation:

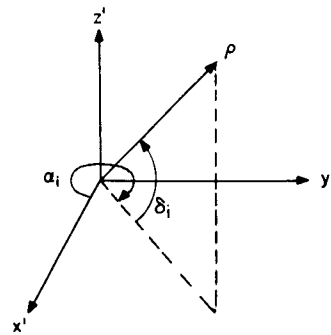
$$\dot{\rho} = \frac{x_{ip} \dot{x} + y_{ip} \dot{y} + z_{ip} \dot{z}}{\rho}$$

The topocentric hour angle-declination system is described in Sketches 2 and 3. In this system the  $x - y$  plane has been translated to the station and rotated through the angle  $\theta_i$  so that  $x'$  lies along the meridian, the  $z'$  axis remaining parallel to the  $z$  axis.

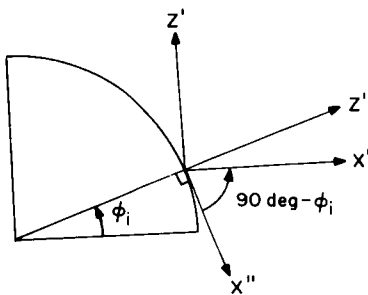
The azimuth-elevation topocentric coordinate system is constructed by rotating the  $x'$  and  $z'$  axis about the  $y'$  axis, causing the resultant  $x'' - y''$  plane to be perpendicular to  $r_i$ , with the  $z''$  axis pointing to the zenith. This system is illustrated in Sketches 4 and 5 following.



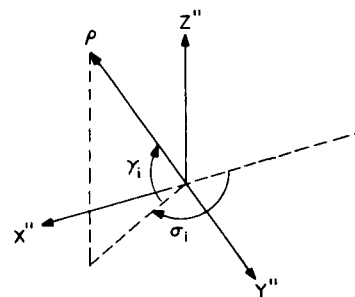
Sketch 2. Rotation to station meridian



Sketch 3. Local hour angle declination coordinate system



Sketch 4. Rotation to station latitude



Sketch 5. Azimuth-elevation coordinate system

The elevation angle and its sine and cosine are found as below:

$$\sin \gamma_i = \frac{\vec{r}_i \cdot \vec{r}_{ip}}{|\vec{r}_i| \rho}$$

This expands to

$$\sin \gamma_i = \frac{x_i x_{ip} + y_i y_{ip} + z_i z_{ip}}{|\vec{r}_i| \rho}$$

The angle  $\gamma_i$  and its cosine are then found. These quantities are stored as follows:

- $\gamma_i$  ELEV
- $\sin \gamma_i$  SIMLAR+23
- $\cos \gamma_i$  SIMLAR+24



The elevation rate,  $\dot{\gamma}_i$  is stored in location ELEVD and is computed as shown below:

$$\dot{\gamma}_i = \frac{(x_i \dot{x} + y_i \dot{y} + z_i \dot{z}) - r_i \sin \gamma_i}{r_i \rho \cos \gamma_i}$$

The local hour angle  $\alpha_i$  is computed as follows and stored in HA:

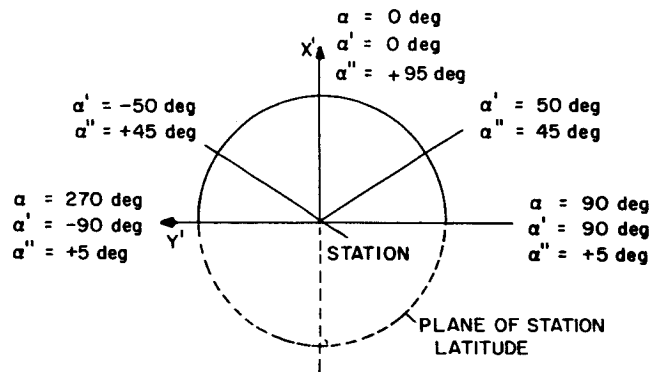
$$\alpha_i = \theta_i - \arctan \frac{y_{ip}}{x_{ip}} \text{ when } \arctan \frac{y_{ip}}{x_{ip}} \geq 0$$

$$\alpha_i = \theta_i - \arctan \frac{y_{ip}}{x_{ip}} + 360 \text{ deg when } \arctan \frac{y_{ip}}{x_{ip}} < 0$$

The local hour angle rate  $\dot{\alpha}_i$  is found as shown below and stored in location HART:

$$\dot{\alpha}_i = \frac{-x_{ip} \dot{y} + y_{ip} \dot{x}}{x_{ip}^2 + y_{ip}^2}$$

In order to determine whether the probe is in view of a given station, the hour angle  $\alpha$  is used to form a function which will be evaluated to determine visibility.



Sketch 6. Determination of viewability of probe from an hour angle-declination station

The functions  $\alpha'$  and  $\alpha''$  illustrated in Sketch 6 have these properties:

$$\begin{aligned} 0 \text{ deg} &\leq \alpha < 360 \text{ deg} \\ + 180 &\leq \alpha' \leq -180 \text{ deg} \\ -85 \text{ deg} &< \alpha'' \leq + 95 \text{ deg} \end{aligned}$$

When the station is an azimuth-elevation type, the above relationships are not used and the probe is assumed to be in view of a given station if the probe's elevation angle  $\gamma_i$  is greater than 5 deg above the local horizon. For hour angle-declination stations if the absolute value of the function  $\alpha'$  is less than 50 deg, the elevation is assumed to be such that the probe will still be in view at the next iteration. If the value  $|\alpha'|$  is greater than 50 deg the function  $\alpha''$  is computed. As indicated on the above diagram, if  $50 \text{ deg} \leq |\alpha'| \leq 90 \text{ deg}$ , then correspondingly,  $45 \text{ deg} \geq \alpha'' \geq 5 \text{ deg}$ . If the relation  $\min[\alpha'', \gamma_i \geq 5 \text{ deg}]$  is satisfied, the station is able to view the probe.

The value of either  $\gamma_i$  or  $\alpha'$ , depending on the above conditions, and the value of  $\dot{\gamma}_i$ , and a code word are stored in a block of three locations, the location of the block being determined by the station from which the probe is being viewed.

If a view period event or a station print is to occur, further calculations must be made. The declination of the probe,  $\delta_i$ , is given as:

$$\delta_i = \arcsin \frac{z_{ip}}{\rho}$$

where

$$-90 \text{ deg} \leq \delta_i \leq 90 \text{ deg}$$

This is measured positive North.

$\delta_i$  is stored in location DCL,  
 $\sin \delta_i$  in SIMLAR+21 and  
 $\cos \delta_i$  in SIMLAR+22

The angular rate of declination,  $\dot{\delta}_i$ , is

$$\dot{\delta}_i = \frac{\dot{z} - \dot{\rho} \sin \delta_i}{\rho \cos \delta_i}$$

and is stored in DCD.

The quantities  $\sigma_i$ ,  $\dot{\sigma}_i$  are computed in the following manner:

$$\cos \sigma_i = \frac{z_{ip} \cos \phi_i - x_{ip} \sin \phi_i \cos \theta_i - y_{ip} \sin \phi_i \sin \theta_i}{\rho \cos \gamma_i}$$

and is stored in SIMLAR+25. The expression in the numerator above is equivalent to  $-x_{ip}''$ .  $\sigma_i$  is then computed from the value of  $\cos \sigma_i$  and stored in SIG.

If the quantity  $y_{ip}'' = y_{ip} \cos \theta_i - x_{ip} \sin \theta_i$  is negative, the value of  $\sigma_i$  is between 180 and 360 deg and is formed by taking  $360 \text{ deg} - \arccos(\cos \sigma_i)$ . The value of  $\dot{\sigma}_i$  is calculated by the following:

$$\sigma_i = \frac{x_{ip}'' + \cos \sigma_i (\rho \cos \gamma_i - \rho \dot{\gamma}_i \sin \gamma_i)}{\rho \cos \gamma_i \sin \sigma_i}$$

and is stored in SIGD.

The vector  $\vec{R}_{ip}$  is determined by rotating the components of the topocentric coordinate system  $\vec{r}_{ip}(x_{ip}, y_{ip}, z_{ip})$  through the angle  $\tau(T)$  such that the resulting coordinate system is parallel to the true of date coordinate system which is input to LOOP (X, Y, Z).

$$\vec{R}_{ip} = \begin{Bmatrix} X_{ip} \\ Y_{ip} \\ Z_{ip} \end{Bmatrix} = \begin{bmatrix} \cos \tau(T) & -\sin \tau(T) & 0 \\ \sin \tau(T) & \cos \tau(T) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} x_{ip} \\ y_{ip} \\ z_{ip} \end{Bmatrix}$$

The station-probe-Sun angle SPS is found by:

$$SPS = \arccos \frac{\vec{C} \cdot \vec{R}_{ip}}{|\vec{R}_{ip}|}$$

and is stored in cell SPS.

A four quadrant polarization angle is computed from the following formula and stored in a cell named POL:

$$POL = \frac{(\vec{C} \times \vec{R}_{ip})^1 \cdot [\vec{R}_{ip} \times (\vec{R}_{ip} \times \vec{R})]^1}{(\vec{C} \times \vec{R}_{ip})^1 \cdot (\vec{R}_{ip} \times \vec{R})^1}$$

The notations  $(\vec{R})^1$  or  $\vec{R}^1$  indicate that unitization of the vector  $\vec{R}$  has taken place.

Herein follow the calculations of the Canopus, Moon, and target clock angles, which are accomplished using the following formula:

$$N\text{-clock angle} = \arctan \frac{-\left[ (\vec{N} \times \vec{R}_{sp}^1) \times \vec{R}_{sp}^1 \right]^1 \cdot \left( \vec{R}_{sp}^1 \times \vec{R}_{ip}^1 \right)^1}{\left[ (\vec{N} \times \vec{R}_{sp}^1) \times \vec{R}_{sp}^1 \right]^1 \cdot \left[ \left( \vec{R}_{sp}^1 \times \vec{R}_{ip}^1 \right) \times \vec{R}_{sp}^1 \right]^1}$$

The vector  $\vec{N}$  denotes the vector from the station to the body to which the clock angle is referenced,

i. e.  $\vec{N} = \vec{R}_{ec}$  for the Canopus clock angle CKC

$\vec{N} = \vec{R}_{em}$  for the Moon clock angle CKM

$\vec{N} = \vec{R}_{et}$  for the target clock angle CKT.

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$\vec{R}_{sp}$  in this formula denotes the true-of-date sun-probe position vector.

The probe-station-Sun angle (PSS) and the probe-station-Moon angle (PSM) are the angles between the probe-station vector and the Sun-station or Moon-station vectors, respectively.

They are computed by:

$$PSS = \left[ (\vec{R}_{sp} - \vec{R}_{ip})^1 \cdot (-\vec{R}_{ip})^1 \right]$$

$$PSM = \left[ (\vec{R}_{mp} - \vec{R}_{ip})^1 \cdot (-\vec{R}_{ip})^1 \right]$$

where  $\vec{R}_{mp}$  is the true-of-date Moon-probe position vector.

The light time correction (DELTA) is the time in seconds which is required for light to travel the station-probe distance and is given by

$$DELTA = \frac{\rho}{c}$$

where  $c$  is the finite speed of light.

The probe right ascension (PRA) is found by  $PRA = \arctan (Y_{ip}/X_{ip})$  where  $X_{ip}$  and  $Y_{ip}$  are components of  $\vec{R}_{ip}$ .

The method of calculation of various quantities associated with frequencies of spacecraft and tracking station transmitting and receiving equipment is indicated in the equations which follow.

The frequency calculations for L-band stations are as follows:

$$XA = \frac{f_a}{A_{4i}} (1 + \rho/c), \text{ cps}$$

$$F1 = A_{6i} [A_{1i} + A_{2i} f_i - A_{7i} - A_{3i} f_t (1 - \dot{\rho}/c)], \text{ cps}$$

$$F2 = A_{6i} [A_{4i} f_{ri} (2\dot{\rho}/c) + A_{5i}], \text{ cps}$$

$$D1 = F1/30, \text{ cps}$$

$$D2 = F2/30, \text{ cps}$$

$$DF1 = A_{6i} A_{3i} f_t (\dot{\rho}/c), \text{ cps}^2$$

$$DF2 = A_{6i} A_{4i} f_r (2\dot{\rho}/c), \text{ cps}^2$$

The calculations for L-S band stations are:

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$$XA = f_{rq}(1 + \dot{\rho}/c), \text{ cps}$$

$$D1 = \left[ LSK1 + \frac{30}{96} \times 10^6 - \frac{LSFT}{96}(1 - \dot{\rho}/c) \right], \text{ cps}$$

$$D2 = \left[ LSK1 + \frac{30}{96} \times 10^6 - \frac{240}{221} f_{rq}(1 - 2\dot{\rho}/c) \right], \text{ cps}$$

$$F1 = 30 D1, \text{ cps}$$

$$F2 = 30 D2, \text{ cps}$$

$$DF1 = 30 \left[ \frac{LSFT}{96}(\dot{\rho}/c) \right], \text{ cps}^2$$

$$DF2 = 30 \left[ \frac{240}{221} f_{rq}(2\dot{\rho}/c) \right], \text{ cps}^2$$

For S-band equipped stations, the equations are:

XA = same as for L-S band

$$D1 = \left[ \frac{240}{221} \times 96 \times SK1 - SFT(1 - \dot{\rho}/c) + 1 \times 10^6 \right], \text{ cps}$$

$$D2 = \left[ \left( \frac{240}{221} \times 96 \times f_{rq} \right) (2\dot{\rho}/c) + 1 \times 10^6 \right], \text{ cps}$$

$$F1 = 30D1, \text{ cps}$$

$$F2 = 30D2, \text{ cps}$$

$$DF1 = 30 \times SFT(\dot{\rho}/c), \text{ cps}^2$$

$$DF2 = 30 \times 96 \times \frac{240}{221} \times f_{rq}(2\dot{\rho}/c), \text{ cps}^2$$

The parameter which determines a station's type is the fifth cell of the station coordinate information for a given station. If this is zero the L-band equations will be used. If it is a fixed point 1 scaled 35, the L-S equations are used, and if it is a fixed point 2 scaled 35, the S-band equations are used. All stations have zero (L-band) as the canned value. This may be modified by input.

The quantity  $\ddot{\rho}$ , slant range acceleration of the probe with respect to the station will be computed only if the Earth was the central body for integration. Otherwise  $\ddot{\rho}$  will appear as zero and the equations which contain  $\ddot{\rho}$  will not be used.  $\ddot{\rho}$  is obtained as follows:

First compute  $\ddot{\mathbf{r}}$ , the Earth-fixed probe acceleration vector

$$\ddot{\mathbf{r}} = \begin{pmatrix} \ddot{x} \\ \ddot{y} \\ \ddot{z} \end{pmatrix} = \begin{bmatrix} \cos \varphi(T) & \sin \varphi(T) & 0 \\ -\sin \varphi(T) & \cos \varphi(T) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{pmatrix} \ddot{X} \\ \ddot{Y} \\ \ddot{Z} \end{pmatrix} + 2\omega \begin{pmatrix} \dot{Y} \\ -\dot{X} \\ 0 \end{pmatrix} - \omega^2 \begin{pmatrix} X \\ Y \\ 0 \end{pmatrix}$$

Now

$$\rho \dot{\rho} = \bar{\mathbf{r}}_{ip} \cdot \dot{\bar{\mathbf{r}}}_{ip} = \bar{\mathbf{r}}_{ip} \cdot \dot{\bar{\mathbf{r}}}$$

differentiating and noting that  $\dot{\bar{\mathbf{r}}} = \dot{\bar{\mathbf{r}}}_{ip}$  yields

$$\rho \ddot{\rho} + \dot{\rho}^2 = \bar{\mathbf{r}}_{ip} \cdot \ddot{\bar{\mathbf{r}}} + \dot{\bar{\mathbf{r}}} \cdot \dot{\bar{\mathbf{r}}}$$

then

$$\ddot{\rho} = \frac{\bar{\mathbf{r}}_{ip} \cdot \ddot{\bar{\mathbf{r}}} + \dot{\bar{\mathbf{r}}}^2 - \dot{\rho}^2}{\rho}$$

$\ddot{\rho}$  is then stored in RDDDT.

The remaining frequency equations are

$$\text{BF1} = B_5 B_6 (1 + \dot{\rho}/c) - 960 \times 10^6, \text{ cps}$$

$$\text{DOPRAT} = (2\ddot{\rho}/c) \times 960 \times 10^6, \text{ cps}^2$$

$$\text{SLOSS} = K_1 + K_2 \log_{10}(K_3 \rho)$$

USE

Calling sequence

CALL LOOP

PZE X, , Y

OP B, , C

where X is the location of the Earth-centered space fixed of date equatorial cartesian position vector of the probe. Y is the corresponding coordinate of the velocity vector.

B contains binary code word which is used to determine which stations are to be considered. Each bit corresponds to a station in the station tables contained in LOOP. Each bit from right to left corresponds to the table entries from beginning to end of the tables.

C contains the unit probe-Sun vector in the same coordinate system as X (defined above). X, Y, and C are BSS 3.

OP is PZE for station prints, MZE for view periods, where appropriate buffering is performed.

The station coordinates and BCD identification are built into the subroutine with the values listed below:

59 JOBURG - MTS	AZEL
-25.73521, 27.70403, 6375.6952, 0, 0	
11 GOLDSTONE	HADEC
35.208070, 243.15802, 6372.0341, 1, 0	
12 GOLDSTONE ECHO	HADEC
35.117400, 243.19428, 6371.8770, 1, 0	
41 WOOMERA	HADEC
-31.211865, 136.88727, 6372.6040, 1, 0	
51 JOBURG - 85	HADEC
-25.739277, 27.685181, 6375.4980, 1, 0	
14 GOLDSTONE - 210	AZEL
35.243770, 243.12129, 6372.1341, 0, 0	
13 GOLDSTONE - 85	AZEL
35.066620, 243.20507, 6372.2599, 0, 0	
15 GOLDSTONE - 30	AZEL
35.06615, 243.20853, 6372.2478, 0, 0	
42 CANBERRA	HADEC
-35.21963, 148.98028, 6371.6686, 1, 0	
61 MADRID	HADEC
40.238000, 355.75050, 6370.0868, 1, 0	
08 CARNARVON	AZEL
-24.75336, 113.71605, 6374.05, 0, 0	
91 ANTIGUA	AZEL
17.0355, 298.2072, 6376.3091, 0, 0	
75 ASCENSION	AZEL
-7.8991, 345.58760, 6377.8013, 0, 0	

76 PRETORIA                      AZEL  
-25.79040, 28.3580, 6375.6810, 0, 0

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02 BERMUDA                      AZEL  
32.1709, 295.3465, 6372.050, 0, 0

These are the values given in reference 2 with typographical errors corrected.

#### CODING INFORMATION

Length of subroutine in 1590 (10) or 3066 (8) words.

#### REFERENCES

1. Holdridge, D. B., TR 32-223, Revision 1, Space Trajectories Program for the IBM 7090 Computer, Jet Propulsion Laboratory, Pasadena, California, September 1, 1962.
2. Scott, J. F., Interoffice Memorandum 372.21/318, Station Coordinates, September 1, 1964.



## IDENTIFICATION

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MARSMM/MARSPC/MARFIX/MHA/PMAT/PPMAT

Alan D. Rosenberg, JPL

IBM 7094 Fap

December 2, 1964

## PURPOSE

- a. To compute the Mars hour angle and the matrices PMAT and PPMAT which rotate from a space-fixed mean Earth equator and equinox of 1950.0 coordinate system to a space-fixed Mars equatorial coordinate system, and from the latter system to a Mars-fixed Mars equatorial coordinate system, respectively.
- b. To apply the PMAT matrix to an input vector.
- c. To apply the PPMAT matrix to input position and velocity vectors.

## RESTRICTIONS

- a. Subroutines SIN, COS, CROSS, UNIT, FIX, FLOAT and MATRIX are called.
- b. COMMON locations XN, XN., T and T+1 are assumed to contain the planetary positions and velocities and double precision seconds past 0 hr January 1, 1950, respectively.
- c. MARSMM must be called before MARSPC or MARFIX may be called.
- d. COMMON+4, COMMON+5 and cells 77764<sub>8</sub> through 77777<sub>8</sub> are used.
- e. Entries MHA, PMAT and PPMAT are provided so the computed Mars hour angle and two rotation matrices are accessible.

## METHOD

- a. The orientation of the Mars spin axis is defined relative to the mean Earth equator and equinox of 1950.0 by the angles:

$$\alpha_0 = 317.7934 \text{ deg}$$

$$\delta_0 = 54.6575 \text{ deg}$$

which correspond to the direction cosines:

$$\hat{P} = \cos \delta_0 \cos \alpha_0, \cos \delta_0 \sin \alpha_0, \sin \delta_0$$

A unit vector normal to the Mars-orbital plane is computed by:

$$\hat{N} = \frac{\bar{R}_{\odot\delta} \times \bar{V}_{\odot\delta}}{|\bar{R}_{\odot\delta} \times \bar{V}_{\odot\delta}|}$$

where  $\bar{R}_{\odot\delta}$  and  $\bar{V}_{\odot\delta}$  are the Sun-Mars position and velocity vectors referenced to the Earth equator and equinox of 1950.0 coordinate system. Next, define

$$\hat{I} = \frac{\hat{P} \times \hat{N}}{|\hat{P} \times \hat{N}|}$$

$$\hat{K} = \hat{P}$$

$$\hat{J} = \hat{K} \times \hat{I}$$

where  $\hat{I}$ ,  $\hat{J}$ ,  $\hat{K}$  are the unit vectors defining the X, Y, Z axes, respectively, of the space-fixed Mars equator and equinox of 1950.0 coordinate system. Hence the matrix to rotate from the space-fixed Earth mean equator and equinox of 1950.0 frame to the space-fixed Mars equatorial frame is as follows:

$$\text{PMAT} = \begin{pmatrix} I_x & I_y & I_z \\ J_x & J_y & J_z \\ K_x & K_y & K_z \end{pmatrix}.$$

Since no precession or nutation of the Mars equator has been defined, the above matrix is sufficient to express the relationship between the Earth and Mars equators as stated.

- b. The rotation from a space-fixed Mars equatorial coordinate system to a Mars-fixed Mars equatorial coordinate system involves only a rotation about the Z-axis by the Mars hour angle, MHA:

$$\text{MHA} = \text{MHA}_{\text{ref}} + \omega_M T_D \qquad 0 \text{ deg} \leq \text{MHA} < 360 \text{ deg}$$

where

$$\text{MHA}_{\text{ref}} = 145.042501 \text{ deg}$$

$$\omega_M = \text{angular rotation rate}$$

$$= 350.891962 \text{ deg/day}$$

$$= 0.7088217655 \times 10^{-4} \text{ rad/sec}$$

$$T_D = \text{days past 0 hr January 1, 1950, U. T.}$$

The rotation matrix is therefore:

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$$\text{PPMAT} = \begin{pmatrix} \cos \text{MHA} & \sin \text{MHA} & 0 \\ -\sin \text{MHA} & \cos \text{MHA} & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

and position and velocity vectors may be expressed in the Mars-fixed Mars equatorial coordinate system as follows:

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} & & \\ & & \\ & & \end{pmatrix} \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}$$

$$\begin{pmatrix} \dot{x} \\ \dot{y} \\ \dot{z} \end{pmatrix} = \begin{pmatrix} & & \\ & & \\ & & \end{pmatrix} \begin{pmatrix} \dot{X} + \omega_M Y \\ \dot{Y} - \omega_M X \\ \dot{Z} \end{pmatrix}$$

MARSMM computes the Mars hour angle MHA and the two matrices PMAT and PPMAT.  
 MARSPC rotates an input vector from space-fixed Earth mean equator and equinox of 1950.0 coordinates to space-fixed Mars equatorial coordinates.  
 MARFIX rotates an input position and velocity vector from space-fixed Mars equatorial coordinates to Mars-fixed Mars equatorial coordinates.

USE

Calling sequences:

- a. CALL MARSMM
- return

Exit with the Mars hour angle computed and stored in MHA, the Earth-equatorial to Mars-equatorial rotation matrix stored row-wise in PMAT through PMAT+8 and the space-fixed Mars equatorial to Mars-fixed Mars equatorial rotation matrix stored row-wise in PPMAT through PPMAT+8.

- b. CALL MARSPC
- PZE A,, B
- return

where A, A+1, A+2 contain the input vector referenced to the space-fixed mean Earth equator and equinox of 1950.0 coordinate system.

B, B+1, B+2 contain the output vector referenced to the space-fixed Mars equatorial coordinate system

and where the matrix used is assumed to have been previously computed and stored internally in PMAT through PMAT+8.

c. CALL MARFIX

PZE A,, B

return

where A, ..., A+5 contain the input position and velocity vectors referenced to the space-fixed Mars equatorial coordinate system.

B, ..., B+5 contain the output position and velocity vectors referenced to the Mars-fixed Mars equatorial coordinate system

and where the matrix used is assumed to have been previously computed and stored internally in PPMAT through PPMAT+8.

#### CODING INFORMATION

Length of subroutine is 160(10) or 240(8) words.

#### REFERENCE

JPL Section 312 RFP 141, July 4, 1963.

IDENTIFICATION

28.1

MATRIX

JPL Staff

IBM 7094 Fap

December 2, 1964

PURPOSE

To perform the matrix multiplication  $C = (A)(B)$ .

RESTRICTIONS

- a. The matrix A must be  $m \times 3$  and B must be  $3 \times n$ .
- b. MATRIX is a subset of a package of several subroutines.

METHOD

The multiplication is performed in the manner indicated by the mathematical definition of matrix multiplication.

USE

Calling sequence:

```
CALL  MATRIX
PZE   M, , A
PZE   N, , B
PZE   , , C
```

where

- M contains the fixed point m dimension of matrix A.
- A, ..., A+8 contain the A matrix, stored row-wise with  $A_{11}$  the first element.
- N contains the fixed point n dimension of matrix B.
- B, ..., B+8 contain the B matrix, stored row-wise with  $B_{11}$  the first element.
- C, ..., C+8 contain the matrix product  $C = (A)(B)$ , stored row-wise with  $C_{11}$  the first element.

CODING INFORMATION

Length of subroutine (includes MATRIX as a subset) is 1046(10) or 2026(8) words.

## IDENTIFICATION

28.2-1 of 9

MNA/MNA1/MNAMD/MNAMDI/NUTEPH/NUTLON/NUTOBL

JPL Staff

IBM 7094 Fap

December 2, 1964

## PURPOSE

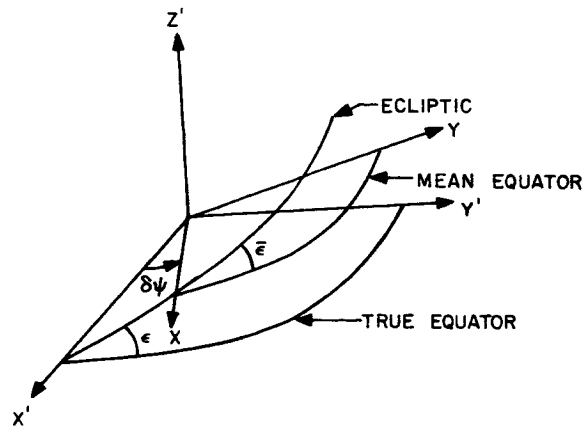
To rotate true Earth equator of-date coordinates to true lunar equator of-date coordinates and vice versa via the  $M$  and  $\dot{M}$  matrices, and to form the matrix  $N$ , which rotates mean Earth equator of-date coordinates to true Earth equator of-date coordinates.

## RESTRICTIONS

- a. MNA, et. al., is a subset of the lunar model package and uses other subroutines in the package.
- b. The input parameter NUTEPH is an internal cell and is accessible via an entry. If NUTEPH is non-zero then the nutation in longitude and nutation in obliquity are computed. If NUTEPH is zero, then the nutations are obtained by interpolation of the nutation data on the double precision JPL Ephemeris Tapes obtained by calling subroutine ANTR1.
- c. Entries NUTLON and NUTOBL have been provided so that the output parameters, nutation in longitude and nutation in obliquity, respectively, are accessible.
- d. It is assumed that the matrix  $A$ , which rotates mean Earth equator of 1950.0 coordinates to mean Earth equator of-date coordinates, has been updated and is in COMMON locations AA through AA+8.
- e. The output  $N$  matrix is stored in NUTMAT through NUTMAT+8 and is accessible via the entry NUTMAT, the output product matrix MNA is stored in COMMON locations (MNA) through (MNA)+8 and the output matrix  $M$  is stored in COMMON locations MM through MM+8.
- f.  $\delta\alpha$ , the nutation in right ascension used in the calculation of the true value of the Greenwich hour angle, is computed and stored in COMMON location NUTRA.

## METHOD

- a. The nutation matrix  $N$ : To describe the nutation of the Earth about its precessing mean equator, it is convenient to construct the nutation matrix  $N$  which relates the cartesian coordinates expressed in the true equator and equinox to those in the mean equator and equinox as shown in the following sketch:



where:

1.  $\bar{\epsilon}$  is the mean obliquity and is given by:

$$\bar{\epsilon} = 23:4457587 - 0:01309404T - 0:0088 \times 10^{-4}T^2 + 0:0050 \times 10^{-4}T^3$$

where T is the number of Julian centuries of 36, 525 days past the epoch 0 hr January 1, 1950, E. T.

The nutations  $\delta\epsilon$  and  $\delta\psi$  may be obtained by interpolation of the nutation data on the double precision JPL Ephemeris Tapes or they may be computed as follows:

$$\Omega = 12:1127902 - 0:0529539222d + 20:795 \times 10^{-4}T + 20:81 \times 10^{-4}T^2 + 0:02 \times 10^{-4}T^3$$

$$\mathbb{C} = 64:37545167 + 13:1763965268d - 11:31575 \times 10^{-4}T - 11:3015 \times 10^{-4}T^2 + 0:019 \times 10^{-4}T^3$$

$$\Gamma' = 208:8439877 + 0:1114040803d - 0:010334T - 0:010343T^2 - 0:12 \times 10^{-4}T^3$$

$$L = 280:08121009 + 0:9856473354d + 3:03 \times 10^{-4}T + 3:03 \times 10^{-4}T^2$$

$$\Gamma = 282:08053028 + 0:470684 \times 10^{-4}d + 4:5525 \times 10^{-4}T + 4:575 \times 10^{-4}T^2 + 0:03 \times 10^{-4}T^3$$

where T is the number of Julian centuries of 36, 525 days past the epoch 0 hr January 1, 1950, E. T., and d is the number of days past the same epoch. The program uses d in double precision.

2.  $\delta\psi$  is the nutation in longitude measured from the true vernal equinox at the X' axis to the mean vernal equinox at the X axis.

$\delta\psi = \Delta\psi + d\psi$ , where  $\Delta\psi$  denotes the long period terms and  $d\psi$  denotes the short period terms. They are given by:

$$\begin{aligned} \Delta\psi = & - (47.8927 + 0.0482T) \times 10^{-4} \sin\Omega + 0.5800 \times 10^{-4} \sin 2\Omega \\ & - 3.5361 \times 10^{-4} \sin 2L - 0.1378 \times 10^{-4} \sin(3L - \Gamma) + 0.0594 \times 10^{-4} \\ & \times \sin(L + \Gamma) + 0.0344 \times 10^{-4} \sin(2L - \Omega) + 0.0125 \times 10^{-4} \sin(2\Gamma' - \Omega) \\ & + 0.3500 \times 10^{-4} \sin(L - \Gamma) + 0.0125 \times 10^{-4} \sin(2L - 2\Gamma') \end{aligned}$$

$$\begin{aligned} d\psi = & - 0.5658 \times 10^{-4} \sin 2\mathcal{C} - 0.0950 \times 10^{-4} \sin(2\mathcal{C} - \Omega) - 0.0725 \times 10^{-4} \\ & \times \sin(3\mathcal{C} - \Gamma') + 0.0317 \times 10^{-4} \sin(\mathcal{C} + \Gamma') + 0.0161 \times 10^{-4} \\ & \times \sin(\mathcal{C} - \Gamma' + \Omega) + 0.0158 \times 10^{-4} \sin(\mathcal{C} - \Gamma' - \Omega) - 0.0144 \times 10^{-4} \\ & \times \sin(3\mathcal{C} + \Gamma' - 2L) - 0.0122 \times 10^{-4} \sin(3\mathcal{C} - \Gamma' - \Omega) + 0.1875 \times 10^{-4} \\ & \times \sin(\mathcal{C} - \Gamma') + 0.0078 \times 10^{-4} \sin(2\mathcal{C} - 2\Gamma') + 0.0414 \times 10^{-4} \\ & \times \sin(\mathcal{C} + \Gamma' - 2L) + 0.0167 \times 10^{-4} \sin(2\mathcal{C} - 2L) - 0.0089 \times 10^{-4} \\ & \times \sin(4\mathcal{C} - 2L) \end{aligned}$$

3.  $\delta\epsilon$  is the nutation in obliquity.  $\delta\epsilon = \Delta\epsilon + d\epsilon$ , where  $\Delta\epsilon$  denotes the long-period terms and  $d\epsilon$  the short-period terms. They are given by:

$$\begin{aligned} \Delta\epsilon = & 25.5844 \times 10^{-4} \cos\Omega - 0.2511 \times 10^{-4} \cos 2\Omega + 1.5336 \times 10^{-4} \\ & \times \cos 2L + 0.0666 \times 10^{-4} \cos(3L - \Gamma) - 0.0258 \times 10^{-4} \cos(L + \Gamma) \\ & - 0.0183 \times 10^{-4} \cos(2L - \Omega) - 0.0067 \times 10^{-4} \cos(2\Gamma' - \Omega) \end{aligned}$$

$$\begin{aligned} d\epsilon = & 0.2456 \times 10^{-4} \cos 2\mathcal{C} + 0.0508 \times 10^{-4} \cos(2\mathcal{C} - \Omega) + 0.0369 \times 10^{-4} \\ & \times \cos(3\mathcal{C} - \Gamma') - 0.0139 \times 10^{-4} \cos(\mathcal{C} + \Gamma') - 0.0086 \times 10^{-4} \\ & \times \cos(\mathcal{C} - \Gamma' + \Omega) + 0.0083 \times 10^{-4} \cos(\mathcal{C} - \Gamma' - \Omega) + 0.0061 \times 10^{-4} \\ & \times \cos(3\mathcal{C} + \Gamma' - 2L) + 0.0064 \times 10^{-4} \cos(3\mathcal{C} - \Gamma' - \Omega) \end{aligned}$$

4. The true obliquity is computed as follows:

$$\epsilon = \bar{\epsilon} + \delta\epsilon$$

5.  $\delta\alpha$  is the nutation in right ascension used in the calculation of the true value of the Greenwich hour angle of the vernal equinox and is given by:

$$\delta\alpha = \delta\psi \cos\bar{\epsilon}$$

If N is defined in the sense

$$\begin{pmatrix} X' \\ Y' \\ Z' \end{pmatrix} = N \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}$$



where the primed system is the true equator and equinox and the unprimed is the mean equator and equinox, then the  $N_{ij}$  are given by

$$N_{11} = \cos \delta \psi$$

$$N_{12} = -\sin \delta \psi \cos \bar{\epsilon}$$

$$N_{13} = -\sin \delta \psi \sin \bar{\epsilon}$$

$$N_{21} = \sin \delta \psi \cos \epsilon$$

$$N_{22} = \cos \delta \psi \cos \epsilon \cos \bar{\epsilon} + \sin \epsilon \sin \bar{\epsilon}$$

$$N_{23} = \cos \delta \psi \cos \epsilon \sin \bar{\epsilon} - \sin \epsilon \cos \bar{\epsilon}$$

$$N_{31} = \sin \delta \psi \sin \epsilon$$

$$N_{32} = \cos \delta \psi \sin \epsilon \cos \bar{\epsilon} - \cos \epsilon \sin \bar{\epsilon}$$

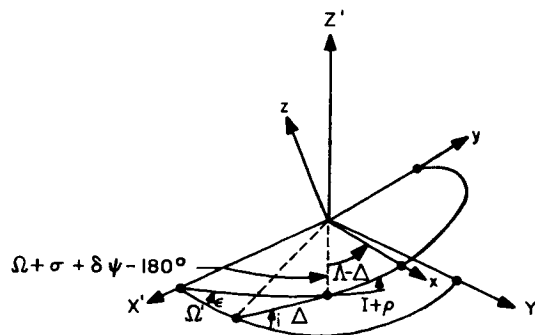
$$N_{33} = \cos \delta \psi \sin \epsilon \sin \bar{\epsilon} + \cos \epsilon \cos \bar{\epsilon}$$

Since  $|\delta \psi| < 10^{-4}$  and  $|\delta \epsilon| < 10^{-4}$ , the  $N_{ij}$  are expanded to first order in  $\delta \psi$  and  $\delta \epsilon$  to obtain a form which is better behaved for numerical calculation:

$$N = \begin{pmatrix} 1 & -\delta \psi \cos \bar{\epsilon} & -\delta \psi \sin \bar{\epsilon} \\ \delta \psi \cos \bar{\epsilon} & 1 & -\delta \epsilon \\ \delta \psi \sin \bar{\epsilon} & \delta \epsilon & 1 \end{pmatrix}$$

- b. The true Earth equator of-date to true lunar equator of-date matrix, M:

The relationship between the two planes is shown in the following sketch:



where the  $X', Y', Z'$  frame is the Earth's true equator and equinox; the  $x - y$  plane lies in Moon's true equator with  $z$  completing the right-hand system by lying along the Moon's spin axis.  $i$  is the inclination of the Moon's true equator to the Earth's true equator.  $\Omega'$  is the right ascension of the ascending node of the Moon's true equator;  $\Lambda$  is the anomaly from the node to the  $x$  axis;  $\Delta$  is the anomaly from the node

to the ascending node of the Moon's true equator on the ecliptic;  $\epsilon$  is the true obliquity of the ecliptic;  $\delta\psi$  is the nutation in longitude;  $\Omega$  is the mean longitude of the descending node of the Moon's mean equator on the ecliptic;  $\mathcal{C}$  is the mean longitude of the Moon;  $I$  is the inclination of the Moon's mean equator to the ecliptic;  $\sigma$  is the libration in the node;  $\tau$  is the libration in the mean longitude; and  $\rho$  is the libration in the inclination. The anomalies are related by  $\Lambda - \Delta = (\mathcal{C} + \tau) - (\Omega + \sigma)$ .

The librations are given by

$$\begin{aligned}\sigma \sin I &= -0.0302777 \sin g + 0.0102777 \sin(g + 2\omega) - 0.00305555 \sin(2g + 2\omega) \\ \tau &= -0.003333 \sin g + 0.0163888 \sin g' + 0.005 \sin 2\omega \\ \rho &= -0.0297222 \cos g + 0.0102777 \cos(g + 2\omega) - 0.00305555 \cos(2g + 2\omega) \\ I &= 1.535\end{aligned}$$

The following expressions have been programmed for  $g$ ,  $g'$ , and  $\omega$ :

$$\begin{aligned}g &= 215.54013 + 13.064992 d \\ g' &= 358.009067 + 0.9856005 d \\ \omega &= 196.745632 + 0.1643586 d\end{aligned}$$

Evidently  $g = \mathcal{C} - \Gamma'$ , the mean anomaly of the Moon;  $g' = L - \Gamma$ , the mean anomaly of the Sun; and  $\omega = \Gamma' - \Omega$ , the argument of the perigee of the Moon. All quantities relate to mean motions of the Sun and the Moon.

$$\begin{aligned}\cos i &= \cos(\Omega + \sigma + \delta\psi) \sin \epsilon \sin(I + \rho) + \cos \epsilon \cos(I + \rho), & 0 < i < 90^\circ \\ \sin \Omega' &= -\sin(\Omega + \sigma + \delta\psi) \sin(I + \rho) \csc i, & -90^\circ < \Omega' < 90^\circ \\ \sin \Delta &= -\sin(\Omega + \sigma + \delta\psi) \sin \epsilon \csc i \\ \cos \Delta &= -\sin(\Omega + \sigma + \delta\psi) \sin \Omega' \cos \epsilon - \cos(\Omega + \sigma + \delta\psi) \cos \Omega', & 0 \leq \Delta < 360^\circ \\ \Lambda &= \Delta + (\mathcal{C} + \tau) - (\Omega + \sigma)\end{aligned}$$

The two rectangular systems are related through  $\Lambda$ ,  $\Omega'$ , and  $i$  by the rotation:

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} m_{11} & m_{12} & m_{13} \\ m_{21} & m_{22} & m_{23} \\ m_{31} & m_{32} & m_{33} \end{pmatrix} \begin{pmatrix} X' \\ Y' \\ Z' \end{pmatrix}$$

where

$$\begin{aligned}m_{11} &= \cos \Omega' \cos \Lambda - \sin \Omega' \sin \Lambda \cos i \\ m_{12} &= \cos \Omega' \sin \Lambda + \sin \Omega' \cos \Lambda \cos i\end{aligned}$$

$$m_{13} = \sin\Lambda \sin i$$

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$$m_{21} = -\sin\Lambda \cos\Omega' - \cos\Lambda \sin\Omega' \cos i$$

$$m_{22} = -\sin\Lambda \sin\Omega' + \cos\Lambda \cos\Omega' \cos i$$

$$m_{23} = \cos\Lambda \sin i$$

$$m_{31} = \sin\Omega' \sin i$$

$$m_{32} = -\cos\Omega' \sin i$$

$$m_{33} = \cos i$$

Combining the above  $m_{ij}$  (M) rotation matrix with the N and A matrices gives the MNA matrix used to rotate a position vector from Earth mean equator of 1950.0 coordinates, (X, Y, Z), to true lunar equator of-date coordinates, (x, y, z):

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \text{MNA} \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}$$

and inversely,

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = (\text{MNA})' \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

for the position transformation in the other direction.

- c. The derivative of M,  $\dot{M}$ : In computing  $\dot{M}$  the rates for the slowly varying angles  $\Omega'$  and  $i$  are taken to be zero.

Thus

$$\dot{M}_{11} = (-\sin\Lambda \cos\Omega' - \cos\Lambda \sin\Omega' \cos i)\dot{\Lambda}$$

$$\dot{M}_{12} = (-\sin\Lambda \sin\Omega' + \cos\Lambda \cos\Omega' \cos i)\dot{\Lambda}$$

$$\dot{M}_{13} = (\cos\Lambda \sin i)\dot{\Lambda}$$

$$\dot{M}_{21} = (-\cos\Lambda \cos\Omega' + \sin\Lambda \sin\Omega' \cos i)\dot{\Lambda}$$

$$\dot{M}_{22} = (-\cos\Lambda \sin\Omega' - \sin\Lambda \cos\Omega' \cos i)\dot{\Lambda}$$

$$\dot{M}_{23} = (-\sin\Lambda \sin i)\dot{\Lambda}$$

$$\dot{M}_{31} = 0$$

$$\dot{M}_{32} = 0$$

$$\dot{M}_{33} = 0$$

From the formula

$$\Lambda = \Delta + (\zeta + \tau) - (\Omega + \sigma)$$

obtain

$$\dot{\Lambda} = \dot{\Delta} + \dot{\zeta} + \dot{\tau} - \dot{\Omega} - \dot{\sigma}$$

The adopted numerical expressions for the rates are

$$\dot{\Delta} = \frac{-\cos(\Omega + \sigma + \delta\psi) \sin\epsilon (\dot{\Omega} + \dot{\sigma})}{\sin\epsilon \cos\Delta}$$

$$\dot{\zeta} = 0.266170762 \times 10^{-5} - 0.12499171 \times 10^{-13} \text{ T rad/sec}$$

$$\dot{\Omega} = -0.1069698435 \times 10^{-7} + 0.23015329 \times 10^{-13} \text{ T rad/sec}$$

$$\begin{aligned} \dot{\tau} = & -0.1535272946 \times 10^{-9} \cos g + 0.569494067 \times 10^{-10} \cos g' \\ & + 0.579473484 \times 10^{-11} \cos 2\omega \text{ rad/sec} \end{aligned}$$

$$\begin{aligned} \dot{\sigma} = & -0.520642191 \times 10^{-7} \cos g + 0.1811774451 \times 10^{-7} \cos(g + 2\omega) \\ & -0.1064057858 \times 10^{-7} \cos(2\omega + 2g) \text{ rad/sec} \end{aligned}$$

To obtain velocity transformations the approximation is made that

$$\dot{N} = \dot{A} = 0$$

thus

$$\begin{pmatrix} \dot{x} \\ \dot{y} \\ \dot{z} \end{pmatrix} = \text{MNA} \begin{pmatrix} \dot{X} \\ \dot{Y} \\ \dot{Z} \end{pmatrix} + \dot{\text{MNA}} \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}$$

and for the inverse transformation

$$\begin{pmatrix} \dot{X} \\ \dot{Y} \\ \dot{Z} \end{pmatrix} = (MNA)' \begin{pmatrix} \dot{x} \\ \dot{y} \\ \dot{z} \end{pmatrix} + (MNA)' \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

A definition of the A matrix can be found in subroutine ROTEQ.

#### USE

##### Calling sequences:

- a. Position vector transformation:

CALL MNA or MNA1

PZE 1, , A

PZE n, , B

where A, A+1, A+2 contain the input vector

B, B+1, B+2 contain the output vector

n = 0 rotates true lunar equator of-date to mean Earth equator of 1950.0

= 1 rotates mean Earth equator of 1950.0 to true lunar equator of-date.

Enter with the fractional part of the day past 0 hr of the epoch, E. T., in the AC and the integer days past 0 hr January 1, 1950, E. T., of the epoch T, in the MQ.

It is assumed that the A matrix has been previously computed and stored in COMMON locations AA through AA+8.

The N matrix is computed and stored in locations NUTMAT through NUTMAT+8. The M matrix is computed and stored in COMMON locations MM through MM+8. The product matrices NA and MNA are formed and stored in COMMON locations (NA) through (NA)+8 and (MNA) through (MNA)+8, respectively. The nutation in right ascension is computed and stored in COMMON location NUTRA. The nutations in longitude and obliquity are stored in locations NUTLON and NUTOBL, respectively.

If CALL MNA1 is used, the contents of MNAET are used to determine whether or not the .01 day test is to be used as criteria for recomputing the matrices M and N, MNAET = 0 forces recomputation.

## b. Velocity vector transformation:

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```
CALL MNAMD
PZE 1,,A
PZE 1,,B
PZE n,,C
```

where A, A+1, A+2 contain the input position vector

B, B+1, B+2 contain the input velocity vector

C, C+1, C+2 contain the output velocity vector

n = 0 rotates true lunar equator of-date to mean Earth equator  
of 1950.0

= 1 rotates mean Earth equator of 1950.0 to true lunar equator  
of-date.

Enter with the fractional part of the day past 0 hr of the epoch, E. T., in the AC and the integer days past 0 hr January 1, 1950, E. T. of the epoch T, in the MQ.

It is assumed that the A matrix has been previously computed and stored in COMMON locations AA through AA+8.

The N matrix is computed and stored in locations NUTMAT through NUTMAT+8. The M matrix is computed and stored in COMMON locations MM through MM+8. The product matrices NA and MNA are formed and stored in COMMON locations (NA) through (NA)+8 and (MNA) through (MNA)+8, respectively. The nutation in right ascension is computed and stored in COMMON location NUTRA. The nutations in longitude and obliquity are stored in locations NUTLON and NUTOBL, respectively.

If CALL MNAMD1 is used then the contents of MNAET are used to determine whether or not the .01 day test is to be used as criteria for recomputing the matrices M and N. MNAET = 0 forces recomputation.

## CODING INFORMATION

Length of subroutine (includes MNA, et. al., as a subset) is 1046 (10) or 2026 (8) words.

## REFERENCE

Holdridge, D. B., Space Trajectories Program for the IBM 7090 Computer, Technical Report No. 32-223, Revision No. 1, Jet Propulsion Laboratory, Pasadena, California, September 1, 1962.

IDENTIFICATION

29

PATH/DIST

Peter S. Fisher, JPL

IBM 7094 Fap

December 2, 1964

PURPOSE

To compute the path (arc) length of a trajectory.

RESTRICTIONS

- a. PATH should be called every end of step.
- b. The subroutine PROD is called.
- c. The current values of time and inertial velocity are expected in T, T + 1 and CX. to CX. + 2 respectively.
- d. The arc length will be computed geocentrically when either the Earth or the Moon is the target, and heliocentrically for all other target bodies.

METHOD

$$S = \int_{t_{inj}}^{t_{end}} v dt \quad \text{is approximated by } \sum \bar{v} \Delta t$$

Where  $\Delta t$  is the stepsize and  $\bar{v}$  is the average velocity over a step  $\bar{v} = \frac{v_i + v_{i+1}}{2}$

USE

Calling sequence:

CALL PATH

return

The path length in km is stored in DIST.

CODING INFORMATION

Length of subroutine is 51(10) or 63(8) words.

IDENTIFICATION

30-1 of 2

PLLLT/PLTSET/PLOTfq/FILENO/RECNUM/CANCLK  
 JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

PURPOSE

To control the SAVE tape option.

RESTRICTIONS

- a. Subroutines REWIND and READB are used to position the tape.
- b. Subroutine SAVEIT is used to write the SAVE tape.
- c. Subroutines FLOTT, ADD, CW1, CHANGE, SIN and COS are used to compute the SAVE tape parameters.
- d. STABCD, PAGBCD, BLATZ, LAUNCH and GCE are referenced indirectly.
- e. ABORT is called if there is an error return from SAVEIT.
- f. Entry CANCLK is provided so three clock angles can be stored internally in this subroutine.
- g. Entries FILENO and RECNUM are provided so the file number and record number are available for output.
- h. Entry PLOTfq is provided for the five input parameters needed to define the request to use the SAVE tape option.

METHOD

This subroutine is the driver subroutine that effects the generation of the SAVE tape. The initialization entry PLTSET does the following:

- a. Checks PLOTfq to see if the SAVE tape option is requested. If zero, the subroutine gives an exit.
- b. Positions the SAVE tape on the basis of the file number.
- c. Fetches the station subtable names and puts them in an internal buffer.
- d. Sets up the initialization calling sequence to SAVEIT.
- e. Calls SAVEIT.
- f. Initializes the record number to 0 and converts launch epoch to seconds past 1950 if it is input non-zero.

The execution entry PLLLT does the following:

- a. Checks PLOTfq to see if the SAVE tape option is requested. If zero, the subroutine gives an exit.
- b. Checks PLOTfq for the frequency of writing the SAVE tape. If PLOTfq = N and this entry to PLLLT is not the first one or is not a multiple of N, or if the current epoch is the same as it was on the previous entry, then the subroutine gives an exit.
- c. Computes time past injection (TTT).



- d. Computes time from launch (TFL) and days past 0 hr of launch day (DM) if launch epoch was input non-zero.
- e. Sets flags for LOOP and PRINTD.
- f. Calls CHANGE, which eventually calls LOOP and PRINTD.
- g. Resets flags used by LOOP and PRINTD.
- h. Computes two angles not computed by LOOP or PRINTD: SI) and CO).
- i. Moves the data to the data buffer, increments the record number and calls SAVEIT.

USE

Calling sequences:

- a. Initialization entry: CALL PLTSET
- b. Execution entry: CALL PLLLLT

The control (input) parameters must be in PLOTfQ to PLOTfQ + 4 as follows:

- PLOTfQ frequency of writing tape 0 = none
- PLOTfQ+1 physical file number
- PLOTfQ+2 time added to seconds past injection
- PLOTfQ+3 stations to put on save tape (maximum of 5)
- PLOTfQ+4 stations to put on save tape

The format and definition of the I. D. and data records on the SAVE tape are found in Section VA.

CODING INFORMATION

Length of subroutine is 515(10) or 1003(8) words.

IDENTIFICATION

31-1 of 2

PRINTD/PRNTD1/CONIC

JPL Staff

IBM 7094 Fap

December 2, 1964

PURPOSE

- a. PRINTD sets up and prints groups of output quantities whenever certain output control words are set.
- b. PRNTD1 sets flags that override the output control words and then goes to PRINTD. The effect is to force computation and printing of the output quantities.
- c. CONIC sets up and prints conic parameters.

RESTRICTIONS

- a. It is assumed that the subroutine SPRAY has previously been called.
- b. COMMON through COMMON +100 are used for temporary storage.
- c. The following subroutines are called: SPRAY, EFFECT, ROT, PRSET, RESET, TIME1, DAYS, ARTAN, PROD, ARSIN, GETTER, SIN, SPACE, RVOUT, GEDLAT, ECLIP, GRUPPE, PROUT, UNIT, ARCOS, CROSS, MNA, MNAMD1, MATRIX, MARSMM, MARSPC, MARFIX, NUTATE, ERPRT, ABORT, COS, JERYL, CLASS, SPECL, ADD, TIME3, BCDNO, SQRT, LN, and LOOP.
- d. The following entries are referenced indirectly: HC, CANCLK, CLUCK, GRAV, CG, MHA, INJFLG, GROP, CAN50, CASE, INJBCD and INJTYP.

METHOD

Each FLAG at GROPS to GROPS +3 and GROPS +5 to GROPS +6 is examined; if any cell is zero the corresponding group is not printed. If the cell has the value of two, the output is in ecliptic coordinates; a value of four gives equatorial coordinates. The following groups may be printed:

- Geocentric
- Geocentric Conic
- Heliocentric
- Heliocentric Conic
- Target Centered
- Target Centered Conic

The conic output quantities are in two groups: those independent of the reference coordinate system and those dependent on the reference coordinate system. The possible coordinate systems are earth equatorial, ecliptic, orbit plane of target and target true equator.

USE

31-2 of 2

Calling sequences:

- a. CALL PRINTD  
return
- b. CALL PRNTDI  
return
- c. CLA I  
CALL CONIC  
return

where I = 0 for geocentric conic

I = 1 for heliocentric conic

I = 2 for targetcentric conic

#### CODING INFORMATION

Length of subroutine is 2820(10) or 5404(8) words.

IDENTIFICATION

32-1 of 8

PROUT/FLUSH  
 JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

PURPOSE

To convert to specific output format from 1 to N lines of single or double precision information, convert the output data on one or several of the following output devices:

- a. User Area Printer (SC 3070)
- b. Peripheral Output Tape (SYSOU1)
  - 1. 1401 off-line printer or punch
  - 2. SC 4020 off-line microfilm recorder.

RESTRICTIONS

- a. Care must be exercised if single and double precision numbers are intermixed within a repeated line format, to ensure that the address modifier  $\Delta L$  will give the correct location for data in lines subsequent to the first.
- b. Requires the SFOF subroutine OUTUS, an output coordinator of SFOF subroutines that require disk write operations. OUTUS includes the necessary buffers to be shared.
- c. Requires the SFOF subroutine TAPEIO for off-line output requests.

USE

- a. Calling sequence:

```

CALL   PROUT
      BCI   1,XXXX
      P    FLAG, T, PROGID
      ZZZ
      .
      .
      .
      .
      FVE  CODE, T, 1000A+B
      ZZZ
      .
      .
      .
      .
      FVE  CODE, T, 1000A+B
    
```

} Conversion control pseudo instructions  
(see Conversion Parameters below)

} Conversion control psuedo instructions

ZZZ . . . . . FVE CODE, T, 1000A+B FVE 0, 0, 0	}	As many conversion control groups as desired
---	---	--

where,

XXXX 4 BCD characters of identification (symbols may not start with Z)  
 P = PZE specifies SC 3070 output with or without peripheral output  
 = MZE peripheral output only  
 FLAG, T is the location of the flag word where the status of the request will be placed  
 PROGID is the beginning location of 12 BCD characters of program identification to be used as part of the SC 3070 page headings; if PROGID = 0, page headings, page numbers, and page ejects (upon 53-line count) will be omitted. The provision for page headings, page numbers, and blocked output is the responsibility of the user program

For User Area Printing (SC 3070),

CODE = 0 indicates user area printing  
 T = 0 indicates user area printing  
 A = 0 indicates no post-print control  
 B = 1 indicates 15 line pre-print paper advance  
 = 10 indicates single space  
 = 20 indicates double space

For Peripheral Output Tape (1401-Printing or Punching),

CODE is the location of the system tape address or logical tape number for printing or punching  
 T = 0 indicates printing,  
 = 7 indicates punching  
 A or B = 0 indicates suppress post-print spacing, pre-print spacing, respectively  
 = I where  $1 \leq I \leq 9$ , indicates skip to Channel I.  
 = 10K indicates K spaces ( $K < 100$ )

For Peripheral Output Tape (SC 4020),

CODE is the location of a control word that has the following format:  
 PZE L(system tape address or logical tape number),  
 0, Line Count  
 T = 1 indicates SC 4020 printing

A or B = 0 indicates suppress post-print spacing, pre-print spacing, respectively  
 = I where  $1 \leq I \leq 9$ , indicates skip to Channel I.  
 = 10K indicates K spaces ( $K < 100$ )

The calling sequence must be terminated by the "end" instructions:

FVE 0, 0, 0

b. Conversion parameters:

<u>Function</u>	<u>Code</u>
FLOATING TO FIXED	SVN L, T, 1000D+PP
FLOATING TO FLOATING	SIX L, T, 1000D+PP
FIXED TO FIXED	FOR L, T, 1000D+PP
BCD TO HOLLERITH	PTH L, T, 1000N+PP
FULL WORD OCTAL	PTW L, T, PP
ADDRESS TO OCTAL	PTW L, T, 1000+PP
DECREMENT TO OCTAL	PTW L, T, 2000+PP
REPEAT LINE FORMAT	PTW ΔL, 0, 3000+K
TTY BINARY CODE	PTW L, T, 4000+N
SET BINARY POINT	PZE BP, 0, 1
NO-OPERATION	PZE 0, 0, 0
REPEAT FIELD FORMAT	PZE ΔL, 0, 1000N+ΔP
INDIRECT ADDRESS	PON L, T, E
END	FVE 0, 0, 0

In these pseudo-instructions, PP represents the rightmost print position which will be used. PP may not exceed 132 for the off-line printer, 128 for the SC 4020, 120 for the SC 3070, and 72 for the off-line punch and teletypewriter. Characters before print position 2 will be lost, except for a teletypewriter line. Characters after limiting print position will result in an error indication. If fields should overlap, the later word will take precedence.

A tag (T) can be used for address modification in any pseudo-instruction except those with a prefix of FVE or PZE. A tag entry in the FVE code is interpreted as a flag only. The tag may be any number of the set 0, 1, 2, 3, 5, 6, 7. Index register 4 may not be used for address modification.

c. Parameter specifications:

Floating to Fixed SVN L, T, 1000D+PP

The floating binary word in L, T will be rounded to D decimal places and converted to fixed decimal. If D is zero, there will be no decimal point. If the absolute value of the number is greater than  $2^{35} - 1$ , it will be printed in floating decimal as described below. D must be less than or equal to 8. An error indication occurs when  $D > 8$  unless  $n > 2^{35} - 1$  (floating point) or  $n = \text{integer}$ .

Floating to Floating SIX L, T, 1000D+PP

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The floating binary word at L, T will be rounded to D decimal digits and converted to floating decimal. If D is less than or equal to 8, the number is taken as a single-precision number. If D is greater than 8 and less than or equal to 16, the number is considered to be in double-precision, floating-point form: the high-order part in L, T and the low order part in L+1, T. Any number less than  $10^{-32}$  in absolute value will print as a single-precision zero. D must not be zero.

Fixed to Fixed FOR L, T, 1000D+PP

The fixed-point word used in L, T will be rounded to D decimal places and converted to fixed decimal. The location of the binary point is set by the last prior pseudo-instruction "SET BINARY POINT" (see below). If D is zero, there will be no decimal point. D must not exceed 8.

BCD to Hollerith PTH L, T, 1000N+PP

The N BCD words starting in L, T will be set for printing such that the last character will be in print position PP. N must be in the range permissible for the output device to be used.

Full Word Logical Octal PTW L, T, PP

The word in L, T will be converted to 12 logical octal digits.

Address in Octal PTW L, T, 1000+PP

The address portion of the word in L, T will be converted to octal.

Decrement in Octal PTW L, T, 2000+PP

The decrement portion of the word in L, T will be converted to octal.

Repeat Line Format PTW  $\Delta L$ , 0, 3000+K

The string of data pseudo-instructions immediately following this instruction, defining a line image and terminating with one or more FVE code instructions, will produce K lines of output. After each line is formed the address fields of each data pseudo-instruction will be effectively incremented by  $\Delta L$  for the next memory references.

Teletype Binary Code PTW L, T, 4000+N

The N six-bit characters starting in L, T will be placed on disk without conversion. This instruction cannot be indirectly addressed. Neither repeat command can be used in conjunction with this instruction. N must not exceed 999. No FVE code is used with this instruction since no line image is set up.

Set Binary Point PZE BP, 0, 1

The binary point for the following "FIXED TO FIXED" pseudo-instructions will be set at BP. Entry to the subroutine automatically performs PZE 35, , 1.

No-Operation PZE 0, 0, 0

This instruction is provided to facilitate modifying the calling sequence.

Repeat Field Format PZE  $\Delta L$ , 0, 1000N+ $\Delta P$

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If the immediately preceding effective pseudo-instruction is "SET BINARY POINT" or either "REPEAT" instruction, error action is taken. Otherwise, the immediately preceding effective pseudo-instruction will be repeated with  $L + n (\Delta L)$  and  $PP + n (\Delta P)$  for  $n = 1, 2, \dots, N$ . In the case of indirect addressing, the word repeated is the effective pseudo-instruction. FVE codes will not be repeated. N must not be zero.

Indirect Addressing PON L, T, E

The word at L, T will be used at this point in the calling sequence as a pseudo-instruction. If E is not equal to zero, it will be used as the decrement in place of the decrement in L, T.

End FVE 0, 0, 0

This pseudo-instruction signals the end of the calling sequence. Control is returned to the user program at the next instruction.

d. Coding information:

1. The user area printer (SC 3070) output is formatted as follows: a 15 line skip; a page header containing the 12 BCD characters of program identification beginning at PROGID, the 4 BCD characters of identification, date and page number; 2 blank lines; 50 lines, including spacing, specified by the user program. Each line image will be formatted, 5 BCD characters per word, with all necessary control indicators for the 7288 output subchannel.
2. Line images for peripheral output devices will be formed in standard format for off-line processing.
3. The BCD name specified in the calling sequence identifies a print output file which is to be placed on the disk. The user area is notified of the availability of the print output file when the file is closed. The size of the file should be arranged so that the print output is made available to the user area at frequent intervals, but not so frequent that the user area would have to make a request through the message composer for every few lines of output; this should be controlled by the frequency of closing the print output file. When the BCD name changes, the previous output file is closed and made available at the user area. When the user program has operated its minimum time and OFFSYS initiates a program interchange, all print output files are closed.

When ENDSYS or FINSYS are called, the print output files are also closed. If it is desired to close a print output file at a specific time other than those above, it may be accomplished by giving the following instruction:

```
CALL  ENDOUT
PZE   N
```



where,

- N = 1 means to close print files
- = 2 means to close plot files
- = 3 means to close print and plot files
- = 4 means to close teletype files
- = 5 means to close teletype and print files
- = 6 means to close teletype and plot files
- = 7 means to close teletype, print, and plot files

4. Before the subroutine FLUSH (described later) has been called, the completion flag of the last PROUT request must be checked to ensure that the file remains open until the output has been completed.
  5. A page eject occurs and a new heading is printed (unless PROGID = 0) when any one of the following occurs:
    - (a) Change of data name.
    - (b) Change of ID heading (page numbers are not reset).
    - (c) Calling ENDOUT.
  6. When an MZE prefix, denoting off-line output only, is used, FVE codes specifying 3070 output cannot be contained in the calling sequence.
  7. All off-line output is to be labeled. The label will consist of the 4-character user program name.
  8. In MODE IV all PROUT 3070 output will be printed on the on-line printer under sense switch control:
    - SSW No. 6 UP = no 3070 output
    - DOWN = 3070 output printed on the on-line printer
  9. User areas for which PROUT output is intended are not specified in the PROUT calling sequence. When data has been placed on disk, a message is sent to the appropriate used area(s) that this specific type of data is available. The user area can request the data when it is desirable. User areas receive only those data availability messages they designate at 7094 initialization.
  10. All peripheral output processed by PROUT will be placed on the same output tape (SYSOU1). The BCD data name normally designated in the PROUT calling sequence is ignored.
  11. FGDOU option: Three types of floating to floating output are available in PROUT depending upon the contents of location FGDOU:
    - (a) c(FGDOU) = 0 indicates no leading +, and no + in the exponent field.
    - = 1 indicates leading +, and + in the exponent field.
    - > 1 indicates leading +, and E+ in the exponent field.
- (b) c(FGDOU) is initially > 1.

## e. Suggestions for output efficiency:

1. Use buffering techniques wherever possible.
2. Organize and group output so that the number of output requests is minimized.
3. Organize output formats to print full lines or as full as possible under format requirements.
4. Arrange user program to continue computations during output processing if it becomes necessary to wait for a free output buffer within OUTUS.
5. Care should be taken not to modify a calling sequence or loop through a calling sequence until the flag word has been tested to determine the status of the previous request.

## f. Operational description:

The type of request is determined and processed in one of the following ways:

1. User Area Printer Request

The request is queued, and control is given to an output coordinating routine (OUTUS) which coordinates printing, plotting, and teletype requests, and their usage of output buffers, the calling of conversion routines, and making the necessary disk write requests. When OUTUS obtains a print (or plot or teletype) request from the queue, if an output buffer is available, OUTUS calls the proper conversion routine, and the converted output is placed in the output buffer. When the buffer is filled, or the data completed, a disk write request is then made by OUTUS to the disk control program (DCP), and control is returned to the user program. When the data has been written on disk, an interrupt occurs and control is routed to OUTUS to continue output of the request or initiate a new request. Then control is returned to the point of interruption. In this way, the print output (or plot output or teletype output) to be converted and placed on disk can be processed to make optimum usage of buffers and efficient requests of disk write operations. During the operation, if a buffer is filled or the queue is emptied or OUTUS has processed output requests as far as possible, control is returned to the user program.

2. IBM 1401 Off-Line Printer or Punch Request

The proper conversion routine is initiated and output is written on the 1401 output tape. The tape operation will be asynchronous under the supervision of IOEX. When the request has been initiated, control is returned to the user program.

3. SC 4020 Off-Line Microfilm Recorder Request

The proper conversion routine is initiated and output is written on the 4020 output tape. The tape operation will be asynchronous under the supervision of IOEX. When the request has been initiated, control is returned to the user program. In each option listed above, the results of the output request can be found in the flag word specified by the calling sequence.

g. Output:

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1. Output Data:

(a) 1401 - Print:

Print lines may contain up to 132 characters.

(b) 1401 - Punch:

Card images may contain up to 72 characters.

(c) SC 4020:

Line images may contain up to 128 characters.

(d) SC 3070:

An integral number of lines of up to 120 characters each will be packed in each 128 word disk output buffer. The printed output is then available to the actual printer in the user area upon request.

2. Flags:

(a) Upon entry, PROUT sets the user program flag word to zero. The user program can determine if the request has been completed by testing the flag word for zero or non-zero.

(b) Upon completion of the request, the user program flag word is set with the results of the output operation as follows:

(1) Sign Bit = 0: No unusual conditions occurred.

= 1: At least one unusual condition occurred. The address will indicate the condition.

Bit 32 = 1: A pseudo-instruction specifies too many (>132) characters for one line of output.

Bit 31 = 1: There is an error in the repeat data pseudo-instruction.

Bit 30 = 1: The binary point exceeds bit position 35.

(2) Decrement = 1: Processing has been successfully completed.

(3) When the address contains a flag bit; the decrement will contain the complement of the address of the pseudo-instruction in question.

3. The Entry Point FLUSH:

PROUT, being a buffered output routine, must have some means of emptying its buffer when desired, even though it may be only partially filled. For this purpose an entry to PROUT has been provided whose calling sequence is simply

```
CALL FLUSH
```

```
return
```

If the buffer in use by PROUT is empty, return is immediate to the next sequential instruction. If there are any words waiting to be written, the buffer is emptied.

At the completion of the I/O, return is made to the location after the call.

CODING INFORMATION

Length of subroutine is 1484(10) or 2714(8) words

IDENTIFICATION

33

READN/READ1/READC/SPAM

Peter S. Fisher, JPL

IBM 7094, Fap

December 2, 1964

PURPOSE

To allow appropriate data communication between the spacecraft ephemeris tape and SPASM's HBANK. To help SPASM find discontinuity points in the ephemeris.

RESTRICTIONS

- a. S/C ephemeris data is sprayed into cells with certain names expected to be entry points elsewhere in core.
- b. TAPIO and PROUT are used for input-output.

METHOD

- a. SPAM sets up an independent variable trigger using the two cells following the calling sequence in order to find discontinuity points in the S/C ephemeris.
- b. READ1 finds the correct ID record corresponding to the (RUNID) given and reads said record. This record contains the injection conditions, constants, and option flags used in the corresponding SPACE run.
- c. READN reads the data record of the tape. This record has two formats depending on whether or not the variational equations were integrated in SPACE. This condition is relayed to READN through the ID record.
- d. READC repositions the S/C ephemeris tape after the processor has finished using it. It is important that this is done so that there is no possibility of SPACE writing over the unused portion.

USE

Calling sequences:

CALL READ1

return

CALL READN

return

CALL READC

return

CODING INFORMATION

Length of subroutine is 224 (10) or 340 (8) words.

IDENTIFICATION

34-1 of 3

ROTEQ/DELTJD  
 JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

PURPOSE

To rotate mean Earth equator and equinox of-date coordinates to mean Earth equator and equinox of 1950.0 and vice versa.

RESTRICTIONS

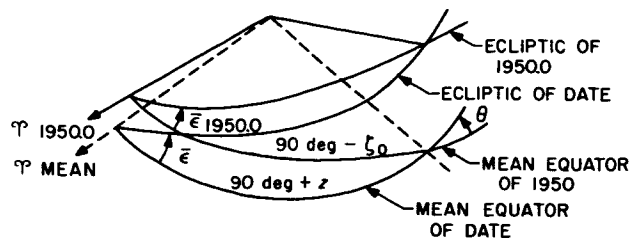
- a. The matrix is stored in the COMMON locations AA through AA+8.
- b. The subroutine uses COMMON through COMMON+2.
- c. The option of recomputing the matrix only if time has changed by at least 1/64 day is controlled by the contents of the external quantity MNAET. Nominally MNAET is zero which turns off the 1/64 day test which forces a recomputation of the matrix.
- d. An entry has been provided for access to DELTJD, the difference between the J. D. of 1950.0 and the J. D. of 0 hr January 1, 1950, in days.

METHOD

The general precession of the Earth's equator and the consequent retrograde motion of the equinox on the ecliptic may be represented by the rotation matrix:

$$\begin{pmatrix} X' \\ Y' \\ Z' \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix} \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}$$

where X, Y, and Z are expressed in the mean equator and equinox of 1950.0 and X', Y', Z' are the coordinates in the mean equator and equinox of date. The geometry of the precession has been represented by the three small parameters  $\zeta_0$ , z, and  $\theta$  in the following sketch.



where  $\gamma_{1950.0}$  is the mean equinox of 1950.0;  $\bar{\epsilon}_{1950.0}$  is the mean obliquity of 1950.0;  $\gamma_{\text{mean}}$  is the mean equinox of date;  $\bar{\epsilon}$  is the mean obliquity of date. Measured in the mean equator of 1950.0 from the mean equinox of 1950.0,  $90 \text{ deg} - \zeta_0$  is the right ascension of the ascending node of the mean equator of date on the mean equator of 1950.0.  $90 \text{ deg} + z$  is the right ascension of the node measured in the mean equator of date from the mean equinox of date.  $\theta$  is the inclination of the mean equator of date to the mean equator of 1950.0.

In terms of  $\zeta_0$ ,  $z$ , and  $\theta$ ,  $(a_{ij})$  is given by

$$\begin{aligned} a_{11} &= -\sin \zeta_0 \sin z + \cos \zeta_0 \cos z \cos \theta \\ a_{12} &= -\cos \zeta_0 \sin z - \sin \zeta_0 \cos z \cos \theta \\ a_{13} &= -\cos z \sin \theta \\ a_{21} &= \sin \zeta_0 \cos z + \cos \zeta_0 \sin z \cos \theta \\ a_{22} &= \cos \zeta_0 \cos z - \sin \zeta_0 \sin z \cos \theta \\ a_{23} &= -\sin z \sin \theta \\ a_{31} &= \cos \zeta_0 \sin \theta \\ a_{32} &= -\sin \zeta_0 \sin \theta \\ a_{33} &= \cos \theta \end{aligned}$$

$$\begin{aligned} \zeta_0 &= 2304''997T + 0''302T^2 + 0''0179T^3 \\ z &= 2304''997T + 1''093T^2 + 0''0192T^3 \\ \theta &= 2004''298T - 0''426T^2 - 0''0416T^3 \end{aligned}$$

with T the number of Julian centuries of 36, 525 days past the epoch 1950.0.

The actual computational form of  $(a_{ij})$  is obtained by expanding the  $a_{ij}$  in power series in  $\zeta_0$ ,  $z$ ,  $\theta$  and replacing the arguments by the above time series. The results are

$$\begin{aligned} a_{11} &= 1 - 0.00029697T^2 - 0.00000013T^3 \\ a_{12} &= -a_{21} = -0.02234988T - 0.00000676T^2 + 0.00000221T^3 \\ a_{13} &= -a_{31} = -0.00971711T + 0.00000207T^2 + 0.00000096T^3 \\ a_{22} &= 1 - 0.00024976T^2 - 0.00000015T^3 \\ a_{23} &= a_{32} = -0.00010859T^2 - 0.00000003T^3 \\ a_{33} &= 1 - 0.00004721T^2 + 0.00000002T^3 \end{aligned}$$

USE

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Calling sequence:

Enter with days past 0 hr January 1, 1950 E. T. in the AC-MQ.

CALL ROTEQ

PFX X,, Y

return

where

X-3, X-2, X-1 contain the input vector.

Y-3, Y-2, Y-1 contain the output vector.

PFX = PZE assumes mean 1950.0 input and rotates to mean of-date.

PFX = MZE assumes mean of-date input and rotates to mean 1950.0.

X = Y is permitted.

CODING INFORMATION

Length of subroutine is 107(10) or 153(8) words.

REFERENCE

Holdridge, D. B., Space Trajectories Program for the IBM 7090 Computer, Technical Report No. 32-223, Revision No. 1, Jet Propulsion Laboratory, Pasadena, California, September 1, 1962.

IDENTIFICATION

35-1 of 3

RVIN/RVOUT  
 JPL Staff  
 IBM 7094 Fap  
 December 2, 1964

PURPOSE

- a. RVIN transforms a set of input spherical coordinates  $R, \Phi, \Theta, V, \Gamma, \Sigma$ , to a set of cartesian coordinates  $X, Y, Z, \dot{X}, \dot{Y}, \dot{Z}$ .
- b. RVOUT transforms a set of input cartesian coordinates  $X, Y, Z, \dot{X}, \dot{Y}, \dot{Z}$ , to a set of spherical coordinates  $R, \Phi, \Theta, V, \Gamma, \Sigma$ .

RESTRICTIONS

- a. Subroutines called are SIN, COS, MATRIX, PROD, ARTAN, UNIT, and ARSIN.
- b. All angles are assumed to be in degrees.

METHOD

- a. RVIN computes the cartesian components of the vector  $\bar{R}$  by

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} R \cos \Phi \cos \Theta \\ R \cos \Phi \sin \Theta \\ R \sin \Phi \end{pmatrix}$$

where  $\Theta$  is the longitude measured clockwise in the  $X - Y$  plane from the  $X$ -axis and  $\Phi$  is the latitude measured positive above the  $X - Y$  plane. The quantities  $\Gamma$ , the path angle, and  $\Sigma$ , the azimuth angle determine the orientation of the velocity vector with respect to the plane of the local horizontal, that is, perpendicular to the  $\bar{R}$  vector.

$\bar{V}$  is expressed in the local horizontal system as

$$\bar{V} = \begin{pmatrix} \dot{X}' \\ \dot{Y}' \\ \dot{Z}' \end{pmatrix} = \begin{pmatrix} V \sin \Gamma \\ V \cos \Gamma \sin \Sigma \\ V \cos \Gamma \cos \Sigma \end{pmatrix}$$



and finally the results in the original system are

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$$\bar{V} = \begin{pmatrix} \dot{X} \\ \dot{Y} \\ \dot{Z} \end{pmatrix} = \begin{pmatrix} \cos \theta & -\sin \theta & 0 \\ \sin \theta & \cos \theta & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \cos \Phi & 0 & -\sin \Phi \\ 0 & 1 & 0 \\ \sin \Phi & 0 & \cos \Phi \end{pmatrix} \begin{pmatrix} \dot{X}' \\ \dot{Y}' \\ \dot{Z}' \end{pmatrix}$$

b. RVOUT performs the computations which follow:

$$R = \sqrt{X^2 + Y^2 + Z^2}$$

$$\Phi = \arcsin \frac{Z}{R}, \quad -90 \text{ deg} \leq \Phi \leq 90 \text{ deg}$$

$$\theta = \arctan \frac{Y}{X}, \quad 0 \text{ deg} \leq \theta < 360 \text{ deg}$$

which gives R, the magnitude of  $\bar{R}$ , the latitude  $\Phi$  and longitude  $\theta$ . The cartesian velocity components  $(\dot{X}, \dot{Y}, \dot{Z})$  are rotated to the local horizontal system where the components are called  $(\dot{X}', \dot{Y}', \dot{Z}')$  by

$$\begin{pmatrix} \dot{X}' \\ \dot{Y}' \\ \dot{Z}' \end{pmatrix} = \begin{pmatrix} \cos \Phi & 0 & \sin \Phi \\ 0 & 1 & 0 \\ -\sin \Phi & 0 & \cos \Phi \end{pmatrix} \begin{pmatrix} \cos \theta & \sin \theta & 0 \\ -\sin \theta & \cos \theta & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \dot{X} \\ \dot{Y} \\ \dot{Z} \end{pmatrix}$$

the spherical set may then be obtained as follows:

$$V = \sqrt{\dot{X}'^2 + \dot{Y}'^2 + \dot{Z}'^2}$$

$$\Gamma = \arcsin \frac{\dot{X}'}{V}, \quad -90 \text{ deg} \leq \Gamma \leq 90 \text{ deg}$$

$$\Sigma = \arctan \frac{\dot{Y}'}{\dot{Z}'}, \quad 0 \text{ deg} \leq \Sigma < 360 \text{ deg}$$

USE

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Calling sequences:

a. Spherical to cartesian:

```
CALL  RVIN
PZE   ,,A
PZE   ,,B
PZE   ,,C
```

where A, ..., A + 5 contain the input R,  $\Phi$ ,  $\Theta$ , V,  $\Gamma$ ,  $\Sigma$ ; the output variables X, Y, Z are placed in B, B + 1, B + 2 and  $\dot{X}$ ,  $\dot{Y}$ ,  $\dot{Z}$  are placed in C, C + 1, C + 2.

b. Cartesian to spherical:

```
CALL  RVOUT
PZE   1,,A
PZE   1,,B
PZE   1,,C
```

where A, A + 1, A + 2 contain the input X, Y, Z and B, B + 1, B + 2 contain the input  $\dot{X}$ ,  $\dot{Y}$ ,  $\dot{Z}$ . The output variables R,  $\Phi$ ,  $\Theta$ , V,  $\Gamma$ ,  $\Sigma$  are placed in C, ..., C + 5.

#### CODING INFORMATION

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

#### REFERENCE

Holdridge, D. B., Space Trajectories Program for the IBM 7090 computer, Technical Report No. 32-223, Revision No. 1, Jet Propulsion Laboratory, Pasadena, California, September 1, 1962.

## IDENTIFICATION

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SAVEIT  
JPL Staff  
IBM 7094 Fap  
December 2, 1964

## PURPOSE

To write labeled binary tapes with information for reading contained in the label. These tapes will be used by the subroutine READIT.

## RESTRICTIONS

Subroutines WRITEB, ENDFIL, BSREC are called.

## METHOD

This subroutine is designed to be a companion to the subroutine READIT. It is designed to write "SAVE" tapes which normally contain trajectory information only at discrete time points along the S/C path. These tapes will be used for input to plotting programs or other programs requiring trajectory information only at discrete time points. It is felt that by correct usage of this program, other needs for retaining the information on magnetic tapes can be serviced. TAPIO is used by this subroutine to obtain asynchronous operation. The burden of supplying a buffer area is left to the user. The tape written is labeled with BCD information supplied by the user via tables. Data record lengths are always equal within one file. The length of the data records is defined by initializing information. A binary record is the first record made for each file of information and is of a fixed length. Following this is a BCD record containing labeling information for the file and for each of the data words in the data records. These two records are written on the tape upon successful execution of the initialization calling sequence. Data records are written on the tape by successful execution of the execution calling sequence.

## USE

Initialization calling sequence:

CALL SAVEIT  
PZE FLC  
PZE L(F)  
PZE L(HEAD)  
PZE L(N2)  
PZE L(MAIN)  
PZE L(N3)  
PZE L(NAME)

PZE L(N4)  
PZE L(TABLE)  
PZE L(N5)  
PZE L(TABLE1)  
PZE L(TABLE2)  
TSX L(ERROR)  
RETURN

FLC is the logical tape number or unit control block communication cell.

F is the file number (fixed point) for identification.

HEAD is the name of a BCD table of labeling information for the file.

N2 is the number of words in the table HEAD (fixed point).

MAIN is the name of a BCD table containing one word labels in the main data table in each data record.

N3 is the number of words in the table MAIN and therefore the number of words in each main table in the data records (fixed point).

NAME is the name of a BCD table containing the names of each subtable within a data record. (Each data record contains the same number of subtables and all corresponding subtables in each data record have the same name.) The names are placed in the table name in the same order that their subtable appears in the data record. Each subtable name entry consists of 4 BCD words.

N4 is the number of subtables found in each data record. The length of the table name is therefore  $(N4 \cdot 4)$ .

TABLE is a BCD table containing the labels of the entries in a subtable, one word for each data word in a subtable (it is assumed that the names of corresponding data words in two or more subtables are the same).

N5 is the number of words in the table TABLE and therefore the number of words in each subtable (fixed point).

TABLE1 is the name of a binary table containing  $N3$  words of main table data words (This table is filled some time prior to the execution of each execution entry).

TABLE2 is the name of a binary table containing  $N4 \cdot N5$  words of subtable data words, the first  $N5$  words representing the first subtable, the next  $N5$  words, the second subtable, etc. (This table is filled some time prior to the execution of each execution entry.)

1. The length of the BCD record which is the second record written on the tape is  $N1$  words where

$$N1 = N2 + N3 + (N4 \cdot 4) + N5 + 1$$

2. The first record written is always 8 words long and contains in order:

F

N1

N2

N3

N4

N5

Format type 0 = FAP

Check sum

3. The third record written and all succeeding records written in the file are  $N3 + (N4 \cdot N5) + 1$ .

K Upon return an integer will be placed in the accumulator, as follows:

1 = normal return.

2 = physical end of tape has been encountered while attempting to write.

The subroutine assumes all tables in the user's FAP program have been defined as blocks starting with symbols (BSS).

Execution calling sequence:

```
CALL SAVEIT
TSX L(ERROR)
RETURN
```

where ERROR is the name of an error return subroutine supplied by the user.

End-of-file calling sequence:

```
CALL FILE
TSX L(ERROR)
RETURN
```

Return indicators are the same as those for the execution entry.

1 = normal return. All buffers will have been dumped to tape and an end of file placed after the last recorded data record. An eight word trailer record will have been written identical to the binary record initially recorded on tape with one exception: F will have the value -37777777777. A subsequent entry into SAVEIT initialization routine for another file will replace the dummy record with the binary identification record of the next. When searching for a specific file, READIT will distinguish the logical files by the tape marks and the end of recorded data by the dummy record placed on tape by the last Call File entry.

36-4 of 4

This routine assumes that each file to be written will always contain the complete tabular structure; i. e., HEADING, MAIN items and SUBTABLE items.

CODING INFORMATION

Length of subroutine is 110 (10) or 156 (8) words.

IDENTIFICATION

37

SEITE/CASE/EJECT/EJECT1/LINES/PAGBCD

JPL Staff

IBM 7094 Fap

December 2, 1964

PURPOSE

To eject the page, set up and print the first three lines (heading) of each page.

RESTRICTIONS

- a. Subroutine PROUT is called. DATCEL is referenced indirectly and contains the BCD date of loading of the program.
- b. Entries are provided for locations CASE, EJECT, EJECT1, LINES and PAGBCD, where

C(CASE) = case number

C(EJECT) = page count

C(EJECT1) = line count

C(LINES) = 63: number of lines to be put on a page

C(PAGBCD through PAGBCD+39) = page heading.

METHOD

- a. The page number, N, is incremented by 1.
- b. The case number, C, is computed.
- c. A page eject is given.
- d. "Case C IBSYS-JPTRAJ-SFPRO C(DATCEL) N" is printed.
- e. The 40 BCD words at PAGBCD are printed on two lines.
- f. The line count is set to 3.

USE

Calling sequence:

CALL SEITE

return

CODING INFORMATION

Length of subroutine is 129(10) or 201(8) words.

IDENTIFICATION

38-1 of 2

SPASM

JPL Staff

IBM 7094 Fap

December 2, 1964

PURPOSE

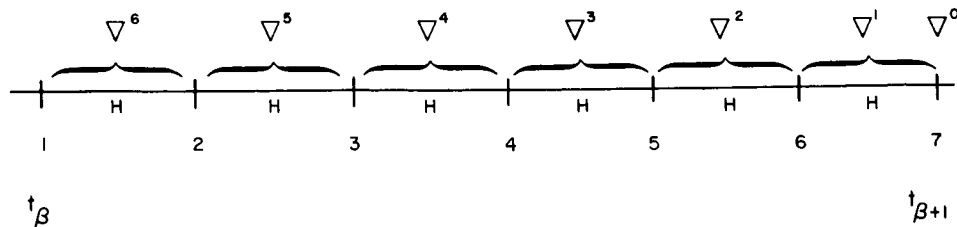
To sum sixth-order backward differences to obtain the values of the n-dependent variable of the differential equations and their derivatives, and then to interpolate for some epoch in the range of the difference array.

RESTRICTIONS

- a. An external buffer, HBANK, is required.
- b. The error exit is taken whenever an independent variable trigger epoch is equal to a time earlier than the left end of the step being taken.
- c. Entries HC, NI, TGLO, Y, YDOT, Y(2), Y0, Y0(2), BABTB, DELX, J, HD, ND, SET, and JJ are provided for communication with other subroutines.

METHOD

This subroutine is a modification of the subroutine MARK (see Reference). Nominally the order of differences is 6,  $t_\beta$  is the epoch at the left end of the interval and  $t_{\beta+1}$  is the epoch at the right end of the interval.  $\nabla^i$ ,  $i = 1, \dots, 6$  designates the  $i^{\text{th}}$  backward differences.  $\nabla^0$  designates the n derivatives at  $t_{\beta+1}$ . The following sketch relates these parameters:





SPASM sums the equally spaced backward differences to obtain the values of the n-dependent variables of the differential equations from  $t_\beta$  to  $t_{\beta+1}$  at each stepsize interval, H. By differentiation, an interpolation formula may be derived for obtaining derivatives as well. Thus, given the  $\nabla^0, \dots, \nabla^6$  and the values of the n-dependent variables of the differential equations at  $t_{\beta+1}$ , both the dependent variables and their derivatives may be obtained by interpolation for any epoch between  $t_\beta$  and  $t_{\beta+1}$ .

**USE**

Same as for MARK (see Reference, page 6.31).

**CODING INFORMATION**

Length of subroutine is 1366(10) or 2526(8) words.

**REFERENCE**

White, R. J. et al., SPACE--Single Precision Cowell Trajectory Program, Technical Memorandum 33-198, Jet Propulsion Laboratory, Pasadena, California, January 15, 1965.

IDENTIFICATION

39

SPRAY

JPL Staff

IBM 7094 Fap

December 2, 1964

PURPOSE

To decode the input quantity GROP into twelve flags and to store the flags into GROPS to GROPS +11 before and after transformation by EFFECT.

RESTRICTIONS

- a. It is assumed that parameter GROP contains 12 octal group output option flags, each octal digit being a flag.
- b. GROPS to GROPS +11, in COMMON, are used. GROP is referenced indirectly.

METHOD

Each of the twelve octal digits in GROP is placed in bits 33 - 35 in an otherwise zero accumulator. These twelve words are stored sequentially into GROPS to GROPS +11.

USE

Calling sequence:

CALL SPRAY

return

CODING INFORMATION

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

## IDENTIFICATION

40

SQRT

JPL Staff

IBM 7094 Fap

December 2, 1964

## PURPOSE

To compute  $\sqrt{x}$  for a normalized floating point, single precision  $x$ .

## RESTRICTIONS

- a. An error return will occur if the argument is negative, in which case the accumulator will contain  $\sqrt{|x|}$ .
- b. Uses COMMON to COMMON +3.

## METHOD

The Newton Raphson method is used to compute the square root of  $x$  where

$$0 \leq x \leq 2^{128}.$$

Accuracy: The result is accurate to 8 decimal digits.

## USE

Enter with the argument in the accumulator. Exit with the result in the accumulator.

Calling sequence:

```
CLA          X
CALL        SQRT
error return
normal return
```

## CODING INFORMATION

Length of subroutine is 41(10) or 51(8) words.

IDENTIFICATION

41-1 of 2

TIME1/TIME2/TIME3/LAUNCH

JPL Staff

IBM 7094 Fap

December 2, 1964

PURPOSE

To compute and print the calendar date, the Julian date and the trajectory time, given the double precision seconds past 0<sup>h</sup> January 1, 1950.

RESTRICTIONS

- a. DAYS, FIXT, ADD, FIX, FLOAT, GRUPPE and PROUT are called.
- b. OPRFLG, EQUNX1, TARBCD and INJEQX are used.
- c. A double precision number is assumed to be two floating point words.
- d. The entry LAUNCH is provided to allow access to the launch epoch if it is input.

METHOD

- a. Subroutine DAYS is used to obtain the integral days and residual seconds past 0<sup>h</sup> January 1, 1950. The Julian date (JD) is then computed as a one word floating point integer and a one word floating point fraction using the following relations:  

$$\text{integral JD} = \text{integral days from } 0^{\text{h}} \text{ January 1, 1950, to date} \\ + 2433282, \text{ the Julian date of } 12^{\text{h}} \text{ January 0, 1950} + I$$

$$\text{fractional JD} = \text{residual days} - 0.5 + (1-I)$$
 where  $I = 0$  if residual days  $< 0.5$   
 $= 1$  if residual days  $\geq 0.5$
- b. The calendar date is computed by calling subroutine FIXT.
- c. The trajectory time is computed using the following relation:  

$$\text{trajectory time} = \text{current epoch minus injection epoch.}$$
- d. If LAUNCH is non-zero, then an additional line is printed in the TIME1 entry, giving TFL the trajectory time from launch using the following relation:  

$$\text{TFL} = \text{current epoch minus launch epoch.}$$

USE

Enter with the time in double precision seconds past 0<sup>h</sup> January 1, 1950, in the AC and MQ.

The three entries provide for three output formats as follows:

- TIME1: X DAYS X HRS. X MIN. X.XXX SEC., C(EQUNX1), Octal sec past 50, JD, calendar date
- TIME2: INJECTION CONDITIONS, C(INJEQX), C(TARBCD), Octal sec past 50, JD, calendar date

TIME3: EPOCH OF PERICENTER PASSAGE, Octal sec past 50,  
JD, calendar date

Calling sequence:

```
CLA  L(SECONDS A)
LDQ  L(SECONDS B)
CALL TIME1 (or TIME2 or TIME3)
return
```

CODING INFORMATION

Length of subroutine is 235(10) or 353(8) words.

## IDENTIFICATION

42.1

TRAJ

JPL Staff

IBM 7094 Fap

December 2, 1964

## PURPOSE

To provide the control and closed subroutines needed to drive the subroutine SPASM.

## RESTRICTIONS

Since TRAJ is the driver subroutine for SFPRO, numerous entries and transfer vectors are used for communication and control.

## METHOD

TRAJ performs the following tasks:

- a. Initializes triggers on the basis of input parameters.
- b. Converts BCD input to integers via subroutine BCDNO.
- c. Converts sexagesimal input to seconds past 0 hr January 1, 1950 via subroutines FLOT or FLOTT.
- d. Obtains injection conditions, physical constants and other data defining the trajectory from the identification record of the spacecraft ephemeris tape.
- e. Initializes the n-body ephemerides by calling EPHSET and INTR1.
- f. Sets control flags and branches on the basis of input parameters.
- g. Obtains the proper set of phase parameters and initializes triggers on the basis of those parameters.
- h. Calls SPASM.
- i. Supplies SPASM with derivative, end-of-step, step-size control and trigger subroutines as required.
- j. Terminates a phase (and repeats starting at g above) or terminates the run and returns to JPTRAJ via JEXIT or ABORT.

## USE

Calling sequence:

```
CALL TRAJ
```

```
return
```

## CODING INFORMATION

Length of subroutine is 1943(10) or 3627(8) words.

## IDENTIFICATION

42. 2

FLOTT  
JPL Staff  
IBM 7094 Fap  
December 2, 1964

## PURPOSE

To convert a sexagesimal date or an interval past the initial epoch, to seconds past 0 hr January 1, 1950.

## RESTRICTIONS

- a. FLOTT is a subset of the driver, TRAJ.
- b. Subroutine FLOT is called to make the time conversion.
- c. T(0) in COMMON is used.

## METHOD

Subroutine FLOT is called to get the time in seconds past 0 hr January 1, 1950. However, if this number is less than  $1 \times 10^8$  then the assumption is made that the input time was a time interval past the initial epoch. In this case the input interval, converted to seconds, is added to T(0), the initial epoch.

## USE

Calling sequence:

```
CALL  FLOTT
      PPP  A, N, B
```

where

A, N and A+1, N contain the input time  
B, PPP and B+1, PPP contain the output seconds past 0 hr January 1, 1950  
and PPP is the FAP code for 0, 1, ..., 7 designating the index register to use to locate the output storage cell.

## CODING INFORMATION

Length of subroutine (includes FLOTT as a subset) is 1943(10) or 3627(8) words.

IDENTIFICATION

43

WOLF/TIM/MACH  
 Peter S. Fisher, JPL  
 IBM 7094 Fap  
 December 2, 1964

PURPOSE

To print an explanatory comment at injection and at each phase change.

RESTRICTIONS

- a. Subroutines PRSET, TIME1, PROUT, GRUPPE and TIME are called.
- b. OPRFLG is set non-zero to signify that if on-line print has been requested then the line generated by this subroutine is also to be printed on-line. KERN1 is referenced to obtain the BCD name of the central body for integration.
- c. Entries TIM and MACH have been provided to allow access to the time of day and computer I.D. character.
- d. It is assumed that the date has been provided by the system at SYSDAT, octal location 101.

METHOD

A test is made to see if the current epoch, T, is injection epoch. If so, then subroutine TIME is called to obtain the time of day and computer I.D. character. Then the following comments are printed on one line:

DATE OF RUN MMDDYYC TTTRS           BBBBBB IS THE CENTRAL BODY FOR  
 INTEGRATION           COWELL EQUATIONS OF MOTION

Where MM is the month, DD is the day, YY is the year, C is the computer I.D. character, TTT is the hour of day, RR is minutes, and S is the tens of seconds. BBBBBB is the name of the body currently used as the central body for integration.

If the current epoch is not injection epoch then TIME1 is called to print the time line and then the following comments are printed on one line:

CHANGE OF PHASE OCCURS AT THIS POINT           BBBBBB IS THE CENTRAL BODY  
 FOR INTEGRATION           COWELL EQUATIONS OF MOTION

Where BBBBBB is the name of the body currently used as the central body for integration.

USE

Calling sequence: CALL WOLF  
 return

CODING INFORMATION

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



## VII. CHECK CASES

Four check cases have been used for several years by JPL trajectory engineers to confirm that the version of the trajectory program being released for use is computationally correct. In addition, other trajectories are run which check the options not used by the four standard cases.

JPL TECHNICAL MEMORANDUM NO. 33-199

SOURCE PROGRAM LISTING

4/17/65 PAGE 1

```

* SPACE Z
  REWSC=1
  RUNID=(TRAJ01)
  SCFORF=1
  PAGBCD=(LARTH-MOON FINE PRINT CHECK 1)
  TARBCD=(MOON) INJBOD=(EARTH)
  FAZFLG=1 INJTYP=0 INJEX=11950.0)
  INJT=63010131b,4201297
  INJX=2156303632078,21462364652678,61255437502578
  INJDX=60341647543178,20442066656078,60353477430378
* C1
  MDCPH1+11=2,0,0,300000,200,0,4,0,400,0,400,0
  MDCPH1+27=110000000000/8
  MDCPH1+38=101000000000/8
  MDCPH2+11=400,0,0,3000000
  MDCPH2+11=400,0,4,0
  MDCPH2+27=1100000/8
  MDCPH2+38=1011/8
  MDCPH2+30=1111/8
  MDCPH2+27=111101100000/8
* C2
* SPACE Z
  RUNID=(TRAJ02)
  SCFORF=1
  PAGBCD=( CHECK 2 )
  PAGBCD=(LARTH-VENUS, RADIATION PRES. ON)
  INJBOD=(LARTH) TARBCD=(VENUS) INJTYP=0
  INJT=620900500,2332000
  INJX=62553503067678,62573042525578,62160647563378
  INJDX=6017002617578,6024654434578,57567374666678
  INJEX=(1950.0)
  RADCP1=.102E9,0,0,3.83,,383,198.22
* C3
  VENPH1+11=4000,0,1000,0,20000,0,20000,0
  VENPH1+27=152400000000/8 VENPH1+38=100001000000/8
  VENPH2+0=5,(VENUS),2.5E6,(VENUS),0
  VENPH2+11=6000,0,1000,0,20000,0,20000,0
  VENPH2+27=152400000000/8 VENPH2+38=100001000000/8
  VENPH3+11=20000,0,200,0
  VENPH3+27=152402200000/8 VENPH3+38=100001000100/8
* C4
* SPACE Z
  RUNID=(TRAJ03)
  SCFORF=1
  PAGBCD=( EARTH - MARS CHECK 3 )
  TARBCD=(MARS) INJBOD=(EARTH) FAZFLG=1 INJTYP=0
  INJT=641101116,3923043
  INJX=21552267336678,21367504263378,61463012730678
  INJDX=60253220617278,20454265736678,20062430377278
  INJEX=(1950.0)
* C5
  MARPH1+27=110000000000/8 MARPH1+38=101000000000/8
  MARPH2+27=002100000000/8 MARPH2+38=01100000/8
  MARPH3+27=102002100000/8 MARPH3+38=0100/8
  MARPH3+27=102002100000/8 MARPH3+38=1011/8
* C6
* X
* SPACE Z
  RUNID=(TRAJ04)
  
```

SOURCE PROGRAM LISTING

4/17/65 PAGE 2

```

  SCFORF=1
  PAGBCD=(LARTH-MOON)
  TARBCD=(MOON) INJBOD=(EARTH) INJTYP=0
  INJT=630000017,0455707
  INJX=61557611406178,61444476721278,61242065117178
  INJDX=2027038172378,60443153750178,60353532055178
  INJEX=(1950.0)
  PAGBCD=(CHECK 4)
* C7
  MDCPH1+27=111000000000/8 MDCPH1+38=103000000000/8
  MDCPH2+27=151001100000/8 MDCPH2+38=1000000103178
* C8
* SPPRO Z
  RUNID=(TRAJ01)
* USE C1,C2
  MDCPH1+11=2,0,0,300000,200,0,4,0,400,0,400,0
  MDCPH1+27=110000000000/8
  MDCPH1+38=101000000000/8
  MDCPH2+11=400,0,0,3000000
  MDCPH2+11=400,0,4,0
  MDCPH2+27=1100000/8
  MDCPH2+38=1011/8
  MDCPH2+30=1111/8
  MDCPH2+27=111101100000/8
* SPPRO Z
  RUNID=(TRAJ02)
* USE C3,C4
  VENPH1+11=4000,0,1000,0,20000,0,20000,0
  VENPH1+27=152400000000/8 VENPH1+38=100001000000/8
  VENPH2+0=5,(VENUS),2.5E6,(VENUS),0
  VENPH2+11=6000,0,1000,0,20000,0,20000,0
  VENPH2+27=152400000000/8 VENPH2+38=100001000000/8
  VENPH3+11=20000,0,200,0
  VENPH3+27=152402200000/8 VENPH3+38=100001000100/8
  VENPH3+30=010000000000/8 VENPH3+30=010000000000/8 VENPH2+6=-120E6
* SPPRO Z
  RUNID=(TRAJ03)
* USE C5,C6
  MARPH1+27=110000000000/8 MARPH1+38=101000000000/8
  MARPH2+27=002100000000/8 MARPH2+38=01100000/8
  MARPH3+27=102002100000/8 MARPH3+38=0100/8
  MARPH3+27=102002100000/8 MARPH3+38=1011/8
  MARPH3+30=010000000000/8 MARPH3+30=010100000000/8
* SPPRO Z
  RUNID=(TRAJ04)
* USE C7,C8
  MDCPH1+27=111000000000/8 MDCPH1+38=103000000000/8
  MDCPH2+27=151001100000/8 MDCPH2+38=1000000103178
* Z
* END
  
```

THERE WERE NO GLARING SOURCE DECK ERRORS.

THE OBJECT STRING HAS 00623 OCTAL OR 403 DECIMAL WORDS.

A. Check case 1 is an Earth-Moon trajectory with a fine print. The spacecraft injects near the Earth on January 13, 1963 and impacts the Moon after a 66.08-hour flight time.

JPL TECHNICAL MEMORANDUM NO. 33-199

START TRAJECTORY (SFPRO) 016390 G

CASE 1 IBSYS-JPTRAJ-SFPRO 041765

1

EARTH-MOON FINE PRINT CHECK 1

DOUBLE PRECISION EPHEMERIS TAPE - EPHEM1  
S/C EPHEMERIS WRITTEN 016265G 041765 RUNID=(TRAJ01)

GME .39860306 04 J .16234500-02 H -.57499999-05 D .78749999-05 RE .63781650 04 REM .63783112 04  
G .66709999-19 A .88781796 29 B .88800194 29 C .88836976 29 DME .41780741-02 AU .14959850 09  
GMP .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

INJECTION CONDITIONS 1450.0 MOON 23561021576202246010000 J.D.= 2438043.27918167 JAN. 13,1963 18 42 01.297

GEOCENTRIC X0 .59369501 04 Y0 .27186042 04 Z0 -.72883219 03 DX0-.42284408 01 DYO .85267773 01 DZ0-.54530145 01  
CARTESIAN TC .67321297 05 GMA .33026725 02 GMD .11175336 03  
DATE OF RUN 041765G 016394 EARTH IS THE CENTRAL BODY FOR INTEGRATION COWELL EQUATIONS OF MOTION

0 DAYS 0 HRS. 0 MIN. 0.000 SEC. 23561021576202246010000 J.D.= 2438043.27918167 JAN. 13,1963 18 42 01.297

GEOCENTRIC			EQUATORIAL COORDINATES								
X	.59300736 04	Y .27355045 04	Z	-.72154209 03	DX	-.42459721 01	DY	.85145659 01	DZ	-.54584695 01	
R	.65703410 04	DEC	-.63048288 01	RA	.24763570 02	V	.10969093 02	PTH	.16309296 01	AZ	.11984846 03
R	.65703404 04	LAT	-.63048288 01	LUN	.39173684 03	VE	.10558881 02	PLT	.16943087 01	AZE	.12113527 03
XS	.57180061 08	YS	-.12437799 04	ZS	-.53932928 04	DXS	-.27926580 02	DYS	-.10710362 02	DZS	-.46452519 01
XM	-.36756323 06	YM	.12677916 06	ZM	-.79800081 05	DXM	-.40581204 00	DYM	-.85550278 00	DZM	-.29049915 00
XT	-.36756323 06	YT	.12677916 06	ZT	-.79800081 05	DXT	-.40581204 00	DYT	-.85550278 00	DZT	-.29049915 00
RS	.14713360 09	VS	.30270378 02	RM	.39691779 06	VM	.99043331 00	RT	.39691779 06	VT	.99043331 00
GED	-.63474453 01	ALT	.19239502 03	LDS	.26166316 03	KAS	.29468988 03	KAM	.16096976 03	LDM	.12749034 03
DUT	.35000000 02	UT	.75000000 01	DR	.31219413 00	SHA	-.65653256 04	DES	-.71503466 02	DEM	.11598331 02
CCL	.10757921 03	MCL	.19058408 03	TCL	.19058408 03						

GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235610215265202267120360 J.D.= 2438043.27878392 JAN. 13,1963 18 41 26.931  
SMA .39375093 06 ECC .96332708 00 B .71601901 05 SLR .13020490 05 APD .78093687 06 RCA .65649734 04  
VH .92250668-01 C3 -.10123167 01 C1 .72041483 05 TFP .34366082 02 TF -.95461337-02 PER .40881892 05  
TA .32895214 01 MTA .18000000 03 EA .30168731 00 MA .50314046-02 C3J .-1.2654848 01 TFI .00000000 00

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE											
X	.59300736 04	Y .27355045 04	Z	-.72154209 03	DX	-.42459721 01	DY	.85145659 01	DZ	-.54584695 01	
INC	.30446937 02	LAN	.19392943 03	APF	.18922662 03	MX	-.41294611 00	MY	.76469264 00	MZ	-.49469753 00
WX	-.12198577 00	WY	.49183847 00	WZ	.86209882 00	PX	.42475982 00	PY	.37177615 00	PZ	-.81250652-01
QX	-.36046998 00	QY	.78732290 00	QZ	-.50018393 00	RX	-.75386592-01	RY	-.30307261-01	RZ	-.99669364 00
BX	-.36046999 00	BY	-.78732293 00	BZ	.50018395 00	TX	.37300945 00	TY	-.92782754 00	TZ	.00000000 00
DAP	-.46064574 01	RAP	.21901339 02								

BTQ .61432682 05 BRQ .-35932925 05 B .71601901 05 THA .32987798 03 T VECTOR IN EARTH EQUATOR PLANE

ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET											
X	-.97460076 03	Y	-.63914189 04	Z	-.11668206 04	DX	.70016068 01	DY	.14831275 00	DZ	-.84425396 01
INC	.51745310 02	LAN	.73114849 02	APF	.18978106 03	MX	.64280274 00	MY	.41223896-01	MZ	-.76492172 00
WX	.79141259 03	WY	-.22008386 00	WZ	.61915821 00	PX	-.18958176 00	PY	-.97353108 00	PZ	-.13340612 00
QX	.63319708 00	QY	-.14662936-01	QZ	-.77385170 00	RX	.24980654-01	RY	.13104436 00	RZ	-.99106173 00
BX	-.63319708 00	BY	.14662936-01	BZ	.77385170 00	TX	-.94231125 00	TY	.18725550 00	TZ	.00000000 00
DAP	-.76664944 01	RAP	.25920733 03								

BTO .44731560 05 BRO .-55907510 05 B .71600014 05 THA .30866328 03 T VECTOR IN ORBIT PLANE OF TARGET

CASE 1 IBSYS-JPTRAJ-SFPRO 041765

2

EARTH-MOON FINE PRINT CHECK 1

0 DAYS 0 HRS. 30 MIN. 0.000 SEC. 235610216200202246010000 J.D.= 2438043.30001501 JAN. 13,1963 19 12 01.297

GEOCENTRIC			EQUATORIAL COORDINATES								
X	-.64478004 04	Y .10748353 05	Z	-.70365115 04	DX	-.68642236 01	DY	-.18130742 01	DZ	-.20008014 01	
R	.14369581 05	DEC	-.29319621 02	RA	.12091979 03	V	.73761785 01	PTH	.47189491 02	AZ	.81460855 02
R	.14369581 05	LAT	-.29319621 02	LON	.80377532 02	VE	.67959470 01	PLT	.52772510 02	AZF	.79570004 02
XS	.57231147 08	YS	-.12439870 04	ZS	-.53924563 08	DXS	-.27926582 02	DYS	.10719672 02	DZS	.46492855 01
XM	-.36828984 06	YM	.12523797 06	ZM	.79276364 05	DXM	-.40153671 00	DYM	-.85692245 00	DZM	-.29140573 00
XT	-.36828984 06	YT	.12523797 06	ZT	.79276364 05	DXT	-.40153671 00	DYT	-.85692245 00	DZT	-.29140573 00
RS	.14713378 09	VS	.30270383 02	RM	.39699710 06	VM	.99018437 00	RT	.39699710 06	VT	.99018437 00
GED	-.29488055 02	ALT	.79965527 04	LDS	.25416511 03	RAS	.29671237 03	KAM	.16121925 03	LDM	.12067200 03
DUT	.35000000 02	UT	.59999999 02	DR	.54112033 01	SHA	.11194083 05	DES	-.21499938 02	DEM	.11518834 02
CCL	-.19864866 03	MCL	.27964880 03	TCL	.27964880 03						

GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 2356102152652022616021000 J.D.= 2438043.27878598 JAN. 13,1963 18 41 27.110  
SMA .37239032 06 ECC .96236781 00 B .69621550 05 SLR .13016341 05 APD .73821458 06 RCA .65660576 04  
VH .9757327-01 C3 -.10703840 01 C1 .72030066 05 TFP .18341874 04 TF -.94964876-02 PER .37692696 05  
TA .95501057 02 MTA .18000000 03 EA .11855552 02 MA .29196966 00 C3J .-1.3245463 01 TFI .50000000 00

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE											
X	-.64478004 04	Y .10748353 05	Z	-.70365115 04	DX	-.68642236 01	DY	-.18130742 01	DZ	-.20008014 01	
INC	.30443388 02	LAN	.19387282 03	APF	.18930823 03	MX	-.89973875 00	MY	-.44576431 00	MZ	-.12944433 00
WX	-.12144386 00	WY	.49173155 00	WZ	.86223631 00	PX	.92460809 00	PY	.37200548 00	PZ	-.81925175-01
QX	-.36104164 00	QY	.78721136 00	QZ	-.49983677 00	RX	-.76004171-01	RY	-.30579408-01	RZ	-.94663844 00
BX	-.36104165 00	BY	-.78721138 00	BZ	.49983678 00	TX	.37326021 00	TY	-.42772669 00	TZ	.00000000 00
DAP	-.46992333 01	RAP	.21916826 02								

BTQ .60232702 05 BRQ .-34916783 05 B .69621550 05 THA .32989921 03 T VECTOR IN EARTH EQUATOR PLANE

ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET											
X	.93177677 04	Y .11378919 04	Z	-.10879762 05	DX	.41303026 01	DY	.52923522 01	DZ	-.30560760 01	
INC	.51730000 02	LAN	.73077271 02	APF	.18983655 03	MX	.12398145 00	MY	.97031129 00	MZ	.20766445 00
WX	.75110449 00	WY	-.22852845 00	WZ	.61936802 00	PX	-.18557264 00	PY	-.47343368 00	PZ	-.13412519 00
QX	.63356514 00	QY	-.14195721-01	QZ	-.77355907 00	RX	.25116913-01	RY	.13175244 00	RZ	-.99096434 00
BX	-.63356517 00	BY	.14195722-01	BZ	.77355909 00	TX	-.98230949 00	TY	.18726470 00	TZ	.00000000 00
DAP	-.77080383 01	RAP	.25920679 03								

BTO .43514059 05 BRO .-54346838 05 B .69620777 05 THA .30866332 03 T VECTOR IN ORBIT PLANE OF TARGET

0 DAYS 1 HRS. 0 MIN. 0.000 SEC. 235610217102202246010000 J.D.= 2438043.32084834 JAN. 13,1963 19 42 01.297

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EARTH-MOON FINE PRINT CHECK 1

GEOCENTRIC EQUATORIAL COORDINATES

X -17560347 05	Y -12524493 05	Z -96155400 04	DX -56012699 01	DY -45820013 00	DZ -10498419 01
R -23615404 05	UFC -24027331 02	KA -14450255 03	V -57171968 01	PTH -57756951 02	AZ -70737336 02
R -23615404 05	LAT -24027331 02	LOM -96634764 02	VE -51090493 01	PTE -71168201 02	AZE -52399568 02
XS -57281411 08	YS -12433940 09	ZS -43916191 08	DXS -27920100 02	DYS -10726981 02	DZS -46533184 01
XM -36900876 06	YM -12369424 06	ZM -78751022 05	DXM -39725542 00	DYM -85832345 00	DZM -29230572 00
XT -36900876 06	YF -12369424 06	ZT -78751022 05	DXT -39725542 00	DYT -85832345 00	DZT -29230572 00
RS -14713396 04	VS -30270388 02	KM -39707613 06	VM -98993617 00	RT -39707613 06	VT -98993617 00
GED -24172734 02	ALT -17240778 05	LDS -24666707 03	KAS -29473486 03	RAM -16146849 03	LOM -11340070 03
DUT -35000000 02	UT -12000000 03	DR -48359625 01	SHA -19093397 05	DES -21496406 02	DEM -11439160 02
CCL -22582174 03	MCL -30592996 03	TCL -30592996 03			

GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235610215265202607632000 J.D.= 2438043.27878542 JAN. 13,1963 18 41 27.061

SMA -37205192 06	ECC -98235115 00	B -69591952 05	SLR -13016892 05	APC -73754945 06	RCA -65663906 04
WH -9766331-01	C3 -10713402 01	C1 -72031531 05	TFP -36342360 04	TF -95100104-02	PER -37642240 05
TA -11718464 03	MTA -18000000 03	EA -17564177 02	MA -57928050 00	C3J -13239474 01	TFI -10000000 01

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE

X -17560347 05	Y -12524493 05	Z -96155400 04	DX -56012699 01	DY -45820013 00	DZ -10498419 01
INC -30433413 02	LAN -19386406 03	APF -18731736 03	MX -65751894 00	MY -69056407 00	MZ -30131392 00
WX -12137595 00	WY -49177971 00	WZ -86221840 00	PX -42460810 00	PY -37198683 00	PZ -82009821-01
QX -36106468 00	QY -78726012 00	QZ -49985377 00	RX -7608232-01	RY -30609682-01	RZ -99663148 00
BX -36106468 00	BY -78726012 00	BZ -49985377 00	TX -37324410 00	TY -92773318 00	TZ -00000000 00
DAP -47404997 01	RAP -21915830 02				

BTQ .60206265 05 BRQ -34903369 05 B .69591952 05 THA .32989765 03 T VECTOR IN EARTH EQUATOR PLANE

ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET

X -15311712 05	Y -10204333 05	Z -14802373 05	DX -27560775 01	DY -47503466 01	DZ -15888903 01
INC -51732033 02	LAN -19386406 03	APF -18984160 03	MX -17431851 00	MY -87236354 00	MZ -47278626 00
WX -75109962 00	WY -22862019 00	WZ -61934015 00	PX -18563194 00	PY -97341250 00	PZ -13419712 00
QX -63355362 00	QY -14173943-01	QZ -77358697 00	RX -25138660-01	RY -13182153 00	RZ -99095464 00
BX -63355361 00	BY -14173943-01	BZ -77358696 00	TX -98229773 00	TY -18732638 00	TZ -00000000 00
DAP -77121970 01	RAP -25920320 03				

BTO .43494155 05 BRTO -54325119 05 B .69591379 05 THA .30868170 03 T VECTOR IN ORBIT PLANE OF TARGET

0 DAYS 1 HRS. 30 MIN. 0.000 SEC.

235610220004202246010000 J.D.= 2438043.34168167 JAN. 13,1963 20 12 01.297

GEOCENTRIC

EQUATORIAL COORDINATES

X -26909438 05	Y -12691467 05	Z -11140858 05	DX -48458458 01	DY -13495155-01	DZ -68978221 00
R -31850063 05	UFC -20474518 02	KA -15440238 03	V -48947118 01	PTH -62480507 02	AZ -66977448 02
R -31850063 05	LAT -20474518 02	LOM -98814059 02	VE -44310939 01	PTE -78419512 02	AZE -35391096 03
XS -57331665 08	YS -12432007 09	ZS -53907612 08	DXS -27915854 02	DYS -10738289 02	DZS -46573509 01
XM -36971996 06	YM -12214801 06	ZM -78224065 05	DXM -39296826 00	DYM -85970578 00	DZM -29319913 00
XT -36971996 06	YF -12214801 06	ZT -78224065 05	DXT -39296826 00	DYT -85970578 00	DZT -29319913 00
RS -14713343 04	VS -30270393 02	KM -39715486 06	VM -98968873 00	RT -39715486 06	VT -98968873 00
GED -20602362 02	ALT -25474498 05	LDS -23916902 03	KAS -29475734 03	RAM -16171748 03	LOM -10612916 03
DUT -35000000 02	UT -24000000 03	DR -43408934 01	SHA -26764537 05	DES -21492873 02	DEM -11359310 02
CCL -23711064 03	MCL -31662791 03	TCL -31662791 03			

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EARTH-MOON FINE PRINT CHECK 1

GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235610215265202602004000 J.D.= 2438043.27878490 JAN. 13,1963 18 41 27.016

SMA -37136224 06	ECC -98234627 00	B -69583701 05	SLR -13017132 05	APC -73735914 06	RCA -65665280 04
WH -97689426-01	C3 -10716141 01	C1 -72032195 05	TFP -54342813 04	TF -95225721-02	PER -37627811 05
TA -12700795 03	MTA -18000000 03	EA -21439325 02	MA -66653158 00	C3J -13233752 01	TFI -15000000 01

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE

X -26909438 05	Y -12691467 05	Z -11140858 05	DX -48458458 01	DY -13495155-01	DZ -68978221 00
INC -30433413 02	LAN -19386406 03	APF -18981955 03	MX -52100998 00	MY -77091448 00	MZ -36638715 00
WX -12136180 00	WY -49179718 00	WZ -86221850 00	PX -42460764 00	PY -37198286 00	PZ -82031064-01
QX -36107014 00	QY -78725114 00	QZ -49986407 00	RX -76103050-01	RY -30617338-01	RZ -99662977 00
BX -36107013 00	BY -78725113 00	BZ -49986401 00	TX -37324077 00	TY -92773452 00	TZ -00000000 00
DAP -47053206 01	RAP -21915625 02				

BTQ .60198679 05 BRQ -34900009 05 B .69583701 05 THA .32989711 03 T VECTOR IN EARTH EQUATOR PLANE

ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET

X -19672663 05	Y -18301019 05	Z -17101970 05	DX -21540860 01	DY -42715453 01	DZ -10353782 01
INC -51732910 02	LAN -19386406 03	APF -18984280 03	MX -23304050 00	MY -78584616 00	MZ -57281283 00
WX -75109912 00	WY -22865144 00	WZ -61932815 00	PX -18565762 00	PY -97340515 00	PZ -13421490 00
QX -63354565 00	QY -14174141-01	QZ -77357542 00	RX -25145330-01	RY -13183832 00	RZ -99095224 00
BX -63354567 00	BY -14174141-01	BZ -77357545 00	TX -98229270 00	TY -18732575 00	TZ -00000000 00
DAP -77132250 01	RAP -25920166 03				

BTO .43488917 05 BRTO -54319335 05 B .69583216 05 THA .30868093 03 T VECTOR IN ORBIT PLANE OF TARGET

0 DAYS 2 HRS. 0 MIN. 0.000 SEC.

235610220706202246010000 J.D.= 2438043.36251501 JAN. 13,1963 20 42 01.297

GEOCENTRIC

EQUATORIAL COORDINATES

X -35157458 05	Y -12708409 05	Z -12197376 05	DX -43488279 01	DY -19455837 00	DZ -50112047 00
R -39323358 05	DEC -18070164 02	RA -16012653 03	V -43819264 01	PTH -65289371 02	AZ -65085562 02
R -39323357 05	LAT -18070165 02	LOM -97017682 02	VE -41922472 01	PTE -71719540 02	AZE -30593275 03
XS -57381912 08	YS -12430074 09	ZS -53899425 08	DXS -27911605 02	DYS -10747595 02	DZS -46613828 01
XM -37042345 06	YM -12059931 06	ZM -77695507 05	DXM -38867531 00	DYM -86106942 00	DZM -29408592 00
XT -37042345 06	YF -12059931 06	ZT -77695507 05	DXT -38867531 00	DYT -86106942 00	DZT -29408592 00
RS -14713431 04	VS -30270397 02	KM -39723332 06	VM -98944204 00	RT -39723332 06	VT -98944204 00
GED -18185229 02	ALT -32947228 05	LDS -23167097 03	KAS -29477983 03	RAM -16196623 03	LOM -98857371 02
DUT -35000000 02	UT -24000000 03	DR -39400672 01	SHA -33864684 05	DES -21489336 02	DEM -11279286 02
CCL -24347842 03	MCL -32255119 03	TCL -32255119 03			

GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235610215265202577744000 J.D.= 2438043.27878471 JAN. 13,1963 18 41 26.000

SMA -37193554 06	ECC -98234480 00	B -69581531 05	SLR -13017264 05	APC -73730508 06	RCA -65665992 04
WH -97697084-01	C3 -10716919 01	C1 -72032559 05	TFP -72342974 04	TF -95270573-02	PER -37623715 05
TA -13292118 03	MTA -18000000 03	EA -24446771 02	MA -11536815 01	C3J -13229201 01	TFI -20000000 01

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CASE 1

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EARTH-PCDN FINE PRINT CHECK 1

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
X -35157458 05 Y -12708409 05 Z -12197376 05 DX -43488279 01 DY -19455837 00 DZ -50112047 00
INC -30434887 02 LAG -19386105 03 APF -18932061 03 MX -43119465 00 MY -80850590 00 MZ -40048648 00
WX -12135567 00 WY -49188769 00 WZ -86220337 00 PX -92460773 00 PY -37198076 00 PZ -82041699-01
QX -36107253 00 QY -78724552 00 QZ -499487109 00 RX -76112474-01 RY -30621161-01 RZ -99662888 00
BX -36107253 00 BY -78724552 00 BZ -499487109 00 TX -37323899 00 TY -92773523 00 TZ -00000000 00
DAP -47053320 01 RAP -21915515 02

BTQ .60196496 05 BRQ -.34899444 05 B .69581531 05 THA .32989661 03 T VECTOR IN EARTH EQUATOR PLANE
ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
X -2325760 05 Y -25658274 05 Z -18681743 05 DX -18088820 01 DY -39207859 01 DZ -74609460 00
INC -51733463 02 LAN -73067059 02 APF -18948430 03 MX -29546519 00 MY -72246756 00 MZ -62509272 00
WX -75109959 00 WY -22867323 00 WZ -61932056 00 PX -18567820 00 PY -97339996 00 PZ -13422400 00
QX -63354002 00 QY -14178708-01 QZ -77357991 00 RX -25150057-01 RY -13184673 00 RZ -99409599 00
BX -63354006 00 BY -14178709-01 BZ -77357996 00 TX -98220887 00 TY -18737375 00 TZ -00000000 00
DAP -77137526 01 RAP -25920043 03

BTO .43486596 05 BRQ -.54318169 05 B .69581231 05 THA .30866402 03 T VECTOR IN ORBIT PLANE OF TARGET
0 DAYS 0 HRS. 0 MIN. 0.000 SEC. 235610227726202246010000 J.U.= 2438043.52718168 JAN. 14,1963 00 42 01.297

GEOCENTRIC EQUATORIAL COORDINATES
X -84114400 05 Y -65059352 04 Z -15548877 05 DX -28179711 01 DY -52034270 00 DZ -99636187-01
SMA -37210406 06 ECC -98235293 00 B -69597264 05 SLR -13017238 05 APD -73764320 06 RCA -65655991 04
R -85786518 05 LAT -10442625 02 RA -17557179 03 V -28673411 01 PTH -72971953 02 AZ -61241663 02
RS -85786518 05 LON -52304021 02 VE -60837608 01 PTE -26785336 02 AZE -27426584 03
XS -57783604 08 YS -12414543 09 ZS -53832072 08 DXS -27877475 02 DYS -10822000 02 DZS -46936178 01
XM -47577210 06 YM -10812474 06 ZM -73410790 05 OXM -35413399 00 OYM -87130586 00 OZM -30094165 00
XT -37577210 06 YT -10812474 06 ZT -73410790 05 OXT -35413399 00 OYT -87130586 00 OZT -30094165 00
RS -14713573 09 VS -30270437 02 RM -39765618 06 VM -98749717 00 RT -39785018 06 VT -98749717 00
GEO -10512209 02 ALT -79409021 05 LOS -17188650 03 RAS -29949966 03 RAM -16394734 03 LOM -40674176 02
DUT -35000000 02 DT -46000000 03 OR -27416413 01 SMA -79254281 05 DES -21460932 02 DEM -10633072 02
CCL -25991191 03 MCL -33699600 03 TCL -33699600 03

GEOCENTRIC CONIC
EPOCH OF PERICENTER PASSAGE 235610215265202645710000 J.U.= 2438043.27878814 JAN. 13,1963 18 41 27.296
SMA -37210406 06 ECC -98235293 00 B -69597264 05 SLR -13017238 05 APD -73764320 06 RCA -65655991 04
VH -9765224-01 C3 -14712056 01 C1 -72023487 05 IFP -21634001 05 TF -94447134-02 PER -37666367 05
TA -14711167 03 MTA -18000000 03 EA -38438245 02 MA -34477074 01 C3J -13210443 01 TFI -59999999 01

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
X -84114400 05 Y -65059352 04 Z -15548877 05 DX -28179711 01 DY -52034270 00 DZ -99636187-01
INC -30447654 02 LAG -19385364 03 APF -18932776 03 MX -43119465 00 MY -80850590 00 MZ -40048648 00
WX -12135567 00 WY -49193702 00 WZ -86213670 00 PX -92461349 00 PY -37194855 00 PZ -82123046-01
QX -36106477 00 QY -78717400 00 QZ -49947633 00 RX -76189428-01 RY -30649074-01 RZ -99662200 00
BX -36106474 00 BY -78717399 00 BZ -49947630 00 TX -37320917 00 TY -92774773 00 TZ -00000000 00
DAP -47106649 01 RAP -21913674 02

BTQ .60205711 05 BRQ -.34914917 05 B .69597264 05 THA .32988939 03 T VECTOR IN EARTH EQUATOR PLANE

CASE 1

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EARTH-PCDN FINE PRINT CHECK 1

ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
X -41175304 05 Y -71487404 05 Z -23525935 05 DX -93534122 00 DY -27071772 01 DZ -13405399 00
INC -51741021 02 LAG -73054934 02 APF -18948665 03 MX -43119465 00 MY -80850590 00 MZ -40048648 00
WX -75112934 06 WY -22865599 00 WZ -61921698 00 PX -18566293 00 PY -97335636 00 PZ -13428465 00
QX -63365081 00 QY -14224354-01 QZ -77365234 00 RX -25186659-01 RY -13190147 00 RZ -99094279 00
BX -63365082 00 BY -14224354-01 BZ -77365236 00 TX -98225282 00 TY -18756172 00 TZ -00000000 00
DAP -77172582 01 RAP -25918947 03

BTO .43489594 05 BRQ -.54336085 05 B .69597091 05 THA .30867313 03 T VECTOR IN ORBIT PLANE OF TARGET
0 DAYS 10 HRS. 0 MIN. 0.000 SEC. 235610236746202246010000 J.U.= 2438043.69584834 JAN. 14,1963 04 42 01.297

GEOCENTRIC EQUATORIAL COORDINATES
X -12038556 06 Y -11858322 04 Z -16261956 05 DX -22807968 01 DY -53816650 00 DZ -13566510-01
R -12148473 06 LAT -76927096 01 RA -18056436 03 V -23434678 01 PTH -75345235 02 AZ -60632451 02
RS -12148473 06 LON -5712693 03 VE -85737836 01 PTE -15333528 02 AZE -27202766 03
XS -58184904 06 YS -12398905 09 ZS -53766255 08 DXS -27843110 02 DYS -10896324 02 DZS -47258164 01
XM -38062099 06 YM -95511378 05 ZM -69030420 05 OXM -31927256 00 OYM -88034611 00 OZM -30737028 00
XT -38062099 06 YT -95511378 05 ZT -69030420 05 OXT -31927256 00 OYT -88034611 00 OZT -30737028 00
RS -14713719 09 VS -30270480 02 RM -39844693 06 VM -98560677 00 RT -39844693 06 VT -98560677 00
GEO -17445006 01 ALT -11510691 06 LOS -11170260 03 RAS -29513943 03 RAM -16591331 03 LOM -34247588 03
DUT -35000000 02 DT -95999999 03 OR -22672296 01 SHA -11447679 06 DES -21432338 02 DEM -99767607 01
CCL -26498468 03 MCL -34093882 03 TCL -34093882 03

GEOCENTRIC CONIC
EPOCH OF PERICENTER PASSAGE 235610215266202204410000 J.U.= 2438043.27880827 JAN. 13,1963 18 41 29.035
SMA -37261506 06 ECC -98237085 00 B -69620343 05 SLR -13015004 05 APD -73826632 06 RCA -65653729 04
VH -97661411-01 C3 -14703106 01 C1 -72026306 05 IFP -3603262 05 TF -89615583-02 PER -37696572 05
TA -15535241 03 MTA -18000000 03 EA -40669480 02 MA -57350989 01 C3J -13200759 01 TFI -10000000 02

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
X -12038556 06 Y -11858322 04 Z -16261956 05 DX -22807968 01 DY -53816650 00 DZ -13566510-01
INC -30464137 02 LAG -19384033 03 APF -18933858 03 MX -43119465 00 MY -80850590 00 MZ -40048648 00
WX -12128280 02 WY -49227853 00 WZ -86196666 00 PX -92463905 00 PY -37185250 00 PZ -82249809-01
QX -36101673 00 QY -78701159 00 QZ -50027925 00 RX -76328626-01 RY -30696292-01 RZ -99661008 00
BX -36101680 00 BY -78701174 00 BZ -50027934 00 TX -37311734 00 TY -92778416 00 TZ -00000000 00
DAP -47190668 01 RAP -21908003 02

BTQ .60213148 05 BRQ -.34948090 05 B .69620343 05 THA .32988885 03 T VECTOR IN EARTH EQUATOR PLANE

ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
X -52632178 05 Y -10674526 06 Z -24368814 05 DX -68707636 00 DY -22404781 01 DZ -45491792-02
INC -51762503 02 LAN -73638667 02 APF -18985119 03 MX -49786965 00 MY -61884523 00 MZ -75940403 00
WX -75128417 00 WY -22913658 00 WZ -61892529 00 PX -18619355 00 PY -97329003 00 PZ -13438261 00
QX -63318976 00 QY -14246840-01 QZ -77386669 00 RX -25242856-01 RY -13199047 00 RZ -99092952 00
BX -63318979 00 BY -14246841-01 BZ -77386872 00 TX -98219904 00 TY -18784318 00 TZ -00000000 00
DAP -77229221 01 RAP -25917305 03

BTO .43484158 05 BRQ -.54370099 05 B .69620254 05 THA .30865215 03 T VECTOR IN ORBIT PLANE OF TARGET
0 DAYS 14 HRS. 0 MIN. 0.000 SEC. 235610245766202246010000 J.U.= 2438043.66251501 JAN. 14,1963 08 42 01.297

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EARTH-MOON FINE PRINT CHECK 1

GEOCENTRIC			EQUATORIAL COORDINATES					
X -15085768 06	Y -88699365 04	Z -16157990 05	DX -19742425 01	DY -52734149 00	DZ -23835855-01			
R -15197959 06	DEC -61030421 01	RA -18336493 03	V -20435975 01	PTH -76593858 02	AZ -60053228 02			
R -15197959 06	LAT -61030421 01	LOV -29976323 03	VE -10796389 02	PTE -10610265 07	AZE -27127716 03			
XS -58585506 08	YS -12383160 09	ZS -53695974 08	DXS -27808509 02	DYS -10970566 02	DZS -47579785 01			
XW -38476583 06	YW -82776450 05	ZW -64560577 05	DXM -28413486 00	DYM -88819066 00	DZM -31336824 00			
XT -38476583 06	YT -82776450 05	ZT -64560577 05	DXI -28413486 00	DYI -88819066 00	DZI -31336824 00			
RS -14713666 09	VS -30270527 02	RM -39402218 06	VM -98375584 00	RT -33990218 06	VT -98375584 00			
GEO -61443159 01	ALT -14560163 06	LOS -51717424 02	RAS -29531912 03	RAM -16786486 03	LOM -28426317 03			
DUT -35000000 02	DT -95999999 03	DR -19879115 01	SHA -14462524 06	DES -21403552 02	DEM -93112143 01			
CCL -26760095 03	MCL -34292233 03	TCL -34292233 03						

EPOCH OF PERICENTER PASSAGE 235610215267202315750000 J.D.= 2438043.27886120 JAN. 13,1963 18 41 33.609

SMA -372e1702 06	ECC -98239812 00	B -69641901 05	SLR -13009046 05	APC -73907177 06	RCA -65622774 04
WH -97432780-01	C3 -106491589 01	C1 -72009819 05	TFP -50427688 05	TF -76910257-02	PER -37757500 05
TA -15655770 03	MTA -18000000 03	EA -52917723 02	MA -80134045 01	C3J -13193548 01	TF1 -14000000 02

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE

X -15085768 06	Y -88699365 04	Z -16157990 05	DX -19742425 01	DY -52734149 00	DZ -23835855-01
INC -30505725 02	LAN -19382076 03	APF -18935274 03	MX -21224571-02	MY -86811068 00	MZ -49636590 00
WX -12126403 00	WY -49292740 00	WZ -86157843 00	PX -92469112 00	PY -37167308 00	PZ -82495185-01
QX -36088967 00	QY -78669020 00	QZ -50087616 00	RX -76543465-01	KY -30766107-01	RZ -99659146 00
BX -36088972 00	BY -78669029 00	BZ -50087622 00	TX -37294428 00	TY -92785375 00	TZ -00000000 00
DAP -47320049 01	RAP -21897315 02				

ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET

X -15085768 06	Y -88699365 04	Z -16157990 05	DX -19742425 01	DY -52734149 00	DZ -23835855-01
INC -30505725 02	LAN -19382076 03	APF -18935274 03	MX -21224571-02	MY -86811068 00	MZ -49636590 00
WX -12126403 00	WY -49292740 00	WZ -86157843 00	PX -92469112 00	PY -37167308 00	PZ -82495185-01
QX -36088967 00	QY -78669020 00	QZ -50087616 00	RX -76543465-01	KY -30766107-01	RZ -99659146 00
BX -36088972 00	BY -78669029 00	BZ -50087622 00	TX -37294428 00	TY -92785375 00	TZ -00000000 00
DAP -47320049 01	RAP -21897315 02				

EPOCH OF PERICENTER PASSAGE 235610255006702246010000 J.D.= 2438044.02918167 JAN. 14,1963 12 42 01.297

SMA -372e1702 06	ECC -98239812 00	B -69641901 05	SLR -13009046 05	APC -73907177 06	RCA -65622774 04
WH -97432780-01	C3 -106491589 01	C1 -72009819 05	TFP -50427688 05	TF -76910257-02	PER -37757500 05
TA -15655770 03	MTA -18000000 03	EA -52917723 02	MA -80134045 01	C3J -13193548 01	TF1 -14000000 02

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE

X -17770549 06	Y -16349802 05	Z -15653149 05	DX -17660922 01	DY -51121891 00	DZ -44518640-01
R -17914122 06	DEC -50128303 01	RA -18525670 03	V -18391325 01	PTH -77380777 02	AZ -59800106 02
R -17914122 06	LAT -50128311 01	LOV -24149074 03	VE -12794071 02	PTE -80638382 01	AZE -27091419 03
XS -58985707 08	YS -12367309 09	ZS -53627230 08	DXS -27773671 02	DYS -11044726 02	DZS -47901038 01
XW -38880297 06	YW -69937162 05	ZW -60007481 05	DXM -24876397 00	DYM -89484113 00	DZM -31893244 00
XT -38880297 06	YT -69937162 05	ZT -60007481 05	DXI -24876397 00	DYI -89484113 00	DZI -31893244 00
RS -14714016 09	VS -30270577 02	RM -39957459 06	VM -98200919 00	RT -33995749 06	VT -98200919 00
GEO -50468166 01	ALT -17276318 06	LOS -35173278 03	RAS -29549874 03	RAM -16980278 03	LOM -22603682 03
DUT -35000000 02	DT -95999999 03	DR -17947056 01	SHA -17149115 06	DES -21374574 02	DEM -86372676 01
CCL -26969944 03	MCL -34415151 03	TCL -34415151 03			

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EARTH-MOON FINE PRINT CHECK 1

EPOCH OF PERICENTER PASSAGE 235610215271202635310000 J.D.= 2438043.27897256 JAN. 13,1963 18 41 43.230

SMA -37331979 06	ECC -98243756 00	B -69658332 05	SLR -12997666 05	APC -74008317 06	RCA -65564062 04
WH -97257058-01	C3 -106491790 01	C1 -71978314 05	TFP -64818067 05	TF -50187110-02	PER -37833904 05
TA -16073869 03	MTA -18000000 03	EA -58632496 02	MA -10279362 02	C3J -13187499 01	TF1 -18000000 02

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE

X -17770549 06	Y -16349802 05	Z -15653149 05	DX -17660922 01	DY -51121891 00	DZ -44518640-01
INC -30574359 02	LAN -19379468 03	APF -18936975 03	MX -35414986-01	MY -86466739 00	MZ -50109422 00
WX -12128732 00	WY -49398366 00	WZ -86096973 00	PX -92477547 00	PY -37139268 00	PZ -82811715-01
QX -36086566 00	QY -78615962 00	QZ -50186919 00	RX -76846193-01	KY -30861668-01	RZ -99656519 00
BX -36086577 00	BY -78615968 00	BZ -50186935 00	TX -37267274 00	TY -92796284 00	TZ -00000000 00
DAP -47502019 01	RAP -21880548 02				

ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET

X -17770549 06	Y -16349802 05	Z -15653149 05	DX -17660922 01	DY -51121891 00	DZ -44518640-01
INC -30574359 02	LAN -19379468 03	APF -18936975 03	MX -35414986-01	MY -86466739 00	MZ -50109422 00
WX -12128732 00	WY -49398366 00	WZ -86096973 00	PX -92477547 00	PY -37139268 00	PZ -82811715-01
QX -36086566 00	QY -78615962 00	QZ -50186919 00	RX -76846193-01	KY -30861668-01	RZ -99656519 00
BX -36086577 00	BY -78615968 00	BZ -50186935 00	TX -37267274 00	TY -92796284 00	TZ -00000000 00
DAP -47502019 01	RAP -21880548 02				

EPOCH OF PERICENTER PASSAGE 235610264026202246010000 J.D.= 2438044.19584834 JAN. 14,1963 16 42 01.297

SMA -37331979 06	ECC -98243756 00	B -69658332 05	SLR -12997666 05	APC -74008317 06	RCA -65564062 04
WH -97257058-01	C3 -106491790 01	C1 -71978314 05	TFP -64818067 05	TF -50187110-02	PER -37833904 05
TA -16073869 03	MTA -18000000 03	EA -58632496 02	MA -10279362 02	C3J -13187499 01	TF1 -18000000 02

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE

X -20197367 06	Y -23590486 05	Z -14912014 05	DX -16112623 01	DY -49446968 00	DZ -57519812-01
R -20389272 06	DEC -41941613 01	RA -18666195 03	V -16864089 01	PTH -77925660 02	AZ -59581681 02
R -20389272 06	LAT -41941613 01	LOV -18273172 03	VE -14618480 02	PTE -6472868 01	AZE -27070455 03
XS -59485409 08	YS -12351350 09	ZS -53558024 08	DXS -27738596 02	DYS -11118803 02	DZS -48221919 01
XW -39212934 06	YW -57010689 05	ZW -55377399 05	DXM -21320225 00	DYM -90030021 00	DZM -32406026 00
XT -39212934 06	YT -57010689 05	ZT -55377399 05	DXI -21320225 00	DYI -90030021 00	DZI -32406026 00
RS -14741468 09	VS -30270629 02	RM -40010285 06	VM -98031154 00	RT -40010285 06	VT -98031154 00
GEO -42226405 01	ALT -19751463 06	LOS -29174806 03	MAS -29567829 03	RAM -17172787 03	LOM -16779764 03
DUT -35000000 02	DT -95999999 03	DR -16491006 01	SHA -19596997 06	DES -21345405 02	DEM -79557309 01
CCL -27111373 03	MCL -34500428 03	TCL -34500428 03			

EPOCH OF PERICENTER PASSAGE 23561021576202166010000 J.D.= 2438043.27917733 JAN. 13,1963 18 42 00.922

SMA -37394621 06	ECC -98249295 00	B -69666085 05	SLR -12978771 05	APC -74134573 06	RCA -65466920 04
WH -97020826-01	C3 -10659304 01	C1 -71925978 05	TFP -79200374 05	TF -10399050-03	PER -37929169 05
TA -16236954 03	MTA -18000000 03	EA -62428375 02	MA -12528675 02	C3J -13182134 01	TF1 -22000000 02

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EARTH-MOON FINE PRINT CHECK 1

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
X -.20197367 06 Y -.23590486 05 Z -.14912014 05 DX -.16112623 01 DY -.49446968 00 DZ .57519812-01
INC .30878652 02 LAN .19376253 03 APF .18938914 03 MX .63262731-01 MY -.86082503 00 MZ .50495360 00
WX -.12138116 00 WY .49557412 00 WZ .86004242 00 PX .92489906 00 PY .37098963 00 PZ -.83237212-01
QX -.38631698 00 QY .78534898 00 QZ -.50338718 00 RX -.77254108-01 RY -.30987677-01 RZ .99652977 00
BX -.38631698 00 BY -.78534898 00 BZ .50338718 00 TX .37228153 00 TY -.92811985 00 TZ .00000000 00
DAP -.47746651 01 RAP .21856396 02

BTO .60124433 05 BKU -.35191135 05 B .69666085 05 THA .32965935 03 T VECTOR IN EARTH EQUATOR PLANE

ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
X .75414606 05 Y .18818541 06 Z -.21705243 05 DX .41806925 00 DY .16307159 01 DZ .99789928-01
INC .51917651 02 LAN .72963995 02 APF .18986397 03 MX -.54396204 00 MY .30801712 00 MZ .78053240 00
WX .75319225 00 WY -.23701937 00 WZ .61598437 00 PX -.18717476 00 PY -.97290240 00 PZ -.13495089 00
QX .63043816 00 QY -.14005840-01 QZ -.17611315 00 RX .25570602-01 RY .13250598 00 RZ -.94085231 00
BX -.63043816 00 BY .14005839-01 BZ .17611313 00 TX -.48188438 00 TY .18948108 00 TZ .00000000 00
DAP -.7757702 01 RAP .25907749 03

BTO .43307357 05 BKU -.54567880 05 B .69666017 05 THA .30843628 03 T VECTOR IN ORBIT PLANE OF TARGET

1 DAYS 2 HRS. 0 MIN. 0.000 SEC. 235610273046202246010000 J.U.= 2438044.36251501 JAN. 14,1963 20 42 01.297

GEOCENTRIC EQUATORIAL COORDINATES

X -.22426694 06 Y -.30593316 05 Z -.14016070 05 DX -.14894586 01 DY -.47827064 00 DZ .66408229-01
R .22677759 06 DEC -.35434440 01 RA .18776804 03 V .15657713 01 PTH .78326461 02 AZ .59353992 02
INC .22677759 06 LAN .35434440 01 LON .12367354 03 VE .16305768 02 PTE .53960380 01 AZE .27056998 03
WX .59186595 06 WY -.12338286 06 WZ .61598437 00 DKS .27703285 02 DYS .11192795 02 DZS .48542428 01
RM -.39494248 06 YM .44014164 05 ZM .50676633 05 DXM .17749132 00 UYM -.90457156 00 UZM -.32874950 00
XT -.39494248 06 YT .44014164 05 ZT .50676633 05 DXT -.17749132 00 DYT .90457156 00 DZT -.32874950 00
RS .14714323 06 VS .30270684 02 RM .40060570 06 VM .97868743 00 VTM .40060570 06 RT .97868743 00
GEO .35675297 01 ALT .22039947 06 LOS .23176327 03 RAS .29585776 03 RAM .17364094 03 LOM .10956645 03
DUT .35000000 02 DT .95999999 03 DR .15333855 01 SHA .21859221 06 DES -.21316048 02 DEM .72673895 01
CCL .27273368 03 MCL .34564152 03 TCL .34564152 03

GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235610215304202630310000 J.U.= 2438043.27952766 JAN. 13,1963 18 42 31.191
VMA .37472680 06 ECC .98256930 00 B .69666089 05 SLR .12449718 05 APD .74292581 06 RCA .65317859 04
SHA .96706058-01 C3 .10637043 01 C1 .71845430 05 TFP .93570106 05 TF .83038806-02 PER .38048298 05
TA .16366297 03 MTA .18000000 03 EA .66307598 02 MA .14755473 02 C3J .-13177218 01 TFI .26000000 02

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
X -.22426698 06 Y -.30593316 05 Z -.14016070 05 DX -.14894586 01 DY -.47827064 00 DZ .66408229-01
INC .30830375 02 LAN .19372335 03 APF .18941050 03 MX .65070010-01 MY .85664632 00 MZ .50875798 00
WX -.12158215 00 WY .49786782 00 WZ .85868830 00 PX .42507084 00 PY .37043490 00 PZ -.83797006-01
QX -.35980784 00 QY .78415429 00 QZ -.50560126 00 RX -.77791771-01 RY -.31150898-01 RZ .99648283 00
BX .35980784 00 BY .78415426 00 BZ .50560124 00 TX .37174238 00 TY -.92833593 00 TZ .00000000 00
DAP -.48088514 01 RAP .21821116 02

BTO .60028069 05 BKU -.35344919 05 B .69666089 05 THA .32951014 03 T VECTOR IN EARTH EQUATOR PLANE

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EARTH-MOON FINE PRINT CHECK 1

ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
X .81140989 05 Y .21680132 06 Z -.20174349 05 DX .37438849 00 DY .15162157 01 DZ .11208100 00
INC .52128210 02 LAN .72930370 02 APF .18986624 03 MX -.55003496 00 MY .28678324 00 MZ .78435768 00
WX .7561303 00 WY .23171147 00 WZ .61389659 00 PX -.18863579 00 PY -.97268761 00 PZ -.13526932 00
QX .62847095 00 QY .13733659-01 QZ .77777181 00 RX .25751592-01 RY .13278633 00 RZ .99081009 00
BX .62847095 00 BY .13733659-01 BZ .77777181 00 TX .-98170943 00 TY .19038541 00 TZ .00000000 00
DAP -.71736747 01 RAP .25902471 03

BTO .43161171 05 BKU -.54678515 05 B .69660798 05 THA .30828624 03 T VECTOR IN ORBIT PLANE OF TARGET

1 DAYS 6 HRS. 0 MIN. 0.000 SEC. 235610302066202246010000 J.U.= 2438044.52918168 JAN. 15,1963 00 42 01.297

GEOCENTRIC EQUATORIAL COORDINATES

X -.24447662 06 Y -.37368612 05 Z -.13010690 05 DX -.18899911 01 DY -.46287676 00 DZ .72894213-01
R .24447662 06 DEC .30056642 01 RA .18867301 03 V .14668482 01 PTH .78635463 02 AZ .59085315 02
INC .24447662 06 LAN .30056642 01 LON .64414211 02 VE .17881174 02 PTE .46129782 01 AZE .27047738 03
WX .60183277 06 WY .12319114 09 ZS .53418227 08 DKS .27667737 02 DYS .11266703 02 DZS .48862561 01
XM .39724057 06 YM .30964657 05 ZM .45911510 05 DXM .14167205 00 DYM .90765972 00 DZM .33299838 00
XT .39724057 06 YT .30964657 05 ZT .45911510 05 DXT .14167205 00 DYT .90765972 00 DZT .33299838 00
RS .14714479 06 VS .30270740 02 RM .40108196 06 VM .37714125 00 VTM .40108196 06 RT .97714125 00
GEO .30254078 01 ALT .24177350 06 LOS .17177636 03 RAS .29603716 03 RAM .17554284 03 LOM .51284040 02
DUT .35000000 02 DT .95999999 03 DR .14380882 01 SHA .23970624 06 DES -.21286500 02 DEM .65730077 01
CCL .27315668 03 MCL .34614435 03 TCL .34614435 03

GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235610215322202110310000 J.U.= 2438043.28009913 JAN. 13,1963 18 43 20.566
VMA .37571466 06 ECC .98267342 00 B .69636995 05 SLR .12906903 05 APD .74491946 06 RCA .65098484 04
SHA .96787670-01 C3 .10609132 01 C1 .71726563 05 TFP .10792773 06 TF .22019148-01 PER .38198547 05
TA .16473160 03 MTA .16000000 03 EA .69787217 02 MA .16951545 02 C3J .-13172613 01 TFI .30000000 02

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
X -.24447662 06 Y -.37368612 05 Z -.13010690 05 DX -.18899911 01 DY -.46287676 00 DZ .72894213-01
INC .31046162 02 LAN .19387674 03 APF .18943334 03 MX .10274311 00 MY .85728494 00 MZ .51304531 00
WX -.12194174 00 WY .50110303 00 WZ .61389659 00 PX -.18863579 00 PY -.97268761 00 PZ -.84527670-01
QX .35980803 00 QY .78244892 00 QZ .50875226 00 RX .78494652-01 RY .31361064-01 RZ .99642111 00
BX .35980803 00 BY .78244892 00 BZ .50875242 00 TX .37101436 00 TY .92862677 00 TZ .00000000 00
DAP -.48868839 01 RAP .21778253 02

BTO .59876005 05 BKU -.35555236 05 B .69636995 05 THA .32929755 03 T VECTOR IN EARTH EQUATOR PLANE

ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
X .86116282 05 Y .23191945 06 Z -.18495561 05 DX .34070546 00 DY .14217474 01 DZ .12063117 00
INC .52343658 02 LAN .72892010 02 APF .18986630 03 MX -.55360104 00 MY .26889734 00 MZ .78117511 00
WX .75668063 00 WY .23289466 00 WZ .61092118 00 PX -.18977354 00 PY -.97241115 00 PZ .-13565612 00
QX .62866011 00 QY .13291084-01 QZ .77998251 00 RX .25784140-01 RY .13314431 00 RZ .99075599 00
BX .62866011 00 BY .13291086-01 BZ .77998251 00 TX .-98148400 00 TY .19154418 00 TZ .00000000 00
DAP -.77985026 01 RAP .25895708 03

BTO .42939624 05 BKU -.54822382 05 B .69636951 05 THA .30806982 03 T VECTOR IN ORBIT PLANE OF TARGET

1 DAYS 10 HRS. 0 MIN. 0.000 SEC. 235610311106202246010000 J.U.= 2438044.69584834 JAN. 15,1963 04 42 01.297



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EARTH-MOON FINE PRINT CHECK 1

GEOCENTRIC EQUATORIAL COORDINATES
X -26437573 06 Y -43927890 05 Z -11423683 05 DX -13066445 01 DY -44824937 00 DZ -77920893-01
R -26826547 06 DEC -25474829 01 RA -18943391 03 V -13835891 01 PTH -78884791 02 AZ -58743026 02
LAT -25474829 01 LDN -50108444 01 VE -19363027 02 PTE -40205823 01 AZE -27041055 03
XS -60581443 08 YS -12302836 06 ZS -93347636 08 DXS -27631951 02 DYS -11340526 02 DZS -49182315 01
XM -39022232 06 YM -17879167 05 ZM -41088381 05 DXM -10578462 00 DYM -90957011 00 DZM -33680550 00
XT -33902232 06 YT -17879167 05 ZT -41088381 05 DXT -10578462 00 DYT -90957011 00 DZT -33680550 00
RS -14714639 09 VS -30270798 02 RM -40153048 06 VM -97567725 00 RT -40153048 06 VT -97567725 00
GED -25648203 01 ALT -26188730 06 LOS -11179342 03 RAS -29621649 03 RAM -17743443 03 LOM -35301137 03
DUT -35000000 02 DT -95999999 03 DR -13576351 01 SHA -25955771 06 DES -21256762 02 DEM -58733265 01
CCL -27394551 03 MCL -34655822 03 TCL -34655822 03

GEOCENTRIC CONIC
EPOCH OF PERICENTER PASSAGE 235611215345202643010000 J.D.= 2438043.28101011 JAN. 13, 1963 18 44 39.274
SMA -3767399 06 ECC -98281512 00 H -69586635 05 SLR -12845176 05 APD -74746973 06 RCA -64782519 04
WH -95729411-01 C3 -10573690 01 CI -71554640 05 TFP -12224202 06 TF -43882846-01 PER -38390761 05
TA -16564213 03 MTA -18600000 03 EA -72937569 02 MA -19104912 02 C3J -13168218 01 TFI -33000000 02

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
X -26437573 06 Y -43927890 05 Z -11923683 05 DX -13066445 01 DY -44824937 00 DZ -77920893-01
INC -31350122 02 LAN -19362201 03 APF -18945700 03 MX -11736732 00 MY -84760748 00 MZ -51836459 00
WX -12253297 00 WY -50563186 00 WZ -85400401 00 PX -92561465 00 PY -36868698 00 PZ -85463703-01
QX -35808332 00 QY -78000422 00 QZ -51319582 00 RX -79415662-01 RY -31632516-01 RZ -996033958 00
BX -35808329 00 BY -78000415 00 BZ -51319577 00 TX -37004149 00 TY -92901523 00 TZ -00000000 00
DAP -49038461 01 RAP -21718177 02

T VECTOR IN EARTH EQUATOR PLANE
BTD -59645586 05 BRU -35842766 05 B -69586635 05 THA -32899712 03
X -91055550 05 Y -25178535 06 Z -16711966 05 DX -31282303 00 DY -13417828 01 DZ -12680315 00
INC -52647885 02 LAN -72844472 02 APF -18986310 03 MX -55483514 00 MY -25325107 00 MZ -79247826 00
WX -75971310 00 WY -23442258 00 WZ -60671023 00 PX -19123658 00 PY -97205318 00 PZ -13616612 00
XW -62167501 00 QY -12597343-01 QZ -78317392 00 RX -26284758-01 RY -13360510 00 RZ -99068603 00
BX -62167504 00 BY -12597344-01 BZ -78317397 00 TX -98119198 00 TY -19303450 00 TZ -00000000 00
DAP -78260971 01 RAP -25687007 03

T VECTOR IN ORBIT PLANE OF TARGET
BTD -42615809 05 BRU -55010759 05 B -69586635 05 THA -30776428 03

1 DAYS 14 HRS. 0 MIN. 0.000 SEC. 235610320126202246010000 J.D.= 2438044.86251501 JAN. 15, 1963 08 42 01.297

GEOCENTRIC EQUATORIAL COORDINATES
X -28266672 06 Y -50281177 05 Z -10770919 05 DX -12355833 01 DY -43423497 00 DZ -82081237-01
R -28730590 06 DEC -21484846 01 RA -19008636 03 V -13122360 01 PTH -79097325 02 AZ -58284026 02
LAT -21484846 01 LDN -30549903 03 VE -20765244 02 PTE -35576730 01 AZE -27036072 03
XS -60979793 06 YS -12286653 06 ZS -53276505 08 DXS -27995929 02 DYS -11414262 02 DZS -49501688 01
XM -40028703 06 YM -47746130 04 ZM -36213617 05 DXM -69868463-01 DYM -91030888 00 DZM -34018981 00
XT -40028703 06 YT -47746130 04 ZT -36213617 05 DXT -69868463-01 DYT -91030888 00 DZT -34018981 00
RS -14714601 09 VS -30270858 02 RM -40153018 06 VM -97429941 00 RT -40153018 06 VT -97429941 00
GED -21631122 01 ALT -28042772 06 LOS -51808410 02 RAS -29639574 03 RAM -17931661 03 LOM -29472928 03
DUT -35000000 02 DT -95999999 03 DR -12885500 01 SHA -27832947 06 DES -21226835 02 DEM -51690606 01
CCL -27463463 03 MCL -34691034 03 TCL -34691034 03

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EARTH-MOON FINE PRINT CHECK 1

GEOCENTRIC CONIC
EPOCH OF PERICENTER PASSAGE 235610215404202760610000 J.D.= 2438043.28245232 JAN. 13, 1963 18 46 43.881
SMA -37861564 06 ECC -98300879 00 H -69498163 05 SLR -12756975 05 APD -75079853 06 RCA -64331408 04
WH -94777210-01 C3 -10527838 01 CI -71308753 05 TFP -13651741 06 TF -78495979-01 PER -38641839 05
TA -16643766 03 MTA -18000000 03 EA -75798269 02 MA -21197347 02 C3J -13163941 01 TFI -38000000 02

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
X -28266672 06 Y -50281177 05 Z -10770919 05 DX -12355833 01 DY -43423497 00 DZ -82081237-01
INC -31781162 02 LAN -19355781 03 APF -18948050 03 MX -12957496 00 MY -84096911 00 MZ -52533931 00
WX -12346662 00 WY -51199887 00 WZ -85006266 00 PX -92603266 00 PY -36733906 00 PZ -86749742-01
QX -35867841 00 QY -77647875 00 QZ -51948179 00 RX -80637086-01 RY -31987156-01 RZ -99623013 00
BX -35867840 00 BY -77647873 00 BZ -51948177 00 TX -36872912 00 TY -92953689 00 TZ -00000000 00
DAP -49766499 01 RAP -21637262 02

T VECTOR IN EARTH EQUATOR PLANE
BTD -59301625 05 BRU -36239647 05 B -69498163 05 THA -32857060 03
X -95445647 05 Y -27058126 06 Z -14851533 05 DX -29068467 00 DY -12728703 01 DZ -13140203 00
INC -53078989 02 LAN -72799048 02 APF -18985507 03 MX -55352363 00 MY -23904040 00 MZ -79779178 00
WX -76370744 00 WY -23642079 00 WZ -80071342 00 PX -19314268 00 PY -97158245 00 PZ -13683361 00
QX -61599291 00 QY -11522565-01 QZ -78766767 00 RX -26679355-01 RY -13420749 00 RZ -99059404 00
BX -61599279 00 BY -11522563-01 BZ -78766752 00 TX -98080789 00 TY -19497662 00 TZ -00000000 00
DAP -78646630 01 RAP -25875663 03

T VECTOR IN ORBIT PLANE OF TARGET
BTD -42144454 05 BRU -55261191 05 B -69498163 05 THA -30733089 03

1 DAYS 18 HRS. 0 MIN. 0.000 SEC. 235610327146202246010000 J.D.= 2438045.02918167 JAN. 15, 1963 12 42 01.297

GEOCENTRIC EQUATORIAL COORDINATES
X -30000779 06 Y -56435753 05 Z -95618061 04 DX -11744021 01 DY -42060585 00 DZ -85814440-01
R -30541954 06 DEC -17940585 01 RA -19065365 03 V -12503974 01 PTH -79292513 02 AZ -57641404 02
LAT -17940585 01 LDN -53205074 08 ZS -53205074 08 DXS -27599669 02 DYS -11687912 02 DZS -49820676 01
XS -40103458 06 YM -83321843 04 ZM -31293600 05 DXM -33962371-01 DYM -90988291 00 DZM -34309058 00
XT -40103458 06 YT -83321843 04 ZT -31293600 05 DXT -33962371-01 DYT -90988291 00 DZT -34309058 00
RS -14714964 09 VS -30270918 02 RM -40233996 06 VM -97301155 00 RT -40233996 06 VT -97301155 00
GED -18062765 01 ALT -29904135 06 LOS -35182332 03 RAS -29657492 03 RAM -18119024 03 LOM -23643865 03
DUT -35000000 02 DT -95999999 03 DR -12286261 01 SHA -29616432 06 DES -21196720 02 DEM -44609135 01
CCL -27523752 03 MCL -34721735 03 TCL -34721735 03

GEOCENTRIC CONIC
EPOCH OF PERICENTER PASSAGE 235610215466202252610000 J.D.= 2438043.28473766 JAN. 13, 1963 18 50 01.334
SMA -38081490 06 ECC -98327692 00 H -69353690 05 SLR -12630457 05 APD -75527131 06 RCA -63684789 04
WH -93345401-01 C3 -18066906 01 CI -70954268 05 TFP -15071996 06 TF -13334370 00 PER -38979752 05
TA -16714648 03 MTA -18000000 03 EA -78383379 02 MA -23199731 02 C3J -13159679 01 TFI -42000000 02

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EARTH-MOON FINE PRINT CHECK 1

X -30000779 06 Y -56435753 05 Z -95618061 04 DX -11744021 01 DY -42060585 00 DZ -85814440-01
INC -32402870 02 LAN -19348238 03 APF -18950222 03 MX -13684666 00 MY -83325221 00 MZ -53495429 00
WX -12443616 00 WY -52110191 00 WZ -84430106 00 PX -42660240 00 PY -36548874 00 PZ -88464571-01
QX -39468141 00 QY -77127899 00 QZ -52851702 00 RX -82294132-01 RY -32460070-01 RZ -99607932 00
BX -35468134 00 BY -77127884 00 BZ -52851691 00 TX -36692734 00 TY -93024960 00 TZ -00000000 00
DAP -5C752613 01 RAP -21526244 02

BTQ .58785854 05 HRQ -36798873 05 B .69353690 05 THA .32795419 03 T VECTOR IN EARTH EQUATOR PLANE
ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
X .99553975 05 Y .28844897 06 Z -12932931 05 DX .27294298 00 DY .12127590 01 DZ .13494879 00
INC .53700903 02 LAN .72742661 02 APF .18983976 03 MX -.54898183 00 MY .22555830 00 MZ .80482420 00
WX .76965669 00 WY -23909248 00 WZ .59200045 00 PX -.19568529 00 PY -.97094692 00 PZ -1.13772932 00
QX .60773101 00 QY -.98416972-02 QZ -.79408167 00 RX -.27210423-01 RY .13501496 00 RZ -.99066992 00
BX -.60773115 00 BY -.98416995-02 BZ -.79408186 00 TX -.98628916 00 TY .19756813 00 TZ .00000000 00
DAP -.79164734 01 RAP .25860521 03

BTD .41452436 05 BRD -.55602358 05 B .69353634 05 THA .30670511 03 T VECTOR IN ORBIT PLANE OF TARGET
1 DAYS 22 HRS. 0 MIN. 0.000 SEC. 235610336166202246010000 J.D.= 2438045.19584834 JAN. 15,1963 16 42 01.297

GEOCENTRIC EQUATORIAL COORDINATES
X -31653008 06 Y -62394955 05 Z -82995664 04 DX -11217080 01 DY -40703204 00 DZ .89533161-01
R .32272791 06 DEC -14736312 01 RA .19115127 03 V .11966286 01 PTH .79491225 02 AZ .56697807 02
S .32272790 06 LAT -14736312 01 LON .18623541 03 VE .23373436 02 PTC .28853382 01 AZE .27024411 03
XS .61772676 08 YS -12253366 09 ZS -53133104 08 DXS .27523172 02 DYS .11561474 07 DZS .50139278 01
XM -40126538 06 YM -21424506 05 ZM .26334720 05 UXM .18955440-02 UYM -.90829977 00 UZM -.34556741 00
XT -40126538 06 YT -21424506 05 ZT .26334720 05 DXT .18955440-02 DYT -.90829977 00 DZT -.34556741 00
RS .14715131 09 VS .30270978 02 RM .40269893 06 VM .97181731 00 VTM .40269893 06 VT .97181731 00
GED -.14836692 01 ALT .31634971 06 LOS .29183815 03 RAS .29675401 03 RAM .18305625 03 LOM .17814039 03
DUT .35000000 02 DT .95999999 03 DR .11765576 01 SMA .31317932 06 DES -.21166414 02 DEM .37495646 01
CCL .27578364 03 MCL .34748894 03 TCL .34748894 03

EPOCH OF PERICENTER PASSAGE 235610215606202120210000 J.D.= 2438043.28843318 JAN. 13,1963 18 55 20.627
SMA .38390618 06 ECC .98365649 00 H .69124322 05 SLR .12446199 05 APD .76153797 06 RCA .62743723 04
VM .92490215-01 C3 .10382761 01 C1 .70434812 05 TFP .16480067 06 TF .22203636 00 PER .39454566 05
TA .16779803 03 MTA .18000000 03 EA .80676696 02 MA .25061839 02 C3J -.13155282 01 TFI .46000000 02

X -31653008 06 Y -62394955 05 Z -82995664 04 DX -11217080 01 DY -40703204 00 DZ .89533161-01
INC .33331057 02 LAN .19339308 03 APF .18951938 03 MX .14778767 00 MY -.82273719 00 MZ .54887301 00
WX -.12127573 00 WY .53453153 00 WZ .83550962 00 PX .92740189 00 PY .36286063 00 PZ -.90872875-01
QX -.35174802 00 QY .76328729 00 QZ -.54190870 00 RX -.84625815-01 RY -.33111186-01 RZ -.99586249 00
BX .35174817 00 BY -.76328760 00 BZ .54190892 00 TX .36436821 00 TY -.93125497 00 TZ .00000000 00
DAP -.52138297 01 RAP .21368708 02

BTQ .57994008 05 HRQ -37814718 05 B .69124322 05 THA .32701269 03 T VECTOR IN EARTH EQUATOR PLANE

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EARTH-MOON FINE PRINT CHECK 1

X .10341513 06 Y .30550418 06 Z -10968566 05 DX .25931491 00 DY .11600335 01 DZ .13782209 00
INC .54629141 02 LAN .72677591 02 APF .18981315 03 MX -.53972122 00 MY .21199654 00 MZ .81471371 00
WX .77843838 00 WY -24279053 00 WZ .57886649 00 PX -.19920705 00 PY -.97005254 00 PZ -1.18977005 00
QX .54527320 00 QY -.71292128-02 QZ -.80349170 00 RX .27956510-01 RY .13613616 00 RZ -.99029559 00
BX -.5927323 00 BY .71292131-02 BZ .80349173 00 TX -.97958506 00 TY .20115918 00 TZ .00000000 00
DAP -.79886574 01 RAP .25839524 03

BTD .40405835 05 BRD -.56085046 05 B .69124265 05 THA .30577043 03 T VECTOR IN ORBIT PLANE OF TARGET
2 DAYS 0 HRS. 0 MIN. 0.000 SEC. 235610341576202246010000 J.D.= 2438045.27918167 JAN. 15,1963 18 42 01.297

GEOCENTRIC EQUATORIAL COORDINATES
X -32452114 06 Y -65300771 05 Z -76477978 04 DX -10983640 01 DY -40011004 00 DZ .91542422-01
R .33311425 06 DEC -13234866 01 RA .19137773 03 V .11725491 01 PTH .79600267 02 AZ .56604826 02
S .33311424 06 LAT -13234866 01 LON .15637924 03 VE .23991241 02 PTC .27553358 01 AZE .27028264 03
XS .61970931 08 YS -12245029 09 ZS -53096948 08 DXS .27504634 02 DYS .11598222 02 DZS .50298434 01
XM -40118728 06 YM -27980045 05 ZM .23842704 05 UXM .19794696-01 UYM -.90707679 00 UZM -.34663930 01
XT -40118728 06 YT -27980045 05 ZT .23842704 05 DXT .19794696-01 DYT -.90707679 00 DZT -.34663930 01
RS .14715215 09 VS .30271009 02 RM .40286656 06 VM .97125636 00 VTM .40286656 06 VT .97125636 00
GED -.13320276 01 ALT .32473605 06 LOS .26184554 03 RAS .29684354 03 RAM .18398668 03 LOM .14898868 03
DUT .35000000 02 DT .95999999 03 DR .11532869 01 SMA .32141168 06 DES -.21151193 07 DEM .33928972 01
CCL .27603786 03 MCL .34761284 03 TCL .34761284 03

EPOCH OF PERICENTER PASSAGE 235610215700202031610000 J.D.= 2438043.29111344 JAN. 13,1963 18 59 12.201
SMA .38595647 06 ECC .98390672 00 H .68963612 05 SLR .12322652 05 APD .76570162 06 RCA .62113059 04
VM .91529582-01 C3 .10327606 01 C1 .70084353 05 TFP .17176410 06 TF .28636265 00 PER .39771055 05
TA .16810641 03 MTA .18000000 03 EA .81696404 02 MA .25913684 02 C3J -.13152964 01 TFI .46000000 02

X -32452114 06 Y -65300771 05 Z -76477978 04 DX -10983640 01 DY -40011004 00 DZ .91542422-01
INC .33374277 02 LAN .19334201 03 APF .18952475 03 MX .15098952 00 MY -.81575430 00 MZ .55636295 00
WX -.12895533 00 WY .54374785 00 WZ .82928852 00 PX .42792951 00 PY .36110393 00 PZ -.92470128-01
QX -.34973803 00 QY .75759675 00 QZ -.55111668 00 RX -.86174984-01 RY -.33535010-01 RZ -.99571542 00
BX .34973906 00 BY .75759681 00 BZ .55111673 00 TX .36265777 00 TY -.93192239 00 TZ .00000000 00
DAP -.53057284 01 RAP .21263510 02

BTQ .57436994 05 HRQ -38170654 05 B .68963612 05 THA .32637335 03 T VECTOR IN EARTH EQUATOR PLANE

X .10341513 06 Y .30550418 06 Z -10968566 05 DX .25931491 00 DY .11600335 01 DZ .13782209 00
INC .55272449 02 LAN .72640962 02 APF .18979365 03 MX -.53243060 00 MY .20482650 00 MZ .82131851 00
WX .78443744 00 WY -.24521199 00 WZ .56467476 00 PX -.20152205 00 PY -.46945588 00 PZ -1.39800401 00
QX .58625526 00 QY -.51373503-02 QZ -.80989311 00 RX .28452274-01 RY .13687447 00 RZ -.99017970 00
BX -.58655517 00 BY .51373495-02 BZ .80989299 00 TX -.97907065 00 TY .20352069 00 TZ .00000000 00
DAP -.80362980 01 RAP .25825708 03

BTD .39676542 05 BRD -.56407202 05 B .68963762 05 THA .30512236 03 T VECTOR IN ORBIT PLANE OF TARGET
2 DAYS 10 HRS. 46 MIN. 13.045 SEC. 235610364533202453700262 J.D.= 2438045.72794378 JAN. 16,1963 05 28 14.343
CHANGE OF PHASE OCCURS AT THIS POINT MOON IS THE CENTRAL BODY FOR INTEGRATION COWELL EQUATIONS OF MOTION
2 DAYS 10 HRS. 46 MIN. 13.045 SEC. 235610364533202453700262 J.D.= 2438045.72794378 JAN. 16,1963 05 28 14.343

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EARTH-MOON FINE PRINT CHECK 1

GEOCENTRIC EQUATORIAL COORDINATES
X -36523823 06 Y -74984803 05 Z -37911595 04 DX -10184934 01 DY -35201941 00 DZ -11197415 00
R -37391297 06 DEC -56094002 00 RA -19235240 03 V -10834134 01 PTH -80653600 02 AZ -45730101 02
R -37391297 06 DEC -56094002 00 RA -19235240 03 V -10834134 01 PTH -80653600 02 AZ -45730101 02
RS -63035470 08 YS -12199675 09 ZS -52900268 08 DXS -27405060 02 DYS -11795732 02 DZS -51153816 01
RM -39855843 06 YF -62934252 05 ZM -10317100 05 DXM -11562157 00 DYM -89559930 00 DZM -35050410 00
RT -39855843 06 YF -62934252 05 ZM -10317100 05 DXT -11562157 00 DYT -89559930 00 DZT -35050410 00
RS -14715677 09 VS -30271171 02 RM -40362852 06 VM -96866896 00 RT -40362852 06 VT -96866896 00
GEU -58489673 00 ALT -36753476 06 LOS -10033062 03 RAS -29732531 03 RAM -18897318 03 LOM -35197849 03
DUT -35000000 02 DLT -95999999 03 DR -10690306 01 SMA -36322043 06 DES -21068411 02 DEM -14646888 01
CCL -27724801 03 MCL -34808360 03 TCL -34808360 03

GEOCENTRIC CONIC
EPOCH OF PERICENTER PASSAGE 235610217570202671100262 J.D.= 2438043.33527507 JAN. 13,1963 20 02 43.446
SMA -41596680 06 ECC -98686110 00 B -67207113 05 SLR -10898714 05 APO -82645569 06 RCA -54652607 04
VH -79604680-01 C3 -95826562 00 C1 -65789743 05 TFP -20673089 06 TF -13450417 01 PER -44497717 05
TA -16700044 03 MTA -16000000 03 EA -84120820 02 MA -27875258 02 C3J -13134935 01 TFI -58770290 02

HELIOCENTRIC EQUATORIAL COORDINATES
X -63400707 08 Y -12191676 09 Z -52896477 08 DX -28423554 02 DY -12147752 02 DZ -50034074 01
R -14724600 09 LAT -21053455 02 LON -11747590 03 V -31312943 02 PTH -70083611 00 AZ -10013326 03
XE -63035470 08 YE -12199675 09 ZE -52900268 08 DXE -27405060 02 DYE -11795732 02 DZE -51153816 01
XT -63434028 08 YT -12193381 09 ZT -52910585 08 DXT -27289439 02 DYT -12691332 02 DZT -54658857 01
LTE -21068411 02 LDE -11732530 03 LTT -21054316 02 LDT -11748495 03 RST -14727953 09 VST -30588548 02
EPS -78123524 02 ESP -14127420 06 SEP -10373514 03 EPM -13596538 03 EMP -42084703 02 MEP -39499116 01
MPS -14696276 03 MSP -27453512-18 SMP -33028755 02 SEM -10763194 03 EMS -72218416 02 ESM -14968061 00
RPM -40000000 05 SPN -75146158 02 SIP -14447234 03 CPT -88422180 02 SIN -85931766 02
GCE -82751986 02 GCT -25083559 03 CPE -86484485 02 CPS -10389195 03
REP -37391297 06 VEP -10834134 01

HELIOCENTRIC CONIC
EPOCH OF PERICENTER PASSAGE 235607633273202051700262 J.D.= 2438037.54273527 JAN. 8,1963 01 01 32.327
SMA -16142967 09 ECC -68703716-01 B -16079327 09 SLR -16015949 09 APO -17574908 09 RCA -14711026 09
VH -26232628 02 C3 -82211717 03 C1 -46103605 10 TFP -70720201 06 TF -13767471 03 PER -40943820 03
TA -86267625 01 MTA -18000000 03 EA -78950769 01 MA -71969685 01 C3J -13134935 01 TFI -58770290 02

SELENOCENTRIC EQUATORIAL COORDINATES
X -33320203 05 Y -17050551 05 Z -14108259 05 DX -11341150 01 DY -54357989 00 DZ -46247825 00
R -40000000 05 DEC -20652943 02 RA -33290035 03 V -13399933 01 PTH -88527735 02 AZ -25193471 03
R -39999995 05 LAT -95993432 01 LON -32067773 03 VP -13467491 01 PTP -84073395 02 AZP -27107525 03
LTS -91549292-01 LNS -28895195 03 LTE -63668248 01 LNE -10455312 01 DP -49314433-04 ASD -24904133 01
ALT -38201312 05 ALS -21202236 05 ALP -13464494 02 DR -13395509 01
HGE -28387647 03 SVL -64635958 01 HNG -14753069 03 SIA -13347496 03

SELENOCENTRIC CONIC
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EARTH-MOON FINE PRINT CHECK 1

EPOCH OF PERICENTER PASSAGE 235610601415202402300262 J.D.= 2438046.03247707 JAN. 16,1963 12 46 46.019
SMA -41620675 04 ECC -10594037 01 B -11059679 04 SLR -38683569 03 APO -80000000 00 RCA -18783868 03
VH -12451704 01 C3 -15504505 01 C1 -13771391 04 TFP -26311675 05 TF -66079089 02 LTF -66038382 02
TA -15919563 03 MTA -16072189 03 EA -18607764 03 MA -59364792 03 C3J -13134935 01 TFI -58770290 02
ZAE -14143332 03 ZAP -14547150 03 ZAC -88754508 02 DEF -14144374 03 IR -37433771 04 GP -63179035 01

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
X -33320203 05 Y -17050551 05 Z -14108259 05 DX -11341150 01 DY -54357989 00 DZ -46247825 00
INC -15282212 03 LAN -20013795 03 APF -29751894 02 MX -53064219 00 MY -79649527 00 MZ -29016748 00
WX -15724388 00 WY -39499588-01 WZ -98677205 00 PX -96709348 00 PY -11557282 00 PZ -22664880 00
QX -19999131 00 QY -89596242 00 QZ -39652180 00 RX -31111934 00 RY -14875512 00 RZ -93865631 00
BX -50807406 00 BY -80757818 00 BZ -29946327 00 TX -43135853 00 TY -90218059 00 TZ -00000000 00
SXI -84683798 00 SYI -40489763 00 SZI -34485263 00 DAI -20172799 02 RAI -15444619 03
SKD -97889370 00 SYD -18671297 00 SZD -83026355-01 DAD -47625423 01 RAD -10798815 02
ETE -15534899 03 ETS -35188020 03 ETC -23880145 03

T VECTOR IN EARTH EQUATOR PLANE
BTO -110481738 04 BRO -35284082 03 B -11059679 04 THA -16139551 03 T VECTOR IN EARTH EQUATOR PLANE

ALL VECTORS REFERENCED TO ECLIPTIC PLANE
X -33320203 05 Y -21255886 05 Z -61604863 04 DX -11341150 01 DY -68270049 00 DZ -20805108 00
INC -17067038 03 LAN -25589908 03 APF -87402341 02 MX -53045122 00 MY -84620354 00 MZ -50655583-01
WX -15724388 00 WY -39499588-01 WZ -98677205 00 PX -96709348 00 PY -19620176 00 PZ -16196217 00
QX -19999131 00 QY -89596242 00 QZ -39652180 00 RX -31111934 00 RY -14875512 00 RZ -93865631 00
BX -50807406 00 BY -80757818 00 BZ -29946327 00 TX -43135853 00 TY -90218059 00 TZ -00000000 00
SXI -84683798 00 SYI -40489763 00 SZI -34485263 00 DAI -20172799 02 RAI -14900803 03
SKD -97889370 00 SYD -13826904 00 SZD -15045484 00 DAD -86532869 01 RAD -80398014 01
ETE -17665351 03 ETS -13184719 02 ETC -26010596 03

T VECTOR IN ECLIPTIC PLANE
BTO -11047399 04 BRC -52098851 02 B -11059677 04 THA -18270003 03 T VECTOR IN ECLIPTIC PLANE

ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
X -34936237 05 Y -18967891 05 Z -44359931 04 DX -11536559 01 DY -66550951 00 DZ -14750169 00
INC -17339225 03 LAN -10296412 03 APF -53759360 02 MX -47390971 00 MY -88003799 00 MZ -30622778-01
WX -11211730 00 WY -25810384-01 WZ -49335722 00 PX -64813837 00 PY -75584742 00 PZ -92792662-01
QX -75322326 00 QY -65423562 00 QZ -68015082-01 RX -95269299-01 RY -55078411-01 RZ -99392658 00
BX -49700623 00 BY -86709756 00 BZ -33565826-01 TX -50050873 00 TY -86573149 00 TZ -00000000 00
SXI -86047355 00 SYI -49746893 03 SZI -11004446 00 DAI -63179018 01 RAI -30033660 02
SKD -36311845 00 SYD -92946225 00 SZD -65134337-01 DAD -37345664 01 RAD -24866061 03
ETE -17201818 03 ETS -85493964 01 ETC -25547064 03

T VECTOR IN ORBIT PLANE OF TARGET
BTO -11053411 04 BRO -37349652 02 B -11059719 04 THA -17806470 03 T VECTOR IN ORBIT PLANE OF TARGET

ALL VECTORS REFERENCED TO TRUE TARGET EQU. PLANE
X -34936237 05 Y -18302078 05 Z -66702965 04 DX -11536559 01 DY -64312123 00 DZ -22595300 00
INC -16946995 03 LAN -14215389 03 APF -93335740 02 MX -47390972 00 MY -87739360 00 MZ -7473352-01
WX -11211732 00 WY -14430088 00 WZ -98315922 00 PX -64813837 00 PY -73934828 00 PZ -18242840 00
QX -75322326 00 QY -65767596 00 QZ -10632943-01 RX -14726263 00 RY -82277774-01 RZ -98566932 00
BX -49700608 00 BY -86489750 00 BZ -70265847-01 TX -48774886 00 TY -87298399 00 TZ -00000000 00
SXI -86047355 00 SYI -48075910 00 SZI -16686881 00 DAI -97115931 01 RAI -29192725 02
SKD -36311845 00 SYD -91502409 00 SZD -17570977 00 DAD -10119965 02 RAD -24835482 03
ETE -17804142 03 ETS -14572628 02 ETC -26149387 03

T VECTOR IN TRUE TARGET EQU. PLANE
BTO -11031585 04 BRT -78841964 02 B -11059723 04 THA -18408793 03 T VECTOR IN TRUE TARGET EQU. PLANE
2 DAYS 10 HRS. 46 MIN. 13.046 SEC. 23561036453202453712157 J.D.= 2438045.72794378 JAN. 16,1963 05 28 14.343

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EARTH-MOON FINE PRINT CHECK 1

\*\*\*\*\* S/C DISCONTINUITY=R STOP

2 DAYS 14 HRS. 46 MIN. 13.045 SEC.

235610373553202453700262 J.D.= 2438045.89461044 JAN. 16,1963 09 28 14.343

GEOCENTRIC

EQUATORIAL COORDINATES

X -.38002094 06 Y -.84781086 05 Z -.20042063 04 DX -.10510077 01 DY -.30554540 00 DZ .14315054 00
R .38936841 06 DEC -.29492244 00 RA .19257649 03 V .11038421 01 PTH .81444086 02 AZ .24997337 02
LAT -.29492244 00 LDN .29541755 03 VE .28344867 02 PTE .22070219 01 AZE .27030094 03
XS .63429640 08 YS -.12182636 03 ZS -.52826378 08 DXS .27367567 02 DYS .11868919 02 DZS .51470765 01
XM -.39663938 06 YM -.75786597 05 ZM .52648548 04 DXM .15087609 00 DYM -.88926003 00 DZM -.35112140 00
XT -.39663938 06 YT -.75786597 05 ZT .52648548 04 DXT .15087609 00 DYT -.88926003 00 DZT -.35112140 00
RS .14715653 04 VS .30271230 02 KM .40384914 06 VM .96790145 00 VT .40364914 06 VI .96790145 00
GED -.29649324 00 ALT .38294020 06 LOS .40345138 02 RAS .29750409 03 RAM .19081722 03 LOM .29365827 03
DUT .35000000 02 DT .24000000 03 OR .10915691 01 SMA .37812480 06 DES -.21037321 02 DEM .74696826 00
CCL .27765387 03 MCL .34791761 03 TCL .34791761 03

GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235610222710202757100262 J.D.= 2438043.41004477 JAN. 13,1963 21 50 27.868
SMA .48084759 06 ECC .98928614 00 B .70198728 05 SLR .10248266 05 APD .95654345 06 RCA .51517305 04
VM .66817385-01 C3 -.82895419 00 C1 .63913734 05 IFF .21466647 06 TF .31407142 01 PER .55305814 05
TA .1678093d 03 MTA .14000000 03 EA .78912623 02 MA .23288669 02 C3J .-13116060 01 TFI .62770290 02

HELIOCENTRIC

EQUATORIAL COORDINATES

X -.63809861 08 Y .12174157 04 Z .52824374 08 DX -.28414574 02 DY -.12174465 02 DZ -.50039259 01
R .14725191 09 LAT .21022512 02 LON .11766091 03 V .31318880 02 PTH .83140136 00 AZ .10018118 03
XE -.63429640 08 YE .12182636 03 ZE .52826378 08 DXE -.27367567 02 DYE -.11868919 02 DZE -.51470765 01
XT -.63826480 08 YT .12175057 04 ZT .52831643 08 DXT -.27216691 02 DYT -.12758179 02 DZT -.54981980 01
LTE .21037321 02 LUE .11750409 03 LTT .21022962 02 LOT .11766531 03 RST .14726915 09 VST .30557316 02
EPS .76352275 02 FSP .14720910 06 SEP .10386259 03 EPM .13463025 03 EMP .43325136 02 MEP .20445681 01
MPS .14840544 03 MSP .27453912-18 SMP .31590432 02 SEM .10582256 03 EMS .74026270 02 ESM .15130585 00
RPM .20246402 05 SPN .75111707 02 SIP .14348069 03 CPT .88131122 02 SIN .83206373 02
GCE .82346128 02 GCT .25026394 03 CPE .86121167 02 CPS .10388202 03

HELIOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235607545134202032700262 J.D.= 2438036.25833576 JAN. 6,1963 18 12 00.210
SMA .16151695 09 ECC .89494149-01 B .1608853 09 SLR .16027333 09 APD .17597177 09 RCA .14706212 09
VM .26244653 02 C3 -.82167296 03 C1 .46112792 10 IFF .83257413 06 IF .-16850030 03 PER .40976487 03
TA .10162288 02 MTA .18000000 03 EA .92940971 01 MA .84659742 01

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EARTH-MOON FINE PRINT CHECK 1

SELENOCENTRIC

EQUATORIAL COORDINATES

X .16618444 05 Y -.89944889 04 Z -.72690611 04 DX -.12018839 01 DY .58371463 00 DZ .49427194 00
R .20246302 05 DEC -.21040731 02 RA .33157618 03 V .14246235 01 PTH .-87529320 02 AZ .25302177 03
LAT .20246302 05 LAT .-94878634 01 LON .31171710 03 VP .14278818 01 PTP .-85408334 02 AZP .72778094 03
LTS .88137612-01 LNS .28692690 03 LTF .-64515772 01 LNE .63822898 00 DP .17379452-03 ASD .49247490 01
ALT .18508212 05 SHA .10605897 05 ALP .14520479 02 DR .-14232992 01
HGE .28394972 03 SVL .-62957729 01 HNG .14897526 03 STA .12970550 03

SELENOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235610401415202320260262 J.D.= 2438046.03247754 JAN. 16,1963 12 46 45.628
SMA .-31727021 04 ECC .10485194 01 B .10002417 04 SLR .31534426 03 APD .00000000 00 RCA .15393765 03
VM .12430623 01 C3 .15452535 01 C1 .12433889 04 IFF .-11911285 05 TF .66078980 02 LTF .66045389 02
TA .-15986263 03 MTA .16250168 03 EA .-15126076 03 MA .26739410 03 C3J .-13116060 01 TFI .62770290 02
ZAE .13429839 03 ZAP .14581398 03 ZAC .88732473 02 DEF .14500336 03 IR .37483117 04 GP .63427407 01

X .16618444 05 Y -.89944889 04 Z -.72690611 04 DX -.12018839 01 DY .58371463 00 DZ .49427194 00
INC .15321724 03 LAN .20119881 03 APF .32661050 02 MX .-54744332 00 MY .-79121388 00 MZ .-22523750 00
WX .-16249502 00 WY .42025195 00 WZ .-89264283 00 PX .-95910610 00 PY .14470649 00 PZ .24325823 00
QX .23139848 06 QY .89579032 06 QZ .37948080 00 RX .-31177721 00 RY .15027412 00 RZ .-93819647 00
BX .-50907499 00 HY .-81083225 00 HZ .-28877969 00 TX .43418492 00 TY .90082183 00 TZ .00000000 00
SXI .-84514787 00 SYI .40735452 00 SZI .34610308 00 DAI .20249146 02 RAI .15426630 03
SXO .98430058 00 SYO .13133390 00 SZO .-11790022 00 DAD .-67709355 01 RAO .76000107 01
ETE .15594766 03 FTS .15210166 03 ETC .23886763 03

BTO .-95168005 03 BRIC .30787735 03 B .10002417 04 THA .16207312 03 T VECTOR IN EARTH EQUATOR PLANE

X .16618444 05 Y -.11143933 05 Z .30907656 04 DX -.12018839 01 DY .73217098 00 DZ .22175359 00
INC .17054289 03 LAN .25942100 03 APF .92840074 02 MX .-54744185 00 MY .-83432765 00 MZ .64728207-01
WX .-16249562 00 WY .30441734-01 WZ .-98614959 00 PX .-95910566 00 PY .22953790 00 PZ .18561035 00
QX .-23139848 00 QY .47281819 00 QZ .82158124-02 RX .13301820 00 RY .80492879-01 RZ .-98783953 00
SX .-50907436 00 SY .-95879096 00 SZ .57631531-01 TX .51771731 00 TY .85551174 00 TZ .00000000 00
SXI .-84514787 00 SYI .51142164 00 SZI .11594765 00 DAI .89444348 01 RAI .14882074 03
SXO .98429932 00 SYO .73589302-01 SZO .-16041714 00 DAD .-92311107 01 RAO .42756565 01
ETE .-17271913 03 FTS .13371134 02 ETC .26013909 03

BTC .-99853791 03 BRIC .-58355204 02 B .10002416 04 THA .18334460 03 T VECTOR IN ECLIPTIC PLANE

X .-17098265 05 Y .-91911945 04 Z .-22553648 04 DX .12302910 01 DY .70081077 00 DZ .15747996 00
INC .17352715 03 LAN .10823258 03 APF .60970128 02 MX .-45500501 00 MY .89032078 00 MZ .-17430032-01
WX .10707021 00 WY .35277303-01 WZ .-99362541 00 PX .67334498 00 PY .73272645 00 PZ .98586406-01
QX .73131175 00 QY .-67961122 00 QZ .5414546-01 RX .95832279-01 RY .54966310-01 RZ .-99387883 00
BX .-49522171 00 BY .86847419 00 BZ .-22540140-01 TX .49752356 00 TY .-86745047 00 TZ .00000000 00
SXI .86214066 00 SYI .49447814 00 SZI .11047579 00 DAI .63427449 01 RAI .29836292 02
SXO .-42223374 00 SYO .-90316310 00 SZO .-17573140-01 DAD .-44490835 01 RAO .24499367 03
ETE .17271913 03 FTS .87290175 01 ETC .25949498 03

BTO .-99998402 03 BRIC .22684500 02 B .10002413 04 THA .17870047 03 T VECTOR IN ORBIT PLANE OF TARGET

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EARTH-MOON FINE PRINT CHECK 1

ALL VECTORS REFERENCED TO TRUE TARGET EQU. PLANE
X -1.7896265 05 Y -88558833 04 Z -33373731 04 DX -12302910 01 DY -67697488 00 DZ -24008477 00
INC -16920170 03 LAN -14514047 03 APF -98247516 02 MX -45500505 00 MY -88602568 00 MZ -89070395-01
WX -10709124 00 WY -15374302 00 WZ -98229283 00 PX -67334490 00 PY -71569852 00 PZ -18542637 00
QX -73153197 00 QY -98128015 00 QZ -26877340-01 RX -14761624 00 RY -81798305-01 RZ -98565638 00
SX -49522192 00 SY -86694594 00 SZ -81386615-01 TX -48468854 00 TY -87468681 00 TZ -00000000 00
SRI -86214664 00 SYI -87773635 00 SZI -16878468 00 DAI -97160038 01 RAI -28992065 02
SXD -42223309 00 SYD -88742492 00 SZD -18492740 00 DAD -10656900 02 RAD -24455508 03
ETE -17861689 03 ETS -14764895 02 ETC -26153066 03

BTT -49682568 03 BRT -82590847 02 B -10002413 04 THA -18473635 03 T VECTOR IN TRUE TARGET EQU. PLANE
2 DAYS 17 HRS. 56 MIN. 20.068 SEC. 23561640121720256565164 J.D.= 2438046.02663616 JAN. 16,1963 12 38 21.365

GEOCENTRIC EQUATORIAL COORDINATES
X -39370375 06 Y -87062974 05 Z -51784053 03 DX -19409183 01 DY -41802673 00 DZ -64834569 00
R -40321566 06 DEC -73565041-01 RA -19246961 03 V -20886029 01 PTH -59831455 02 AZ -30798739 03
R -40321566 06 LAT -73585041-01 LON -24765127 03 VE -30290947 02 PTE -34175406 01 AZE -27122424 03
RS -63741659 08 VS -12169063 09 ZS -52767523 08 DXS -27337696 02 DVS -11926830 02 DZS -51721553 01
RM -39475965 06 YR -85897950 05 ZR -12583334 04 JRM -17863677 00 DYM -88345073 00 DZM -35129676 00
XT -39475985 06 YX -85897950 05 ZT -12583334 04 DXT -17863677 00 DYT -88345073 00 DZT -35129676 00
RS -14715993 09 VS -30271275 02 RM -40399923 06 VM -96737050 00 KT -40399923 06 VT -96737050 03
GED -74086506-01 ALT -39683745 06 LOS -35282732 03 RAS -29764565 03 RAM -19227594 03 LOM -24756760 03
DUT -35000000 02 IT -30000000 02 UR -18057034 01 SHA -39094342 06 DES -21012561 02 DEM -17846004 00
GCL -27800318 03 MCL -33402653 03 TCL -33402653 03

GEOCENTRIC CONIC
EPOCH OF PERICENTER PASSAGE 235610252335202634765164 J.D.= 2438043.96604659 JAN. 14,1963 11 13 59.226
SMA -16711740 06 ECC -19206555 01 B -27403774 06 SLR -44936490 06 APD -00000000 00 RCA -15385755 06
WH -19443942 01 C3 -23851533 01 C1 -42322232 06 TFP -17786214 06 TF -16532758 02 LTF -30851336 01
TA -86583683 02 MTA -12137624 03 EA -67455208 02 MA -94176516 02 C3J -12929574 01 TFI -65938907 02

HELIOCENTRIC EQUATORIAL COORDINATES
X -64135562 08 Y -12160357 09 Z -52768041 08 DX -29278615 02 DY -11508803 02 DZ -44523809 01
R -14725917 09 LAT -20997946 02 LON -11780784 03 V -31782930 02 PTH -29341340 01 AZ -99923428 02
XE -63741659 08 YE -12169063 09 ZE -52767523 08 DXE -27337696 02 DYE -11926830 02 DZE -51721553 01
XT -64136618 08 YT -12160474 04 ZT -52768782 08 DXT -27159060 02 DYT -12810280 02 DZT -55234521 01
LFE -21012961 02 LOE -11764566 03 LTF -20998002 02 LOT -11780800 03 RST -14726086 09 VST -30523282 02
EPS -75679693 02 ESP -15211196 00 SEP -10417224 03 EPM -11668619 03 EMP -63093561 02 MEP -22017590 00
MPS -16612275 03 MSP -00000000 00 SMP -13877082 02 SEM -10439096 03 EMS -75656784 02 ESM -15211196 00
RPM -17380899 04 SPN -74769311 02 SIP -76122749 02 CPT -84107641 02 SIN -58923587 01
GCE -81996811 02 GCN -23602335 03 CPE -85891898 02 CPS -10387388 03

HELIOCENTRIC CONIC
EPOCH OF PERICENTER PASSAGE 235606420414202544565164 J.D.= 2438022.11540262 DEC. 23,1962 14 46 10.787

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EARTH-MOON FINE PRINT CHECK 1

SMA -16750454 09 ECC -13111141 06 B -16605843 09 SLR -16462511 09 APD -18946630 09 RCA -14554278 09
WH -24670310 02 C3 -79230154 03 C1 -46741923 13 TFP -20659306 07 TF -432793069 03 PER -427793069 03
TA -25914514 02 MTA -18000000 03 EA -22802370 02 MA -19891018 02 C3J -12929574 01 TFI -65938907 02
SELENCENTRIC EQUATORIAL COORDINATES
X -10560991 04 Y -11650243 04 Z -74049290 03 DX -21195550 01 DY -13014775 01 DZ -99964245 00
R -17380699 04 UEC -25216403 02 RA -31219243 03 V -26880648 01 PTH -74743889 02 AZ -26078864 03
R -17380697 04 LAT -73609024 01 LON -29706478 03 VP -26818005 01 PTP -74650484 02 AZP -27793069 03
LTS -65465302-01 LNS -28532264 03 LIE -65132043 01 LME -67274375 00 DP -23251989-01 ASD -90000000 02
ALT -45776367-04 SMA -41686305 03 ALP -30377679 02 DR -25861384 01 HNG -16747764 03 SIA -26686194 02
HGE -24432435 03 SVL -60294826 01 HNG -16747764 03 SIA -26686194 02

HELIOCENTRIC CONIC
EPOCH OF PERICENTER PASSAGE 23561040C1415202155327764 J.D.= 2438046.C3246359 JAN. 16,1963 12 46 44.855
SMA -31747777 04 ECC -10471702 01 B -98656127 03 SLR -30657376 03 APD -00000000 00 RCA -14975489 03
WH -12426759 01 C3 -15442438 01 C1 -12259161 04 TFP -50348978 03 TF -66076766 02 LTF -66046055 02
TA -14186097 03 MTA -16273738 03 EA -53987633 02 MA -11291661 02 C3J -12929574 01 TFI -65938907 02
ZAE -13770351 03 ZAP -14599427 03 ZAC -88726667 02 DEF -14547475 03 IR -37492740 04 GP -63501737 01

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE
X -10560991 04 Y -11650243 04 Z -74049290 03 DX -21195550 01 DY -13014775 01 DZ -99964245 00
INC -15325757 03 LAN -20135351 03 APF -33086642 02 MA -77714300 00 MY -61243373 00 MZ -14482228 00
WX -16384731 00 WY -41908968 00 WZ -89303848 00 PX -49784397 00 PY -14897102 00 PZ -24564717 00
QX -23598499 00 QY -89564019 00 QZ -37701409 00 RX -31196700 00 RY -15070544 00 RZ -93806617 00
BX -50959702 00 BY -81108836 00 BZ -28713506 00 TX -43496463 00 TY -90043788 00 TZ -00000000 00
SXI -84466851 00 SYI -40804349 00 SZI -34664513 00 DAI -20271038 02 RAI -15421568 03
SXD -98472650 00 SYD -12352237 00 SZD -12270225 00 DAD -70480841 01 RAD -71497390 01
ETE -15635654 03 ETS -35220839 03 ETC -23888631 03

T VECTOR IN EARTH EQUATOR PLANE
BTQ -93920787 03 BRQ -30197967 03 B -98656127 03 THA -16217605 03 T VECTOR IN EARTH EQUATOR PLANE
ALL VECTORS REFERENCED TO ECLIPTIC PLANE
X -10560991 04 Y -13634529 04 Z -21588749 03 DX -21195550 01 DY -15917410 01 DZ -39936096 00
INC -17041953 03 LAN -25988900 03 APF -93589395 02 MX -77714299 00 MY -61949734 00 MZ -11077731 00
WX -16384732 00 WY -29218065-01 WZ -98605283 00 PX -49784399 00 PY -23440102 00 PZ -16610562 00
QX -23598494 00 QY -97170070 00 QZ -10419622-01 RX -13299074 00 RY -80643914-01 RZ -98783097 00
BX -50959710 00 BY -85837021 00 BZ -5924332-01 TX -15950509 00 TY -82507394 00 TZ -00000000 00
SXI -84466852 00 SYI -51219637 00 SZI -1555128 00 DAI -89476109 01 RAI -14876790 03
SXD -98472653 00 SYD -64511701-01 SZD -16171536 00 DAD -43064775 01 RAD -37482217 01
ETE -17762070 03 ETS -13470561 02 ETC -26014847 03

T VECTOR IN ECLIPTIC PLANE
BTC -98478553 03 BRC -59166277 02 B -98656128 03 THA -18343822 03 T VECTOR IN ECLIPTIC PLANE
ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET
X -17072627 04 Y -26328510 03 Z -19260247 03 DX -24311512 01 DY -10884874 01 DZ -30056464 00
INC -17353626 03 LAN -10897661 03 APF -62006959 02 MX -15457317 00 MY -98778217 00 MZ -19830499-01
WX -10645493 00 WY -36606773-01 WZ -99364332 00 PX -67707782 00 PY -72916713 00 PZ -99402598-01
QX -72817092 00 QY -68335567 00 QZ -52837809-01 RX -96003769-01 RY -54924237-01 RZ -99386647 00
BX -49444642 00 BY -86495537 00 BZ -20959839-01 TX -49658148 00 TY -86799011 00 TZ -00000000 00
SXI -86266493 00 SYI -49353469 00 SZI -11060468 00 DAI -63501754 01 RAI -29774086 02
SXD -43049277 00 SYD -89910845 00 SZD -79245274-01 DAD -45451852 01 RAD -24441491 03

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CASE 1

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EARTH-MOON FINE PRINT CHECK 1

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ETE -.17297407 03  ETS .88239332 01  ETC .25550184 03
BTD -.98634243 03  BRC .20805829 02   B .98656184 03  THA .17879158 03  T VECTOR IN ORBIT PLANE OF TARGET

      ALL VECTORS REFERENCED TO TRUE TARGET EQU. PLANE
X -.17072627 04  Y -.23838514 03  Z -.22268204 03  DX .24311512 01  DY .10447752 01  DZ .42847257 00
INC .16915018 03  LAN .14553108 03  APF .98928698 02  MX -.15457314 00  MY .97833566 00  MZ .13771661 00
WX .10645491 00  WY .15907303 00  WZ -.98215024 00  PX .67707777 00  PY .71206567 00  PZ .18581723 00
QX .72817097 00  QY -.68477315 00  QZ -.29193567-01  RX .14772316 00  RY .81644573-01  RZ -.98565308 00
BX -.49444650 00  BY .86523426 00  BZ .83020126-01  TX .48372284 00  TY -.87522124 00  TZ .00000000 00
SXI .86266451 00  SYI .47678290 00  SZI .16878379 00  DAI .97171146 01  RAI .28928827 02
SXD -.43049266 00  SYD -.88319800 00  SZD -.18611027 00  DAD -.10725871 02  RAD .244401424 03
ETE .17901415 03  ETS .14864007 02  ETC .26154192 03

BTD -.986305602 03  BRT -.83096680 02   B .98656181 03  THA .18483166 03  T VECTOR IN TRUE TARGET EQU. PLANE
215563036320  214523646526  612554325025  603416475431  204420666560  603534774303  EARTH
                630101318                4201297                000000000000  INITIAL
213406755133  613444001540  612567723572  602416525766  201516557516  201400455161  MOON
                235610401217  202256565164  END
    
```

END TRAJECTORY (SFPRC) 016405 G

B. Check case 2 is an Earth-Venus trajectory made during the Mariner II mission. The spacecraft injects near Earth-Sun phase change on September 5, 1962 and encounters Venus 100.81 days later with a miss of 41,000 km. Radiation pressure was included as a perturbation on the spacecraft.

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START TRAJECTORY (SFPRO) 016405 G

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

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EARTH-VENUS, RADIATION PRES. ON

CHECK 2

DOUBLE PRECISION EPHEMERIS TAPE - EPHEM1  
S/C EPHEMERIS WRITTEN 016311G 041765 HUNID=(TRAJJC2)

GME .39860063 06 J .16234500-02 H -.57499999-05 D .78749999-05 KE .63781650 04 REM .63783112 04  
G .66709998-19 A .88781796 29 H .88800194 29 C .88836976 29 DME .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 .79200000-02 HA .00000000 00 DA .00000000 00 RA .34170000 04  
RADIATION PRESSURE INPUT  
ARA .36300000 01 GB .36300000 00 MAS .19822000 03 GBI .00000000 00 GB2 .00000000 00 SC .10200000 09  
INJECTION CONDITIONS 1950.0 VENUS 235575400641202000000000 J.D.= 2437912.51634260 SEPT. 5,1962 00 23 32.000

GEOCENTRIC X0=-.14297030 07 Y0=-.19355307 07 Z0=-.99998901 05 DX0=-.17513577 01 DY0=-.24185118 01 DZ0=-.10838549 00  
CARTESIAN TO .14120000 04 GMA .34951873 03 GHO .34361929 03  
DATE OF RUN 041765G 016411 EARTH IS THE CENTRAL BODY FOR INTEGRATION COWELL EQUATIONS OF MOTION

0 DAYS 0 HRS. 0 MIN. 0.000 SEC. 235575400641202000000000 J.D.= 2437912.51634260 SEPT. 5,1962 00 23 32.000

GEOCENTRIC

EQUATORIAL COORDINATES

X -.14242090 07 Y -.19394898 07 Z -.10167162 06 DX -.17445130 01 DY -.24233611 01 DZ -.11043330 00  
K .24081872 07 DEC -.24194955 01 RA .23370936 03 V .29880094 01 PTH .89380513 02 AZ .60890359 02  
R .24081872 07 LAT -.24194955 01 LON .24419063 03 VE .17546301 03 PTE .97569593 00 AZE .27000513 03  
XS -.14343227 09 YS .42810504 08 ZS .18564279 08 OXS -.87218609 01 OYS -.25899198 02 OZS -.11230749 02  
XM -.27632910 06 YM -.27943325 06 ZM -.81923071 05 OXM .72901663 00 OYM -.58854660 00 OZM -.27195625 00  
XT -.88131502 08 YT -.41412272 08 ZT -.22861356 08 OXT .21205738 02 OYT -.90988719 01 OZT -.55559089 01  
XS .15081166 09 YS .29546049 02 ZS .40143479 06 RMS .97560880 00 RT .10003094 00 VT .23734804 02  
GEO .24359660 01 ALT .24020091 07 LOS .17386238 03 RAS .16338111 03 RAM .22532043 03 LOM .23580169 03  
DUT .35000000 02 DT .38400000 04 TDR .29878348 01 SHA -.22746660 07 DES .70698621 01 DEM -.11775395 02  
CCL .60726652 02 PCL .18216895 03 TCL .33871826 03

GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235574613015202240000000 J.D.= 2437903.65617187 AUG. 27,1962 03 44 53.250  
SMA -.46366060 05 ECC .11521704 01 H .26532655 05 SLR .15184072 05 APO .00000000 00 RCA .70552370 04  
VH .29320965 01 C3 .85971898 01 C1 .77797048 05 TFP .76551875 06 TF -.88601705 01 LTF -.88860944 01  
TA .14959398 03 MTA .15021865 03 EA .25901344 03 MA .27738007 04 TFI .00000000 00

X -.14242090 07 Y -.19394898 07 Z -.10167162 06 DX -.17445130 01 DY -.24233611 01 DZ -.11043330 00  
INC .29204827 02 LAN .23804503 03 APF .20544248 03 MX .69203649 00 MY .53365594 00 MZ .48603182 00  
WX -.41391320 00 WY .25820200 00 WZ .87288096 00 PX .15975404 00 PY .96464240 00 PZ -.20958780 00  
QX .89613328 00 QY .52662815-01 QZ .44054734 00 RX .21561010-01 RY .29956756-01 RZ .99931861 00  
BX .69847200 00 BY .52485563 00 BZ .48648066 00 TX .81163524 00 TY .58416457 00 TZ .00000000 00  
SXI .30645677 00 SYI .86339653 00 SZI .40077204 00 DAI .23623387 02 RAI .10954197 03  
SXO .38376653 00 SYO .81108220 00 SZO .36909137-01 DAO .21152174 01 RAO .23425600 03

BTQ .25271185 05 BRQ .80586099 04 B .26532655 05 THA .34231852 03 T VECTOR IN EARTH EQUATOR PLANE

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

2

EARTH-VENUS, RADIATION PRES. ON

CHECK 2

HELIOCENTRIC

ECLIPTIC COORDINATES

X .14200807 09 Y -.48482164 08 Z .67773075 06 DX .69773480 01 DY .25962118 02 DZ .86299610 00  
R .15005575 09 LAT .25877623 03 LON .34114987 03 V .26897207 02 PTH .37969414 01 AZ .88140099 02  
XE .14343227 09 YE -.46662315 06 ZE .58024999 03 OXE .87218609 01 OYE .28229385 02 OZE .22423267-03  
XT .55292774 08 YT .93751323 06 ZT .44498112 07 OXT .29927599 02 OYT .17671232 02 OZT .14772718 01  
LFE .22041709-03 LDE .34197892 03 LIT .23874050 01 LOT .30053131 03 LST .10893507 09 VSI .34786721 02  
EPS .10831392 03 ESP .86857472 00 SEP .70817518 02 EPM .24705000 01 EMP .16501275 03 MFP .12516769 02  
MPS .10696074 03 MSP .73425371 00 SMP .72305031 02 SEM .64412562 02 EMS .11544974 03 ESM .13759044 00  
EPT .14907056 03 ETP .70903655 00 TEP .30220393 02 TPS .46474513 02 TSP .40692629 02 STP .92832855 02  
SET .46190403 02 STE .92306648 02 EST .41502947 02 RPM .20183694 07 RPT .97957366 08 SPN .10816219 03  
GCE .29927335 03 GCF .97991816 02 GCP .46470888 02 GPT .90244641 02 SIN .90241014 02  
REP .24081872 07 VEP .29880094 01 CPE .65410268 02 CPS .82023973 02

HELIOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235607570307202040000000 J.D.= 2438036.71366030 JAN. 7,1963 05 07 40.250  
SMA .12645262 09 ECC .19329432 00 H .12455836 03 SLR .12220933 09 APO .15149183 09 RCA .10241340 09  
VH .26384071 02 C3 .10453830 04 C1 .40272697 10 TFP .10730648 08 TF .12419732 03 PER .28554204 03  
TA .16376221 03 MTA .18000000 03 EA .16031381 03 MA .15658301 03 TFI .00000000 00

X .14200807 09 Y -.48482164 08 Z .67773075 06 DX .69773480 01 DY .25962118 02 DZ .86299610 00  
INC .18778048 01 LAN .33323168 03 APF .17168459 03 MX .32278481 00 MY .94591575 00 MZ .3245293-01  
WX .14758198-01 WY .29256456-01 WZ .99946298 00 PX .81834786 00 PY .57470330 00 PZ .47389873-02  
QX .57453331 00 QY .81783845 00 QZ .32423542-01 RX .38781845-02 RY .27235427-02 RZ .99998854 00  
BX .57453331 00 BY .81783845 00 BZ .32423550-01 TX .45470988 00 TY .81835723 00 TZ .00000000 00  
DAP .27152963 00 RAP .14492068 03

BTQ .12449287 09 BRQ .40386688 07 B .12455836 09 THA .35814192 03 T VECTOR IN ECLIPTIC PLANE

0 DAYS 0 HRS. 4 MIN. 10.114 SEC. 235575400737202416430016 J.D.= 2437912.51923743 SEPT. 5,1962 00 27 42.114

EXTREME ELEVATION

11 GOLDSTONE

HELIC

R .24091445 07 LAT-.24194033 01 LON .24314580 03 DEC-.25121188 01 ELE .52279807 02 AZI .18002709 03  
MIN .41889607 01 HA .90277709-02 DEC .33881390 03 PSS .70830197 02 PSM .13006480 02  
CKL .60822521 02 CAM .18226588 03 DGE .48975676-06 DEL-.13432677-10 DAZ .20703512-02  
UT .69476011-01 DHA .41864582-02 DNG .29877987 01 ODR .27545438-04 SLS .21971309 03  
ET .59753790-01 HGE .24040910 07 RHI .24315082 03 SP5 .10830272 03 PDL .26163253 03  
NDI .63720340 04 PHI .35208070 02 TH1 .96004999 09 RF2 .29668212 08 FA .90004999 09  
DT .80191811 01 KFB .96004999 09 F2 .11913614 06 XA .29668507 08 PKA .23370951 03  
DF1 .59564071 05 F1 .88568071 05 DNP .17641262 00 DF1 .88211004-01 DF2 .17642201 00  
D1 .29522690 04 D2 .39712047 04

0 DAYS 5 HRS. 31 MIN. 11.877 SEC. 235575412410202760217776 J.D.= 2437912.74634117 SEPT. 5,1962 05 54 43.877

END OF VIEW PERIOD



JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

3

EARTH-VENUS, RADIATION PRES. ON

CHECK 2

11 GOLDSTONE

HADEC

R .24677288 07 LAT-.24121658 01 LON .16117712 03
MIN .33119795 03 HA .82093542 02 DEC-.24981126 01
CKC .60774648 02 CKM .18229802 03 CKT .33874847 03
UT .55199657 01 UHA .41785403-02 DDE .84879161-06
ET .55102495 01 HGE .24671653 07 DKG .33601944 01
RDI .63720340 04 PHI .35208070 02 TH1 .28315082 03
DT .82295764 01 RFB .98004999 09 RFI .96004999 09
BF1 .60760625 05 F1 .89760625 05 F2 .12152125 06
D1 .29920208 04 D2 .40567083 04 DDP .23330112-01

0 DAYS 8 HRS. 31 MIN. 27.578 SEC. 235575417630202712017425 J.D.= 2437912.87152289 SEPT. 5,1962 08 54 59.578

GEOCENTRIC

EQUATORIAL COORDINATES

X -.14777297 07 Y -.20137724 07 Z -.10504899 06 DX -.17436422 01 DY -.24178359 01 DZ -.10967355 00
R .24999999 07 DEC -.24082530 01 RA .73372834 03 V .29829929 01 PTH .89438460 02 AZ .57581176 02
LON .11599464 03 LAT -.24082530 01 LON .11599464 03 VE .18214160 03 PTE .93834846 00 AZE .27000494 03
KS -.14369731 09 YS .42014938 08 ZS .18219292 04 DXS -.85508244 01 DYS -.25948871 02 DZS -.11252379 02
MM -.25316542 06 YM -.29664618 06 ZM -.90016714 05 DXM .77970859 00 DYM -.53263596 00 DZM -.25524645 00
XT -.87488807 08 YT -.41689206 08 ZT -.23030191 08 DXT .21201135 02 DYT .88840181 01 DZT -.54473050 01
RS .15081815 09 VS .29547888 02 RM .40024329 06 VM .97816016 00 VT .99612185 08 VZ .23623466 02
GE0 -.24244551 01 ALT .24936217 07 LOS .45968165 02 LPS .16370187 03 RAM .22952170 03 LOM .11178800 03
DUT .35000000 02 DT .38400000 04 DR .29828497 01 SHA -.23566905 07 DES .69384518 01 DEM -.12997290 02
CCL .66634217 02 MCL .18219923 03 TCL .33859821 03

HELICENTRIC

ECLIPTIC COORDINATES

X .14221998 09 Y -.47664513 06 Z .70419224 06 DX .68071821 01 DY .26021667 02 DZ .86157906 00
R .15002239 09 LAT .26897968 00 LCN .34149433 03 V .26911098 02 PTH .38651443 01 AZ .88182988 02
XE .14369731 09 YS .45795169 08 ZL .57224999 03 DXL .85508244 01 DYL .28283563 02 DZL .30839443-03
XT .96208505 08 YT .93204504 08 ZT .45449275 07 DXT .29751959 02 DYT .17965735 02 DZT -.14630241 01
LTE -.2173763-03 LOE .34232334 03 LTT -.23911262 01 LOT .30109276 03 KST .10893636 09 VST .34786307 02
EPS .16859382 03 ESP .90013292 00 SEP .70505962 02 EPM .2145634 01 EMP .16647676 03 EMP .16647676 03
MPS .10809608 03 MSP .76239607 00 SMP .71139539 02 SEM .68344733 02 EMS .11151381 03 ESM .14127420 00
EPT .14925942 03 ETP .73501950 00 TEP .30005538 02 TPS .46484706 02 TSP .40448233 02 STP .93067058 02
SET .48186826 02 STE .92325719 02 EST .41287451 02 ESM .21091007 07 RPT .97455262 08 SPN .10844765 03
GEE .29386574 03 GCI .97964005 02 SIP .46481061 02 CPT .90265339 02 SIN .90261693 02
REP .24999599 07 VEP .29829929 01 CPE .65391742 02 CPS .82079078 02

0 DAYS 8 HRS. 31 MIN. 27.578 SEC. 235575417630202712017425 J.D.= 2437912.87152289 SEPT. 5,1962 08 54 59.578
CHANGE OF PHASE OCCURS AT THIS POINT SUN IS THE CENTRAL BODY FOR INTEGRATION COMELL EQUATIONS OF MOTION

0 DAYS 8 HRS. 31 MIN. 27.578 SEC. 235575417630202712017425 J.D.= 2437912.87152289 SEPT. 5,1962 08 54 59.578
\*\*\*\*\* S/C DISCONTINUITY STOP

10 DAYS 0 HRS. 0 MIN. 0.000 SEC. 235576246541202000000000 J.D.= 2437922.51634260 SEPT. 15,1962 00 23 32.000

CASE 1

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4

EARTH-VENUS, RADIATION PRES. ON

CHECK 2

GEOCENTRIC

EQUATORIAL COORDINATES

X -.29459900 07 Y -.39596962 07 Z -.18561650 06 DX -.18101584 01 DY -.22479060 01 DZ -.83382725-01
R .49388769 07 DEC -.21538386 01 RA .23335097 03 V .28873356 01 PTH .87750912 02 AZ .28278007 03
LON .23397583 03 LAT -.21538386 01 LON .23397583 03 VE .36001617 03 PTE .45916459 00 AZE .27000399 03
KS .14886689 09 YS .19932581 08 ZS .86430340 07 DXS .38169667 01 DYS -.26933975 02 DZS -.11680032 02
SM .39563800 06 YM .31766000 05 ZM .15071250 05 DXM .42791216-01 DYM .10293403 01 DJM .38498199 00
XT -.70143962 08 YT .46752834 08 ZT .26364873 08 DXT .20130531 02 DYT .33992767 01 DZT .25942826 01
RS .15043795 09 VS .29604584 02 RM .35139170 06 VM .11010743 01 RT .88323888 08 VT .20579691 02
GE0 -.21685026 01 ALT .49324987 07 LUS .17299827 03 RAS .17237341 03 RAM .51038925 01 LOM .57287521 01
DUT .35000000 02 DT .86399999 05 DR .28851114 01 SHA -.43277107 07 DES .32935974 01 DEM -.24168855 01
CCL .58092839 02 MCL .18001176 03 TCL .33497454 03

GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235574564071202614000000 J.D.= 2437903.11304506 AUG. 26,1962 14 42 47.094
SMA -.48756736 05 ECC .41369376 01 B .19572228 06 SLR .78567839 06 APO .00000000 00 RCA .15294684 06
VH .28592470 01 C3 .81752934 01 C1 .55961764 06 TFP .16764449 07 TF .-94032974 01 LTF .-96835464 01
TA .10172630 03 MTA .10398835 03 EA .22349110 03 MA .56328600 04

X -.29459900 07 Y -.39596962 07 Z -.18561650 06 DX -.18101584 01 DY -.22479060 01 DZ -.83382725-01
INC .16704291 03 LAN .22394338 03 APF .24862286 03 MX .-78739428 00 MY .-7545421 00 MZ .22105679 00
WX -.15560298 00 WY .16145056 00 WZ .-97453827 00 PX .89220446 00 PY .-40046986 00 PZ .20880220 00
QX .-42398222 00 QY .-90197513 00 QZ .-81732545-01 RX .18089977-01 RY .22456040-01 RZ .-99958414 00
BX .76329770 00 BY .-60662247 00 BZ .22236653 00 TX .-77874733 00 TY .-62733772 00 TZ .00000000 00
SX1 .-19574112 00 SY1 .-97203039 00 SZ1 .-12478141 00 DA1 .-74569622 01 RA1 .25861442 03
SX0 .-62707683 00 SY0 .-77842347 00 SZ0 .-28836106-01 DA0 .-16524148 01 RA0 .23114602 03

BTQ -.19236543 06 BRQ .36093665 05 B .19572228 06 THA .16937310 03 T VECTOR IN EARTH EQUATOR PLANE

HELICENTRIC

ECLIPTIC COORDINATES

X .14591490 09 Y -.25432466 06 Z .14052120 07 DX .20068083 01 DY .27261957 02 DZ .81851411 00
R .14817139 09 LAT .54356693 00 LON .35011285 03 V .27347971 02 PTH .56579202 01 AZ .88222545 02
XE .14886689 09 YS .-21725787 06 ZE .21093750 03 DXE .38169667 01 DYE .29357489 02 DZE .72395800-03
XT .78716934 08 YT .-75108355 06 ZT .-55886440 07 DXT .23947498 02 DYT .25206705 02 DZT .-10270783 01
LTE .60317629-04 LOE .35169668 09 LTT .-29406613 01 LOT .31634385 03 KST .1089427 09 VST .34788339 02
EPS .11713199 03 ESP .16742844 01 SEP .61193739 02 EPM .29980944 01 EMP .45491967 02 EMS .13154992 03
MPS .12009608 03 MSP .17042457 01 SMP .58205692 02 SEM .16725533 03 ESM .12714714 02 ESM .27976454-01
EPT .15400725 03 ETP .14042330 01 TEP .24588489 02 TPS .46490702 02 TSP .33935479 02 STP .99573822 02
SET .45688628 02 STE .98852535 02 EST .35458836 02 ESM .51828308 07 RPT .83858056 08 SPN .11705800 03
GCE .30190716 03 GCI .96885707 02 STP .46486466 02 CPT .90610493 02 SIN .90606257 02
REP .49388769 07 VEP .28873356 01 CPE .65333435 02 CPS .83681660 02

HELICENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235607601007202420000000 J.D.= 2438036.91812644 JAN. 7,1963 10 02 06.125
SMA .12714439 09 ECC .-19174311 00 B .12475574 09 SLR .12244098 09 APO .15148770 09 RCA .10274108 09
VH .26609980 02 C3 .-10440525 04 C1 .40310850 10 TFP .-98843141 07 TF .12440178 03 PER .28608802 03
TA .15471579 03 MTA .18000000 03 EA .-14952899 03 MA .-14395794 03 TFI .10000000 02

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

5

EARTH-VENUS, RADIATION PRES. ON

CHECK 2

ALL VECTORS REFERENCED TO ECLIPTIC PLANE

X .14591490 09 Y -.25432486 08 Z .14052120 07 DX .20068083 01 DY .27261957 02 DZ .81854111 00
INC .18587005 01 LAN .33311393 03 APF .17172312 03 MX .17133551 00 MY .98472437 00 MZ .31016013-01
WX -.14667433-01 WY -.28928543-01 WZ .99947385 00 PX -.81755167 00 PY .57583563 00 PZ .46691569-02
GX -.57566773 00 GY -.81705306 00 GZ -.32096611-01 QZ -.38173202-02 RX -.38173202-02 RY .26886973-02 RZ -.99998870 00
HX -.57566795 00 HY .81705337 00 HZ .32096624-01 TX .57584214 00 TY .81756091 00 TZ .00000000 00
DAP .26792399 00 RAP .14484137 03

BTC .12469147 09 BRC -.40042806 07 B .12475575 09 THA .35816066 03 T VECTOR IN ECLIPTIC PLANE
20 DAYS 0 HRS. 0 MIN. 0.000 SEC. 235577114441202000000000 J.D.= 2437932.51634260 SEPT. 25,1962 00 23 32.000

GEOCENTRIC

EQUATORIAL COORDINATES

X -.45979200 07 Y -.58249575 07 Z -.25234741 06 DX -.20370898 01 DY -.20667679 01 DZ -.75129389-01
R .74297728 07 DEC -.19475678 01 RA .23171426 03 V .29029138 01 PTH .83685803 02 AZ .27412054 03
R .74297724 07 LAT -.19475678 01 LON .22248273 03 VE .54147273 03 PTE .30530860 00 AZE .27000243 03
XS -.14498174 09 YS -.35242666 07 ZS -.15280271 07 DXS .12410339 01 DYS -.27232440 02 DZS -.21035767 02
XM -.32069800 06 YM .23379312 06 ZM .10962314 06 DXM -.65192327 00 DYM -.70124340 00 DZM -.21031082 00
XT -.53876485 08 YT -.47598874 08 ZT -.27452568 08 DXT .17300964 02 DYT .12471921 01 DZT .13377666-02
RS .15003292 09 VS .29707984 02 RM .40114597 06 VM .98029428 00 RT .76923876 08 VT .17425654 02
GED -.19608297 01 ALT .74188946 07 LOS .17211453 01 RAS .18134607 03 RAM .14270815 03 LOM .13347661 03
DUT .35000000 02 DT .86399999 05 DR .28853040 01 SHA .57189834 07 DES .58354574 00 DEM .15859237 02
CCL .54908527 02 MCL .17902846 03 TCL .32988437 03

HELIOCENTRIC

ECLIPTIC COORDINATES

X .14538582 09 Y -.16032803 07 Z .20856724 07 DX -.32781237 01 DY .27755994 02 DZ .75229430 00
R .14540962 09 LAT .82184592 00 LON .35936818 03 V .27959028 02 PTH .73417984 01 AZ .88339303 02
XE .14498374 09 YE .38412656 07 ZE .16750000 03 DXE .12410339 01 DYE .29682056 02 DZE .10052919-02
XT .96147257 08 YT .50746559 08 ZT .62519542 07 DXT .16139931 02 DYT .30825770 02 DZT .49840641 00
LFE .63966244-04 LOE .14670947 01 LFE .32912470 01 LOT .33217489 03 RST .10889718 09 VST .34799049 02
EPS .12737365 03 ESP .22540303 01 SEP .50372317 02 EPM .30935140 01 EMP .87329832 02 MEP .89576652 02
MPS .12438191 03 MSP .23480519 01 SMP .59270038 02 SEM .41534791 02 DSM .13836366 01 ESM .11580656 02
EPT .15635381 03 EIP .22187835 01 IEP .21427371 02 IPS .49843535 02 TSP .27490426 02 STP .10666604 03
SET .44126349 02 STE .10641343 03 EST .29460212 02 RPM .74331404 07 RPT .70064357 08 SPN .12732443 03
GCE .30507147 03 GCT .94975840 02 SGP .45838464 02 CPT .90458623 02 SIN .90453552 02
REP .74252728 07 VEP .65895949 02 CPE .65895949 02 CPS .85551184 02

30 DAYS 0 HRS. 0 MIN. 0.000 SEC.

235577762341202000000000 J.D.= 2437942.51634260 OCT. 5,1962 00 23 32.000

GEOCENTRIC

EQUATORIAL COORDINATES

X -.65251300 07 Y -.75245950 07 Z -.32267187 06 DX -.24711199 01 DY -.18707223 01 DZ -.94630717-01
R .99649270 07 DEC .18555933 01 RA .22906903 03 V .31008048 01 PTH .78063383 02 AZ .27032214 03
R .99649879 07 LAT .18555933 01 LON .20998124 03 VE .72692496 03 PTE .23911980 00 AZE .27000028 03
XS -.14670615 09 YS .26886199 08 ZS .11658137 08 DXS .63318504 01 DYS .26704604 02 DZS .11580656 02
XM -.68789000 05 YM .38469767 06 ZM .13060500 06 DXM .98580337 00 DYM .89724778-01 DZM .10839426 00
XT .44545242 08 YT .44982924 06 ZT .26523195 08 DXT .13416545 02 DYT .45558889 01 DZT .20502792 01
RS .14980440 09 VS .29788250 02 RM .39343938 06 VM .99579522 00 RT .66059772 08 VT .14316945 02
GED -.18682299 01 ALT .99586087 07 LOS .17129732 03 RAS .19038511 03 RAM .25931701 03 LOM .24022922 03
DUT .35000000 02 DT .86399999 05 DR .30337561 01 SHA .62315690 07 DES .44669387 01 DEM .19387606 02
CCL .50752467 02 MCL .18124768 03 TCL .32224025 03

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

6

EARTH-VENUS, RADIATION PRES. ON

CHECK 2

ECLIPTIC COORDINATES

X .14018102 09 Y .22273076 08 Z .76971427 07 DX -.88029703 01 DY .27353559 02 DZ .65822661 00
R .14196088 09 LAT .10886058 01 LON .90281427 01 V .28742699 02 PTH .87820086 01 AZ .88503715 02
XE .14670615 09 YE .29304966 08 ZE .34662500 03 DXE .63318504 01 DYE .29107516 02 DZE .81241129-03
XT .10624691 09 YT .22516788 08 ZT .64386654 07 DXT .70846950 01 DYT .34103020 02 DZT .69377898-01
LFE .13275111-03 LOE .11296306 02 LTT .33927342 01 LDT .34803441 03 RST .10879737 09 VST .34831217 02
EPS .13877656 03 ESP .25157991 01 SEP .38707620 02 EPM .13205653 01 EMP .14428713 03 MEP .34392275 03
MPS .13981677 03 MSP .23858315 01 SMP .37797382 02 SEM .68698255 02 EMS .11120126 03 ESM .14040588 00
EPT .15442746 03 EIP .37349310 01 IEP .21639737 02 IPS .44352715 02 TSP .21457743 02 STP .11419003 03
SET .41039022 02 STE .11546660 03 EST .23494375 02 RPM .98428862 07 RPI .56930815 08 SPN .13873989 03
GCE .30474753 03 GCT .91987786 02 SGP .44346476 02 CPT .89687298 02 SIN .89681058 08
REP .99649670 07 VEP .31008048 01 CPE .67054296 02 CPS .87620699 02

40 DAYS 0 HRS. 0 MIN. 0.000 SEC.

235600630241202000000000 J.D.= 2437952.51634260 OCT. 15,1962 00 23 32.000

GEOCENTRIC

EQUATORIAL COORDINATES

X -.89645493 07 Y -.90925694 07 Z -.43980175 06 DX -.32316775 01 DY -.18013380 01 DZ -.19977844 00
R .12776218 08 DEC .19727080 01 RA .22540614 03 V .37051949 01 PTH .73707002 02 AZ .26572977 03
R .12776217 08 LAT .19727072 01 LON .19646200 03 VE .93214765 03 PTE .21860020 00 AZE .26999523 03
XS .13904721 09 YS .49439307 06 ZS .21438519 08 DXS .11238484 02 DYS .25377741 02 DZS .11004352 02
XM .28497600 06 YM .23467350 06 ZM .67616500 05 DXM .70543373 00 DYM .76178503 00 DZM .33864570 00
XT .30873043 08 YT .40179650 06 ZT .24108129 08 DXT .86948352 01 DYT .62786870 01 DZT .34134866 01
RS .14917627 09 VS .29856808 02 RM .36035674 06 VM .10920779 01 RPI .56111333 03 VT .11254938 02
GED -.19811400 01 ALT .12769839 08 LOS .17062259 03 RAS .19956673 03 RAM .14529191 02 LOM .12580503 02
DUT .35000000 02 DT .86399999 05 DR .35563928 01 SHA .56965965 07 DES .82630526 01 DEM .10814954 07
CCL .41557154 02 MCL .17956780 03 TCL .30400056 03

HELIOCENTRIC

ECLIPTIC COORDINATES

X .13013264 09 Y .45370412 08 Z .32141952 07 DX -.14470161 02 DY .25928771 02 DZ .53328121 00
R .13785249 09 LAT .13360396 01 LON .19220979 02 V .29697999 02 PTH .49150500 01 AZ .88721579 02
XE .13049721 09 YE .53887430 08 ZE .37475000 03 DXE .11238484 02 DYE .27660902 02 DZE .61392783-04
XT .10822417 09 YT .74332876 07 ZT .61330476 07 DXT .25436489 01 DYT .34779311 02 DZT .63375914 00
LFE .14349377-03 LOE .21176789 02 LTT .32358661 01 LDT .39291406 01 RST .10885237 09 VST .34877962 02
EPS .15111731 03 ESP .23681655 01 SEP .26474337 02 EPM .26318715 00 EMP .93801988 01 MEP .17035640 03
MPS .15131390 03 MSP .24183492 01 SMP .26269723 02 SEM .19819700 03 EMS .21751701 02 ESM .51396029-01
EPT .14878112 03 EIP .67759441 01 IEP .28435940 02 IPS .41815304 02 TSP .15954735 02 STP .12222996 03
SET .33698980 02 STE .12676150 03 EST .17539519 02 RPM .3131621 08 RPT .44794839 08 SPN .15112370 03
GCE .31844284 03 GCT .87443398 02 SGP .61807374 02 CPT .88201058 02 SIN .88193128 02
REP .12776218 08 VEP .37051949 01 CPE .8895252 02 CPS .89872499 02

50 DAYS 0 HRS. 0 MIN. 0.000 SEC.

235601476141202000000000 J.D.= 2437962.51634260 OCT. 25,1962 00 23 32.000

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

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EARTH-VENUS, RADIATION PRES. ON

CHECK 2

GEOCENTRIC

EQUATORIAL COORDINATES

X	-12182598	08	Y	-10732624	08	Z	-71985549	06	DX	-42535830	01	DY	-20558822	01	DZ	-48200560	00
R	-16251865	08	DEC	-25386720	01	RA	-22137940	03	V	-47488892	01	PTH	-74116566	02	AZ	-25756036	03
R	-16251864	08	LAT	-25386720	01	LOA	-22137940	03	VE	-11852195	04	PTE	-22080635	00	AZE	-26998646	03
XS	-12735948	09	YS	-70529329	08	ZS	-30582920	08	DXS	-15878383	02	DYS	-23311213	02	DZS	-10107572	02
XM	-40167300	06	YM	-36811000	05	ZM	-44580750	05	DXM	-13040566	00	DYM	-90233684	00	DZM	-32850051	00
XT	-25464137	08	YT	-34625345	06	ZT	-20852825	08	DXT	-38591230	01	DYT	-63074894	01	DZT	-39913621	01
RS	-14876201	09	VS	-29961620	02	RM	-40581238	06	VM	-96908718	00	RT	-47772137	08	VT	-84028699	01
GED	-25559476	01	ALT	-16245486	06	LDS	-17017628	03	RAS	-20897687	03	RAM	-17476380	03	LOM	-13596321	03
DUT	-35000000	02	DT	-86399999	05	DR	-45675790	01	SHA	-43232354	07	DES	-11863622	02	DEM	-63069898	01
CCL	-19765542	02	MCL	-17739505	03	TCL	-28021402	03									

HELIOCENTRIC

ECLIPTIC COORDINATES

X	-11517683	09	Y	-66741462	06	Z	-36090505	07	DX	-20131966	02	DY	-23330238	02	DZ	-37499619	00
R	-13316592	09	LAT	-15530142	01	LOA	-30090971	02	V	-30817797	02	PTH	-10676357	02	AZ	-88997368	02
XE	-12735948	09	YE	-76874577	08	ZE	-29725000	03	DXE	-15878383	02	DYE	-25408181	02	DZE	-68032741	-03
XT	-101819534	09	YT	-36811345	06	ZT	-53588093	07	DXT	-12019260	03	DYT	-32782931	02	DZT	-11519040	01
LTE	-11448601	-03	LGE	-31115308	02	LTT	-28306284	01	LOT	-19863077	02	RST	-10847318	09	VST	-34935799	02
EPS	-16271230	03	ESP	-18604239	01	SEP	-15427257	02	EPM	-10706862	01	EMP	-13155425	03	MEP	-47375064	02
MPS	-16198915	03	MSP	-19073919	01	SMP	-16103431	02	SEM	-38573790	02	EMS	-14132854	03	ESM	-97165341	-01
EPT	-14165444	03	ETP	-12184368	02	TEP	-26161183	02	TPS	-38059895	02	TSP	-11124842	02	STP	-13081526	03
SET	-27162146	02	STE	-14123952	03	EST	-11598330	02	RPM	-15979840	08	RPT	-33949931	08	SPN	-16268981	03
GCE	-34023445	03	GCT	-80448475	02	SIP	-38049432	02	CPT	-85932632	02	SIN	-85922168	02			
REP	-16251865	08	VEP	-47488892	01	CPL	-71495394	02	CPS	-92277241	02						

60 DAYS 0 HRS. 0 MIN. 0.000 SEC. 235602344041202000000000 J.D.= 2437972.51634260 NOV. 4, 1962 00 23 32.000

GEOCENTRIC

EQUATORIAL COORDINATES

X	-16374339	08	Y	-12775431	08	Z	-13410055	07	DX	-54786102	01	DY	-27682579	01	DZ	-10034055	01
R	-20811796	08	DEC	-36944057	01	RA	-21796162	03	V	-62197462	01	PTH	-77591237	02	AZ	-24268670	03
R	-20811795	08	LAT	-36944057	01	LOA	-21796162	03	VE	-15156661	04	PTE	-22963010	00	AZE	-26997681	03
XS	-11178401	09	YS	-89502878	08	ZS	-38810484	08	DXS	-20083005	02	DYS	-20488341	02	DZS	-88854039	01
XM	-16354000	06	YM	-31999500	06	ZM	-13356550	06	DXM	-89676700	00	DYM	-47770262	00	DZM	-10968220	00
XT	-24075564	08	YT	-29275462	08	ZT	-17432042	08	DXT	-53176308	00	DYT	-47914758	01	DZT	-38026623	01
RS	-14436672	09	VS	-30034140	02	RM	-38338215	06	VM	-10219637	01	RT	-42037031	08	VT	-61013451	01
GED	-27195117	01	ALT	-20805418	08	LDS	-17020645	03	RAS	-21868345	03	RAM	-29707023	03	LOM	-24841323	03
DUT	-35000000	02	DT	-86399999	05	DR	-45675790	01	SHA	-41462567	07	DES	-15164120	02	DEM	-20388711	02
CCL	-32567589	03	MCL	-18399321	03	ICL	-21489162	03									

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EARTH-VENUS, RADIATION PRES. ON

CHECK 2

HELIOCENTRIC

ECLIPTIC COORDINATES

X	-95409609	08	Y	-85300785	08	Z	-38521260	07	DX	-25561615	02	DY	-19393148	02	DZ	-18180579	00
R	-12003928	08	LAT	-17240311	01	LOA	-41798249	02	V	-32086187	02	PTH	-10999425	02	AZ	-89333904	02
XE	-11178401	09	YE	-97552008	08	ZE	-21500000	02	DXE	-20083005	02	DYE	-22332096	02	DZE	-10894537	-02
XT	-87708444	08	YT	-63348316	06	ZT	-41674630	07	DXT	-20614768	02	DYT	-28240895	02	DZT	-15836764	01
LTE	-83028001	-05	LGE	-41111584	02	LTT	-22058770	01	LOT	-35839082	02	RST	-10827349	09	VST	-35000354	02
EPS	-16665256	03	ESP	-18557237	01	SEP	-11491716	02	EPM	-10379981	01	EMP	-10045162	03	MEP	-78510362	02
MPS	-16620530	03	MSP	-19113637	01	SMP	-26300146	02	SEM	-74141950	02	EMS	-10571553	03	ESM	-14213722	00
EPT	-13533242	03	ETP	-20367428	02	TEP	-11883337	02	TPS	-33140288	02	TSP	-71373136	01	STP	-13972239	03
SET	-14854359	02	STE	-15942650	03	EST	-57141354	01	RPM	-20738633	08	RPT	-24607579	08	SPN	-16663500	03
GCE	-34324107	02	GCT	-69215731	02	SIP	-33125852	02	CPT	-82900689	02	SIN	-82886251	02			
REP	-20811796	08	VEP	-62197462	01	CPE	-74275088	02	CPS	-94776907	02						

95 DAYS 14 HRS. 20 MIN. 28.240 SEC. 235605301654202036557427 J.D.= 2438008.11389166 DEC. 9, 1962 14 44 00.240

GEOCENTRIC

EQUATORIAL COORDINATES

X	-38114915	08	Y	-32470177	08	Z	-10737317	08	DX	-69861472	01	DY	-11839936	02	DZ	-59359686	01
R	-51208877	08	DEC	-12103416	02	RA	-22042775	03	V	-14974180	02	PTH	-68705464	02	AZ	-12448577	03
R	-51208876	08	LAT	-12103416	02	LOA	-28156642	03	VE	-36467469	04	PTE	-21920553	00	AZE	-26995161	03
XS	-33001654	08	YS	-13173211	09	ZS	-57122265	08	DXS	-29507772	02	DYS	-60166952	01	DZS	-26084711	01
XM	-21883625	06	YM	-27911400	06	ZM	-88068499	05	DXM	-85077953	00	DYM	-59187478	00	DZM	-29572740	00
XT	-38807242	08	YT	-38870662	08	ZT	-12688474	08	DXT	-55834930	01	DYT	-87147206	01	DZT	-16056959	01
RS	-14732756	09	VS	-30227691	02	RM	-36544492	06	VM	-10777371	01	RT	-53052172	08	VT	-10473777	02
GED	-12183442	02	ALT	-51202499	08	LDS	-31707434	03	RAS	-25593566	03	RAM	-51902168	02	LOM	-11304084	03
DUT	-35000000	02	DT	-86399999	05	DR	-13951831	02	SHA	-29675361	08	DES	-22812884	02	DEM	-13944966	02
CCL	-27278204	03	MCL	-17997888	03	TCL	-61752705	02									

HELIOCENTRIC

ECLIPTIC COORDINATES

X	-51132606	07	Y	-10952209	04	Z	-30669430	07	DX	-36493919	02	DY	-66663640	01	DZ	-73618439	00
R	-10968427	09	LAT	-16022872	01	LOA	-92673030	02	V	-37105101	02	PTH	-77066202	01	AZ	-90930744	02
XE	-33001654	08	YE	-14358377	09	ZE	-38800000	03	DXE	-29507772	02	DYE	-65578001	01	DZE	-45493245	-03
XT	-58055881	07	YT	-10745695	09	ZT	-18337960	07	DXT	-35091265	02	DYT	-20763944	01	DZT	-19933603	01
LTE	-15089344	-03	LGE	-77058006	02	LTT	-97944912	00	LOT	-93092518	02	RST	-10762939	09	VST	-35209114	02
EPS	-12888771	03	ESP	-15697150	02	SEP	-35415132	02	EPM	-79129368	-01	EMP	-11248624	02	MEP	-16867161	03
MPS	-12896576	03	MSP	-15755504	02	SMP	-35278726	02	SEM	-15557318	03	EMS	-24368171	02	ESM	-58516955	-01
EPT	-13656698	03	ETP	-41576446	02	TEP	-18565540	01	TPS	-34345667	02	ISP	-75079015	00	STP	-14490346	03
SET	-34155269	02	STE	-12977892	03	EST	-16065797	02	RPM	-15667252	08	RPT	-24999996	07	SPN	-12888057	03
GCE	-87217954	02	GCT	-32897067	03	SIP	-34203573	02	CPT	-12723123	02	SIN	-72581027	02			
REP	-51208877	08	VEP	-14974180	02	CPE	-80194516	02	CPS	-10226701	03						

95 DAYS 14 HRS. 20 MIN. 28.240 SEC. 235605301654202036557427 J.D.= 2438008.11389166 DEC. 9, 1962 14 44 00.240  
CHANGE OF PHASE OCCURS AT THIS POINT VENUS IS THE CENTRAL BODY FOR INTEGRATION COWELL EQUATIONS OF MOTION

95 DAYS 14 HRS. 20 MIN. 28.240 SEC. 235605301654202036557423 J.D.= 2438008.11389166 DEC. 9, 1962 14 44 00.240  
\*\*\*\*\* S/C DISCONTINUITY=4 STOP

95 DAYS 16 HRS. 53 MIN. 43.705 SEC. 235605306246202732137777 J.D.= 2438008.22032065 DEC. 9, 1962 17 15 15.705

EXTREME ELEVATION

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

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EARTH-VENUS, RADIATION PRES. CN

CHECK 2

11 GOLDSTONE

HADEC

R .51337278 08	LAT-.12135106 02	LON .24319437 03	ELE .42651574 02	AZI .17994024 03
MIN -1.13781373 06	HA .35995644 03	DEC-.12140337 02	PSS .35467366 02	PSM .16745569 03
CKC -2.7278288 03	CKM .17997188 03	CKT -.61460581 02	DEL .35270805-09	DAZ .53753114-02
UT .22968954 04	DHA .41733529-02	DDE-.34460419-05	DDR .00000000 00	SLS .24630199 03
ET .22968857 04	RGE .51332960 08	DRG .13975647 02	SP5 .12876903 03	PUL .67495580 02
ROI .63720340 04	PHI .35208070 02	THI .24315082 03	RF1 .96004999 09	FA .96004999 09
DT .17122830 03	RFB .96004999 09	RF2 .29668212 08	XA .29669594 08	PRA .22047504 03
BF1 .94755354 05	F1 .12375535 06	F2 .18951071 06		
D1 .41251785 04	D2 .63170235 04			

95 DAYS 21 HRS. 52 MIN. 44.727 SEC. 235605317054202135000076 J.D.= 2438008.42797137 DEC. 9,1962 22 16 16.727

END OF VIEW PERIOD

11 GOLDSTONE

HADEC

R .51588432 08	LAT-.12196989 02	LON .16832835 03	ELE .49999998 01	AZI .25125303 03
MIN -1.13811274 06	HA .74828172 02	DEC-.12201297 02	PSS .35572730 02	PSM .16367384 03
CKC -2.7279575 03	CKM .17996884 03	CKT .60901667 02	DEL-.32307599-02	DAZ .24991200-02
UT .23018690 04	DHA .41729830-02	DDE-.33640906-05	DDR .00000000 00	SLS .24634502 03
ET .23018693 04	RGE .51587877 08	DRG .14380041 02	SP5 .12852815 03	PHL .11054749 03
ROI .63720340 04	PHI .35208070 02	THI .24315082 03	RF2 .29668212 08	FA .96004999 09
DT .17207861 03	RFB .96004999 09	RF1 .96004999 09	XA .29669634 08	PRA .22056223 03
BF1 .96050377 05	F1 .12505038 06	F2 .19210075 06		
D1 .41683454 04	D2 .64033584 04			

96 DAYS 11 HRS. 53 MIN. 28.702 SEC. 235605347557202131637777 J.D.= 2438009.01181367 DEC. 10,1962 12 17 00.702

START OF VIEW PERIOD

11 GOLDSTONE

HADEC

R .52299049 08	LAT-.12371365 02	LON .31783551 03	ELE .49999998 01	AZI .10896810 03
MIN -1.1395348 06	HA .28530967 03	DEC-.12375620 02	PSS .35849109 02	PSM .15700028 03
CKC -2.7284703 03	CKM .17997103 03	CKT .59330653 02	DEL .32221787-02	DAZ .25056196-02
UT .23158913 04	DHA .41728503-02	DDE-.35470234-05	DDR .00000000 00	SLS .24646385 03
ET .23158815 04	RGE .52298493 08	DRG .13795244 02	SP5 .12787748 03	PUL .31034434 02
ROI .63720340 04	PHI .35208070 02	THI .24315082 03	RF1 .96004999 09	FA .96004999 09
DT .17444897 03	RFB .96004999 09	RF2 .29668212 08	XA .29669577 08	PRA .22083945 03
BF1 .94177634 05	F1 .12317763 06	F2 .18835527 06		
D1 .41054211 04	D2 .62785089 04			

96 DAYS 16 HRS. 51 MIN. 36.500 SEC. 235605360347202100000000 J.D.= 2438009.21884838 DEC. 10,1962 17 15 08.500

EXTREME ELEVATION

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

10

EARTH-VENUS, RADIATION PRES. CN

CHECK 2

11 GOLDSTONE

HADEC

R .52552614 08	LAT-.12433335 02	LON .24319481 03	ELE .42353440 02	AZI .17993862 03
MIN -1.13925161 06	HA .35995594 03	DEC-.12438469 02	PSS .35952588 02	PSM .15370370 03
CKC -2.7286141 03	CKM .17996652 03	CKT .58762363 02	DEL-.30526236-10	DAZ .52312657-02
UT .23208601 04	DHA .41731118-02	DDE-.34651272-05	DDR .00000000 00	SLS .24650524 03
ET .23208504 04	RGE .52548321 06	DRG .14198296 02	SP5 .12733865 03	PUL .67921023 02
ROI .63720340 04	PHI .35208070 02	THI .24315082 03	RF1 .96004999 09	FA .96004999 09
DT .17524231 03	RFB .96004999 09	RF2 .29668212 08	XA .29669616 08	PRA .22092974 03
BF1 .95468363 05	F1 .12446836 06	F2 .19093673 06		
D1 .41489454 04	D2 .63645574 04			

96 DAYS 21 HRS. 49 MIN. 42.096 SEC. 235605371136202414200015 J.D.= 2438009.42585759 DEC. 10,1962 22 13 14.096

END OF VIEW PERIOD

11 GOLDSTONE

HADEC

R .52806970 08	LAT-.12495167 02	LON .16856428 03	ELE .49999998 01	AZI .25087456 03
MIN -1.13954470 06	HA .74592113 02	DEC-.12499584 02	PSS .36054075 02	PSM .14988854 03
CKC -2.7287887 03	CKM .17996432 03	CKT .58191034 02	DEL-.32232876-02	DAZ .25008325-02
UT .23258283 04	DHA .41727512-02	DDE-.33831196-05	DDR .00000000 00	SLS .24654760 03
ET .23258186 04	RGE .52806412 08	DRG .14601377 02	SP5 .12739937 03	PUL .10950829 03
ROI .63720340 04	PHI .35208070 02	THI .24315082 03	RF1 .96004999 09	FA .96004999 09
DT .17614322 03	RFB .96004999 09	RF2 .29668212 08	XA .29669656 08	PRA .22102092 03
BF1 .96759181 05	F1 .12575418 06	F2 .19351836 06		
D1 .41419727 04	D2 .64506120 04			

97 DAYS 11 HRS. 52 MIN. 22.345 SEC. 235605421676202454100003 J.D.= 2438010.01104565 DEC. 11,1962 12 15 54.345

START OF VIEW PERIOD

11 GOLDSTONE

HADEC

R .53530446 08	LAT-.12671106 02	LON .31759792 03	ELE .50000015 01	AZI .10934855 03
MIN -1.14039237 06	HA .28554739 03	DEC-.12675269 02	PSS .36321583 02	PSM .14309546 03
CKC -2.7294229 03	CKM .17996816 03	CKT .56539357 02	DEL .32165546-02	DAZ .25073634-02
UT .23398728 04	DHA .41726186-02	DDE-.35658786-05	DDR .00000000 00	SLS .24666600 03
ET .23398631 04	RGE .53529891 08	DRG .14017982 02	SP5 .12674910 03	PUL .39044234 02
ROI .63720340 04	PHI .35208070 02	THI .24315082 03	RF1 .96004999 09	FA .96004999 09
DT .17855647 03	RFB .96004999 09	RF2 .29668212 08	XA .29669598 08	PRA .22131016 03
BF1 .94890928 05	F1 .12389093 06	F2 .18978185 06		
D1 .41296976 04	D2 .63269618 04			

97 DAYS 14 HRS. 20 MIN. 28.240 SEC. 235605426154202036557427 J.D.= 2438010.11389166 DEC. 11,1962 14 44 00.240

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

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EARTH-VENUS, RADIATION PRES. CN

CHECK 2

GEOCENTRIC

EQUATORIAL COORDINATES

X -39292249 08 Y -34585063 08 Z -11798440 08 DX -66286401 01 DY -12640377 02 DZ -63478138 01
R -53658276 08 DEC -12702049 02 RA -22135425 03 V -15620907 02 PTH -67168155 02 AZ -12255903 03
S -53658275 08 LAT -12702050 02 LON -28052158 03 VE -38119831 04 PTE -21639405 00 AZE -26995096 03
XS -27883219 08 YS -13269048 09 ZS -57537650 08 DXS -29723859 02 DYS -50734308 01 DZS -21989640 01
XM -51534905 08 YM -34426450 08 ZM -12676725 06 DMX -10446186 01 DYM -14998627 00 DZM -14414167 00
XT -39740388 08 YT -35456520 08 ZT -12997606 08 DXT -52004492 01 DYT -95668209 01 DZT -20150284 01
RS -14729161 09 VS -30233804 02 RM -37046414 06 VM -10653256 01 RT -54821537 08 VT -11075864 02
GED -12785775 02 ALT -53651898 06 LOS -31730000 03 RAS -25813268 03 RAM -81486513 02 LOM -14065304 03
DUT -35000000 02 DT -76800000 04 DR -14396972 02 SHA -31822035 08 DES -22994183 02 DEM -20010047 02
CCL -27295560 03 MCL -17997039 03 TCL -56240365 02

GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 23560241426520276557427 J.D. = 2437973.47138876 NOV. 4, 1962 23 18 47.990
SMA -16336234 04 ECC -12745619 05 B -20821539 08 SLR -26538343 12 APD -00000000 00 RCA -20819907 08
VH -15620431 02 C3 -24399787 03 CL -32524145 09 TFP -31659122 07 TF -60955045 02 LTF -60943603 02
TA -67172293 02 MTA -90004494 02 EA -91665283 02 MA -17344531 07 TFI -97597547 02

ALL VECTORS

REFERENCED TO EARTH EQUATOR PLANE

X -39292249 08 Y -34585063 08 Z -11798440 08 DX -66286401 01 DY -12640377 02 DZ -63478138 01
INC -34693324 02 LAN -22352560 02 APF -13555276 03 DMX -64569876 00 MY -55448230 00 MZ -52699744 00
WX -21646322 00 WY -52641588 00 WZ -82221034 00 PX -87921651 00 PY -26099517 00 PZ -39857203 00
QX -42440770 00 QY -80917719 00 QZ -40633771 00 RX -18872320 00 RY -35988791 00 RZ -91370904 00
OX -87924989 00 OY -26093171 00 OZ -39854019 00 TX -88561855 00 TY -46441339 00 TZ -00000000 00
SXI -42447668 00 SYI -80915671 00 SZI -40630644 00 DAI -23973022 02 RAI -24231888 03
SXD -42433871 00 SYD -80919766 00 SZD -40636898 00 DAO -23976943 02 RAO -24232773 03

BTQ -18735903 06 BRU -90830831 07 B -20821539 08 THA -33413609 03 T VECTOR IN EARTH EQUATOR PLANE

HELIOCENTRIC

ECLIPTIC COORDINATES

X -11409030 08 Y -10820414 09 Z -29346385 07 DX -36352499 02 DY -85929000 01 DZ -79604676 00
R -10884352 09 LAT -15449947 01 LON -96019018 02 V -57362760 02 PTH -73091441 01 AZ -91033023 02
XE -27883219 08 YE -14462829 09 ZE -26950000 03 DXE -29723859 02 DYE -55294794 01 DZE -90044736-03
XT -11857164 08 YT -10692755 04 ZT -21811440 07 DXT -34428699 02 DYT -40493277 01 DZT -19563566 01
LTE -10483430-03 LYE -79087698 02 LTI -11614574 01 LDT -96321662 02 RST -10760506 09 VST -35217018 02
EPS -12662666 03 ESP -16999598 02 SEP -36373740 02 EPM -24787221 00 EMP -38850398 02 EPP -91370904 03
MPS -12687366 03 MSP -16993096 02 SMP -36133232 02 SEM -17568276 03 EMS -43063947 01 ESM -00000000 00
EPT -13814754 03 ETP -40772486 02 TEP -10799443 01 TPS -36651964 02 TSP -49218042 00 STP -14285578 03
SET -35659721 02 STE -12706242 03 EST -17277850 02 RPM -53946285 08 RPT -15486327 07 SPN -12661984 03
SGE -87044997 02 SGT -32328476 03 STP -36422580 02 CPT -72903288 02 SIN -72673901 02
REP -53658276 08 VEP -15620907 02 GPE -80256417 02 GPS -10247121 03

HELIOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235607604571202316557427 J.D. = 2438037.00636128 JAN. 7, 1963 12 09 09.095
SMA -12728584 09 ECC -19193415 00 B -12491931 09 SLR -12259680 09 APD -15171634 09 RCA -10285535 09
VH -26586160 02 C3 -10426462 04 CL -40336490 10 TFP -23235094 07 TF -12449002 03 PER -28666702 03
TA -48026488 02 MTA -18000000 03 EA -40984314 02 MA -33771896 02 TFI -97597547 02

CASE 1

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EARTH-VENUS, RADIATION PRES. CN

CHECK 2

X -11409030 08 Y -10820414 09 Z -29346385 07 DX -36352499 02 DY -85929000 01 DZ -79604676 00
INC -18584504 01 LAN -33224521 03 APF -17258636 03 MX -99437648 00 MY -10435814 00 MZ -18022150-01
WK -15102577-01 WY -28659463-01 WX -99947400 00 PY -57592164 00 PZ -41845776-02
QX -57573879 00 QY -81700073 00 QZ -32159537-01 RX -34208974-02 RY -24100104-02 RZ -99999103 00
BX -57573890 00 BY 81700090 00 BZ -32159544-01 TX -57592680 00 TY -81750127 00 TZ -00000000 00
DAP -23975927 00 RAP -14483543 03

BTC -12485467 09 BRC -40173818 07 B -12491929 09 THA -35815706 03 T VECTOR IN ECLIPTIC PLANE

APHRUOICENTRIC

ECLIPTIC COORDINATES

X -44813947 06 Y -12765891 07 Z -75349489 06 DX -14238000 01 DY -45435722 01 DZ -27524033 01
R -15486327 07 DEC -29114400 02 RA -7065657 02 V -54997253 03 PTH -88076883 02 AZ -24107256 03
ALT -15424327 07 SHA -43510054 06 ALP -44169141 02 DR -54966278 01 DP -68282368-05 ASD -22938678 00
HGE -23337333 03 SVL -24755004 02 HNG -22464570 02 SIA -13791816 03

APHRUOICENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235605635463202017157427 J.D. = 2438013.32310322 DEC. 14, 1962 19 45 16.119
SMA -10888129 05 ECC -49093327 01 B -52332792 05 SLR -25153263 06 APD -00000000 00 RCA -42565318 05
VH -94616609 01 C3 -29827556 02 C1 -78581342 06 TFP -27727588 06 TF -10080676 03 LTF -10077004 03
TA -99823254 02 MTA -10175304 03 EA -23297472 03 MA -79687521 04 TFI -97597547 02
ZAE -13737671 03 ZAP -36622976 02 ZAC -72228841 02 DEF -23506073 02 IR -13170148 05 GP -30196549 02

X -44813947 06 Y -12765891 07 Z -75349489 06 DX -14238000 01 DY -45435722 01 DZ -27524033 01
INC -13987522 03 LAN -20929608 03 APF -23079818 03 MX -90375707 00 MY -67839262-01 MZ -42258339 00
WX -31534191 00 WY -56202240 00 WZ -74664279 00 PX -86115457 00 PY -20748265 00 PZ -49939815 00
QX -43932598 00 QY -80067352 00 QZ -40732552 00 RX -14960900 00 RY -47762633 00 RZ -86573101 00
BX -91301253 00 BY -40041880-01 BZ -40596154 00 TX -95428022 00 TY -29891348 00 TZ -00000000 00
SXI -25877667 00 SYI -82614998 00 SZI -50050592 00 DAI -30033716 02 RAI -25260764 03
SXD -60145226 00 SYD -74182469 00 SZD -29706229 00 DAO -17281242 02 RAO -23095819 03
ETE -31588812 03 ETS -47668824 02 ETC -26220584 03

BTC -46222361 05 BRC -24540072 05 B -12491929 09 THA -15203557 03 T VECTOR IN ECLIPTIC PLANE

97 DAYS 16 HRS. 49 MIN. 34.068 SEC. 235605632450202410577774 J.D. = 2438010.21743134 DEC. 11, 1962 17 03 06.068

EXTREME ELEVATION

11 GOLDSTONE HADEC
R -53787170 08 LAT -12733219 02 LON -24319538 03
MIN -14068956 06 HA -35995543 03 DEC -12738260 02 ELE -42053649 02 AZI -17993823 03
CKC -27296101 03 CKM -17996448 03 CKT -55926993 02 PSS -36421226 02 PSM -14006545 03
UT -23448261 04 UHA -41728723-02 DDE -34841772-05 DEL -59478588-10 DA2 -51955657-02
ET -23448163 04 RGE -53782901 08 DRG -14419971 02 DDR -00000000 00 SLS -24670695 03
RDI -63720340 04 PHI -35208070 02 TH1 -24315082 03 SPS -12651186 03 PDL -6977658 02
DT -17940042 03 RFB -96004999 09 RF1 -96004999 09 RF2 -29668212 08 FA -96004999 09
BF1 -96178251 05 F1 -12517825 06 F2 -19235650 06 XA -29669638 08 PRA -22140440 03
DI -41726083 04 U2 -64118833 04

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EARTH-VENUS, RADIATION PRES. CN

CHECK 2

97 DAYS 21 HRS. 46 MIN. 43.673 SEC.

235605443221202726100000 J.D.= 2438010.42379250 DEC. 11,1962 22 10 15.673

END OF VIEW PERIOD

11 GOLDSTONE

HADEC  
R .5404684 08 LAT-.12795400 02  
MIN .14098673 06 HA .74353144 02  
CKC .27298207 03 CKM .17996305 03  
UT .23497787 04 DHA .41725204-02  
ET .23497640 04 RGE .54044127 06  
RDI .63720340 04 PHI .35208070 02  
DT .18027178 03 RFB .96004999 09  
BF1 .97466207 05 F1 .12646621 06  
D1 .42159402 04 D2 .64977470 04

LON .16880253 03  
DEC-.12799528 02  
CKT .25927931 02  
UDE-.34024723-05  
DRG .14822158 02  
TH1 .24315082 03  
RF1 .96004999 09  
F2 .19493241 06  
ELE .49949981 01  
PSS .36518864 02  
DEL-.32156265-02  
DDR .00000000 00  
SPS .12627420 03  
RF2 .29668212 08  
XA .29669678 08  
AZI .25049356 03  
PSM .13631710 03  
DAZ .25025536-02  
SLS .24674904 03  
PUL .10844218 03  
FA .96004999 09  
PRA .22149951 03

98 DAYS 11 HRS. 51 MIN. 21.325 SEC.

235605474017202251440000 J.D.= 2438011.01033940 DEC. 12,1962 12 14 53.325

START OF VIEW PERIOD

11 GOLDSTONE

HADEC  
R .54781106 08 LAT-.12972554 02  
MIN .14181135 06 HA .28578749 03  
CKC .27307533 03 CKM .17996436 03  
UT .23638559 04 DHA .41723878-02  
ET .23638461 04 RGE .54780550 08  
RDI .63720340 04 PHI .35208070 02  
DT .18027178 03 RFB .96004999 09  
BF1 .95608915 05 F1 .12646621 06  
D1 .41536305 04 D2 .63739276 04

LON .31735794 03  
DEC-.12976631 02  
CKT .53360464 02  
UDE-.39865708-05  
DRG .14242186 02  
TH1 .24315082 03  
RF1 .96004999 09  
F2 .19121783 06  
ELE .50000006 01  
PSS .36717444 02  
DEL .32067363-02  
DDR .00000000 00  
SPS .12562437 03  
RF2 .29668212 08  
XA .29669620 08  
AZI .10973161 03  
PSM .12942838 03  
DAZ .25091171-02  
SLS .24688660 03  
PUL .47720675 02  
FA .96004999 09  
PRA .22180080 03

98 DAYS 16 HRS. 47 MIN. 36.383 SEC.

235605504553202061000000 J.D.= 2438011.21606924 DEC. 12,1962 17 11 08.383

EXTREME ELEVATION

11 GOLDSTONE

HADEC  
R .55040991 08 LAT-.13034851 02  
MIN .14212701 06 HA .35995489 03  
CKC .27310796 03 CKM .17996541 03  
UT .23687934 04 DHA .41726334-02  
ET .23687837 04 RGE .55038147 06  
RDI .63720340 04 PHI .35208070 02  
DT .18158281 03 RFB .96004999 09  
BF1 .96887618 05 F1 .12589672 06  
D1 .41765572 04 D2 .64597811 04

LON .24314593 03  
DEC-.13039798 02  
CKT .52590690 02  
UDE-.35059628-05  
DRG .14644325 02  
TH1 .24315082 03  
RF1 .96004999 09  
F2 .19379343 06  
ELE .41752110 02  
PSS .36873261 02  
DEL-.38922904-10  
DDR .00000000 00  
SPS .12538876 03  
RF2 .29668212 08  
XA .29669660 08  
AZI .17993783 03  
PSM .12668496 03  
DAZ .31640097-02  
SLS .24690712 03  
PUL .71151220 02  
FA .96004999 09  
PRA .22189893 03

98 DAYS 21 HRS. 43 MIN. 49.406 SEC.

235605515306202263777774 J.D.= 2438011.42177553 DEC. 12,1962 22 07 21.406

END OF VIEW PERIOD

CASE 1

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EARTH-VENUS, RADIATION PRES. CN

CHECK 2

11 GOLDSTONE

HADEC  
R .55301687 08 LAT-.13097232 02  
MIN .14242382 06 HA .28603047 03  
CKC .27310541 03 CKM .17996465 03  
UT .23711301 04 DHA .41722898-02  
ET .23717206 04 RGE .55301131 08  
RDI .63720340 04 PHI .35208070 02  
DT .18446669 03 RFB .96004999 09  
BF1 .98186745 05 F1 .12718674 06  
D1 .42395981 04 D2 .65457829 04

LON .16904324 03  
DEC-.13101273 02  
CKT .51154115 02  
UDE-.34257759-05  
DRG .15047159 02  
TH1 .24315082 03  
RF1 .96004999 09  
F2 .19637349 06  
ELE .50000006 01  
PSS .36967043 02  
DEL-.32077712-02  
DDR .00000000 00  
SPS .12515273 03  
RF2 .29668212 08  
XA .29669601 08  
AZI .25010981 03  
PSM .12307660 03  
DAZ .25042806-02  
SLS .24694875 03  
PUL .10734222 03  
FA .96004999 09  
PRA .22199793 03

99 DAYS 11 HRS. 50 MIN. 25.742 SEC.

235605566141202337000000 J.D.= 2438012.00969609 DEC. 13,1962 12 13 57.742

START OF VIEW PERIOD

11 GOLDSTONE

HADEC  
R .56051542 08 LAT-.13276151 02  
MIN .14422143 06 HA .28603047 03  
CKC .27319304 03 CKM .17997115 03  
UT .23878404 04 DHA .41721350-02  
ET .23878307 04 RGE .56050986 06  
RDI .63720340 04 PHI .35208070 02  
DT .18686594 03 RFB .96004999 09  
BF1 .96370720 05 F1 .12537072 06  
D1 .41790740 04 D2 .64247146 04

LON .31711519 03  
DEC-.13280143 02  
CKT .48700013 02  
UDE-.36177725-05  
DRG .14480073 02  
TH1 .24315082 03  
RF1 .96004999 09  
F2 .19274144 06  
ELE .50000006 01  
PSS .37216475 02  
DEL .31987020-02  
DDR .00000000 00  
SPS .12450346 03  
RF2 .29668212 08  
XA .29669644 08  
AZI .11011788 03  
PSM .11609826 03  
DAZ .25108887-02  
SLS .24706573 03  
PUL .83096472 02  
FA .96004999 09  
PRA .22231138 03

99 DAYS 14 HRS. 20 MIN. 28.240 SEC.

23560552454202036557427 J.D.= 2438012.11389166 DEC. 13,1962 14 44 00.240

GEOCENTRIC

EQUATORIAL COORDINATES

X -.40481315 08	Y -.36840644 08	Z -.12933012 08	DX -.62044062 01	DY -.13476355 02	DZ -.67974975 01
R .56188213 08	DH .13307983 02	RA .22236052 03	V .16318712 02	PTH .65605731 02	AZ .12098424 03
R .56188212 08	LAT .13307983 02	LON .27955649 03	VE .39813214 04	PIL .21380554 00	AZE .26995005 03
XS -.22330310 08	YS .13348523 09	ZS -.97887082 08	DXS .29906197 02	DYS -.41233146 01	DZS -.17867313 01
XM -.23878400 06	YM .33046900 06	ZM .13650800 06	DXM -.99311659 00	DYM -.30104887 00	DZM -.31415671-01
XT -.42060138 02	YT .17181991 08	ZT .13381116 08	DXT .47487228 01	DYT .10398495 02	DZT .24227590 01
RS .14729431 09	VS .30241937 02	WS .39975230 06	VM .10382186 01	RT .56657099 08	VT .11685821 02
GEU -.13495416 02	ALT .-88178835 08	LOS .-31753213 03	RAS .26033617 03	HAM .11116315 03	LOM .16835911 03
DUF .-35000000 02	ET .19200000 04	DR .14861859 02	SHA .-36020608 08	OES .-23145176 02	DEM .21067397 02
CCL .27320710 03	MCL .17997388 03	CL .47981663 02			

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CASE 1

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EARTH-VENUS, RADIATION PRES. CN

CHECK 2

HELIOCENTRIC

X -1.17671205 08 Y +1.0654955 09  
 R +1.0804104 09 LAT +1.4802061 01  
 XT -1.17671072 08 YL +1.4549448 09  
 LIE +35.989975-04 LDE +1.0608111 09  
 EPS -1.2438064 03 ESP +1.8353928 02  
 MPS +1.2473202 03 MSP +1.8283875 02  
 EPT +1.4195066 03 ETP +3.7676784 02  
 SET +3.7029535 02 STE +1.2447948 03  
 GCE +8.6792896 02 SCT +3.1477456 03  
 REP +5.6185213 08 VEP +1.6318712 02

Z +2.7908750 07 DX -3.36109603 02  
 LON +9.9416771 02 V +3.7636293 02  
 ZE +9.2500000 02 DXE -2.9906197 02  
 LIT +2.5135560 07 DXT +3.4654920 02  
 LTT +1.3398415 01 LDT +9.9564643 02  
 SEP +3.7265422 02 EPM +3.5200672 00  
 SMP +3.6984094 02 SEM +1.5141594 03  
 TEP +3.7266289 00 TSP +3.9820246 02  
 EST +1.8490979 02 RPM +5.6342391 08  
 SIP +3.9225915 02 CPT +7.4211037 02  
 CPE +8.0294715 02 CPS +1.0263574 03

ECLIPTIC COORDINATES

DY -1.0574465 02 DZ -1.87625891 00  
 PTH -6.9360767 01 AZ +9.1164229 02  
 DYE +4.4937880 01 DZE -1.11228770-02  
 DYT -6.0106769 01 DZT -1.9131060 01  
 RST +1.0758265 09 VST +3.5224305 02  
 EMP +6.5374236 02 MEP +1.1427372 03  
 EKS +2.8513518 02 ESM +6.9941139-01  
 TSP +2.0367177 00 STP +1.3997590 03  
 RPT +5.9771421 06 SPN +1.2437414 03  
 SIN +7.3616706 02

APHRICENTRIC

X +1.9966693 06 Y +.49144134 06  
 R +.59771421 06 DEC +2.7427178 02  
 ALT +5.9151421 06 SHA +3.8439586 06  
 HGE +2.3561935 03 SVL +2.8408768 02

Z +2.7531963 06 DX -1.4546834 01  
 RA +6.7868647 02 V +.5542975 01  
 ALP +3.5237906 02 DR -5.5236167 01  
 HNG +2.9165777 02 SIA +1.4135633 03

ECLIPTIC COORDINATES

DY -4.5637881 01 DZ -2.7893649 01  
 PTH -8.5207301 02 AZ +2.3340268 03  
 DR -4.4393975-04 ASD +5.9433147 00

APHRICENTRIC CONIC

EPDCH OF PERICENTER PASSAGE

SMA -1.10957719 05 ECC +.47467960 01  
 WH +5.4440910 01 C3 +2.9638127 02  
 TA -9.7325680 02 MTA +1.0216152 03  
 ZAE +1.3758618 03 ZAP +.36744028 02

235605635703202176657427 J.D. = 2438013.32977998 DEC. 14, 1962 19 54 52.991  
 B +.50846750 05 SLR +2.3594240 06 APU +0.0000000 00 RCA +4.1056337 05  
 CI +2.7681426 06 TFP -1.10505275 06 TF +1.0081344 03 LTF +1.0077715 03  
 EA -1.8054369 03 MA -2.29904414 04 TFI +.99597547 02  
 ZAC +.71997601 02 DEF +.24323049 02 IR +.13202868 05 GP -3.0414800 02

X +1.9966693 06 Y +.49144134 06  
 INC +1.3544712 03 LAN +2.1605784 03  
 MX +.41294392 00 MY +.56716335 00  
 QX +.43063725 00 QY +.80436009 00  
 BX +.87232404 00 BY +.21410391-01  
 SXI +.26177404 00 SYI +.82332705 00  
 SXO +.59783670 00 SYO +.75906513 00  
 ETE +.31441521 03 ETS +.43093203 02

Z +2.7531963 06 DX -1.4546834 01  
 APF +2.3628763 03 MX +.84715059 00 MY +.46073606-01  
 WZ +.71260336 00 MZ +.79759858 00 PY +.15251911 00  
 UZ +.38938659 00 QZ +.38938659 00 RX +.15259087 00 KY +.47991693 00  
 HZ +.48845918 00 TZ +.95298885 00 TY +.30300536 00  
 SZI +.50359134 00 DAI +.30237887 02 RAI +.25236179 03  
 SZO +.25770428 00 DAD +.14933885 02 RAD +.23177616 03

ALL VECTORS REFERENCED TO ECLIPTIC PLANE

DY -4.5637881 01 DZ -2.7893649 01  
 MY -4.6073606-01 MZ +.52917415 00  
 PY +.15251911 00 PZ +.58358786 00  
 KY +.47991693 00 KZ +.86394195 00  
 TY +.30300536 00 TZ +.00000000 00  
 RAI +.25236179 03 RAZ +.25236179 03  
 RAD +.23177616 03

BTC +.41939799 05 BRC +.28747949 05  
 99 DAYS 16 HRS. 45 MIN. 43.425 SEC.

B +.50846745 05 THA +.14557102 03  
 235605556656202666277777 J.D. = 2438012.21476186 DEC. 13, 1962 17 09 15.425

EXTREME ELEVATION

CASE 1

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EARTH-VENUS, RADIATION PRES. CN

CHECK 2

11 GOLDSTONE

R +.56314655 08 HAEC +.13338846 02  
 MIN +1.4356572 06 HA +.35999413 03  
 CKC +2.7321600 03 CKM +.17996891 03  
 UT +2.3427620 04 DHA +4.1723913-02  
 ET +2.3427523 04 RGE +.56310637 06  
 RDI +.63720340 04 PHI +.35208070 02  
 DT +1.8783204 03 KFH +.96004999 09  
 BFI +.97681373 05 F1 +1.2668137 06  
 D1 +4.2227124 04 D2 +.65120915 04

LON +2.4319668 03  
 DEC -1.3343706 02  
 CKT +.47192466 02  
 DDE +.35428809-05  
 DRG +.14889348 02  
 THI +.24315082 03  
 RFI +.96004999 09  
 F2 +.19536275 06

ELE +4.1448203 02  
 PSS +.37308352 02  
 DUR +.00000000 00  
 SPS +.12426452 03  
 RF2 +.29668212 08  
 XA +.29669685 08

AZI +.17993744 03  
 PSM +.11364111 03  
 DAZ +.31551705-02  
 SLS +.24710588 03  
 PUL +.72443400 02  
 FA +.96004999 09  
 PRA +.22241341 03

99 DAYS 21 HRS. 40 MIN. 59.154 SEC.

235605567373202623600003 J.D. = 2438012.41980502 DEC. 13, 1962 22 04 31.154

END OF VIEW PERIOD

11 GOLDSTONE

R +.56579154 08 HAEC +.13401751 02  
 MIN +1.4386098 06 HA +.73868842 02  
 CKC +2.7324451 03 CKM +.17996858 03  
 UT +2.3427620 04 DHA +4.1720535-02  
 ET +2.3427633 04 RGE +.56578597 08  
 RDI +.63720340 04 PHI +.35208070 02  
 DT +1.8872366 03 RFI +.96004999 09  
 BFI +.95009405 05 F1 +1.2600981 06  
 D1 +4.2669935 04 D2 +.66006538 04

LON +1.6928718 03  
 DEC -1.3405710 02  
 CKT +.45227621 02  
 DDE -3.4715348-05  
 DRG +.15304175 02  
 THI +.24315082 03  
 RFI +.96004999 09  
 F2 +.19801962 06

ELE +.49999998 01  
 PSS +.37398106 02  
 DEL -3.1997026-02  
 DUR +.00000000 00  
 SPS +.12403520 03  
 RF2 +.29668212 08  
 XA +.29669726 08

AZI +.24972218 03  
 PSM +.11022675 03  
 DAZ +.25127548-02  
 SLS +.24714711 03  
 PUL +.10620616 03  
 FA +.96004999 09  
 PRA +.22251635 03

100 DAYS 11 HRS. 49 MIN. 36.368 SEC.

235605620265202061577761 J.D. = 2438013.00912486 DEC. 14, 1962 12 13 08.389

START OF VIEW PERIOD

11 GOLDSTONE

R +.57346940 08 HAEC +.13584950 02  
 MIN +1.4470360 06 HA +.28627852 03  
 CKC +2.7333547 03 CKM +.17997595 03  
 UT +2.4118267 04 DHA +4.1718964-02  
 ET +2.4118170 04 RGE +.57345984 06  
 RDI +.63720340 04 PHI +.35208070 02  
 DT +1.9128559 03 RFI +.96004999 09  
 BFI +.9720124 05 F1 +1.2672012 06  
 D1 +4.2240041 04 D2 +.65146749 04

LON +3.1686715 03  
 DEC -1.3588860 02  
 CKT +.30617401 02  
 DDE -3.7506941-05  
 DRG +.14901448 02  
 THI +.24315082 03  
 RFI +.96004999 09  
 F2 +.19544025 06

ELE +.49999998 01  
 PSS +.37636859 02  
 DEL +.31902922-02  
 DUR +.00000000 00  
 SPS +.12338666 03  
 RF2 +.29668212 08  
 XA +.29669686 08

AZI +.11051125 03  
 PSM +.10316422 03  
 DAZ +.25127548-02  
 SLS +.24726413 03  
 PUL +.25613208-05  
 FA +.96004999 09  
 PRA +.22284269 03

100 DAYS 16 HRS. 43 MIN. 54.897 SEC.

235605630763202562637777 J.D. = 2438013.21350574 DEC. 14, 1962 17 07 26.897

EXTREME ELEVATION

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRD 041765

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EARTH-VENUS, RADIATION PRES. CN

CHECK 2

11 GOLDSTONE

HADEC

R -57619118 08 LAT -13650689 02  
 MIN -14500391 06 HA -35995068 03  
 CKC -27336137 03 CKM -17997409 03  
 UT -24167319 04 UHA -41721331-02  
 ET -24167221 04 KGE -57614926 06  
 RDI -64720340 04 PHI -35208070 02  
 DT -19218268 03 RFB -96004999 04  
 BFI -11064737 06 FL -12942737 06  
 DL -44142458 04 U2 -66951583 04

LON -24320013 03  
 DEC -13655460 02  
 CKT -79897165 01  
 DDE -37863361-05  
 DRG -15746835 02  
 TH1 -24315062 03  
 RFI -96004999 04  
 F2 -20085475 06

ELE -41136446 02  
 PSS -37723421 02  
 DEL -24364495-09  
 DDR -00000000 00  
 SP5 -12153559 03  
 RFB -29668212 08  
 XA -29669769 08

AZI -17993513 03  
 PSM -10097619 03  
 DAZ -52816880-02  
 SLS -24730477 03  
 PUL -13683747 02  
 FA -96004999 09  
 PRA -22294910 03

100 DAYS 19 HRS. 31 MIN. 50.356 SEC.

235605635712202455507536 J.D. = 2438013.33011986 DEC. 14, 1962 19 55 22.357

GEOCENTRIC

X -4.1081922 04 Y -36296860 08  
 R -57782641 08 DHC -13687849 02  
 R -57782640 08 LAT -13687850 02  
 XS -14582444 04 YS -13388803 09  
 XM -22577100 06 YM -28624600 06  
 XT -41084644 06 YI -38300817 08  
 RS -19724146 09 VS -30247603 02  
 GED -13777587 02 ALT -57776254 08  
 DUT -35000000 02 DI -24000000 03  
 CCL -27336419 03 MCL -17998013 03

EQUATORIAL COORDINATES

Z -13673227 04 DX -74023300 01 DY -14859380 02 DZ -72436947 01  
 VA -18112613 02 V -18112613 02 PTH -68235511 02 AZ -12005623 03  
 LCN -20116672 04 VE -40881274 04 PTE -23575764 00 AZE -26995292 03  
 ZS -58056638 08 OXS -30000255 02 OYS -35421508 01 DZS -15347133 01  
 ZM -12788162 06 UXM -85772726 00 OYM -53310871 00 DZM -13084948 00  
 ZI -13648677 08 UXI -44341001 01 OYI -10897770 07 DTI -26887891 01  
 RW -38634573 06 VM -10183430 01 RTI -57802575 08 DTI -12059645 02  
 LOS -23983393 03 WAS -26167842 03 RAM -12826393 03 LOM -10641894 03  
 UR -16821471 02 SHA -35392949 08 DES -23222040 02 DES -19329668 02  
 ICL -32630208 03

HELIOCENTRIC

X -21469078 08 Y -10535806 09  
 R -10755688 09 LAT -14336311 07  
 RE -19882444 08 DL -14687849 02  
 XT -21501601 08 YI -10536418 09  
 LIE -10117320-04 LHF -82357275 02  
 EPS -12301625 03 ESP -19211890 02  
 MPS -12334400 03 MSP -19108989 02  
 EPT -11913395 03 ETP -60830594 02  
 SET -37400169 02 STL -12297074 03  
 GCE -86615805 02 GCI -73291786 03  
 REP -57782631 08 VEP -18112613 02

ECLIPTIC COORDINATES

Z -26909360 07 DX -37402585 02 DY -12654299 02 DZ -73542869 00  
 LON -10151762 03 V -39492093 02 PTH -71978411 01 AZ -90894727 02  
 ZE -24000000 02 DXE -30000255 02 DYE -18603336 01 DZE -11356622-02  
 ZI -27150700 07 UXI -34434355 02 UYI -71950176 01 UZI -18838057 01  
 LTI -14463002 01 LOT -10153394 03 RST -10756998 09 VST -35228423 02  
 SEP -37771895 02 EPM -37813586 00 EMP -80750818 02 MEP -98871069 02  
 SMP -37497010 02 SEM -13659433 03 EMS -43302559 02 ESM -10326686 00  
 TEP -35663121-01 TPS -10864178 03 TSP -19782341-01 STP -13133549 02  
 EST -19237084 02 RPH -57843469 08 RPT -40941986 05 SPN -12300993 03  
 SLP -99931756 02 CPT -11913896 03 SIN -11042893 03  
 CPF -80314032 02 CPS -10271886 03

APHRICENTRIC

X -32522779 05 Y -61173124 04  
 R -40941986 05 DEC -36070985 02  
 ALT -34741986 05 SHA -38789263 05  
 HGE -23678074 03 SVL -31715796 02

ECLIPTIC COORDINATES

Z -24105883 05 DX -29682299 01 DY -54592814 01 DZ -26192343 01  
 RA -34493475 03 V -67454686 01 PTH -12660726-06 AZ -24127988 03  
 ALP -12302172 02 DL -67706495-07 DP -94370840-02 ASD -87100270 01  
 HNG -11207159 03 SIA -11042393 03

APHRICENTRIC CONIC

EPOCH OF PERICENTRIC PASSAGE

235605635712202455501147 J.D. = 2438013.33011986 DEC. 14, 1962 19 55 22.356

CASE 1

IBSYS-JPTRAJ-SFPRD 041765

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EARTH-VENUS, RADIATION PRES. CN

CHECK 2

SMA -110968193 05 ECC -47327923 01  
 VH -54414910 01 C3 -29609825 02  
 TA -25613208-05 MTA -10219806 03  
 ZAE -13776095 03 ZAP -34980848 02

B -50738202 05  
 C1 -27609149 06  
 EA -00000000 00  
 ZAC -71962126 02

SLR -23471190 06  
 FFP -98943083-04  
 MA -28124896-05  
 DEF -24396129 02

APU -00000000 00  
 TF -10061377 03  
 TW -13207785 05  
 REA -40941986 05  
 LFF -10077751 03  
 TFI -10081377 03  
 GP -30447669 02

ALL VECTORS REFERENCED TO ECLIPTIC PLANE

X -32522779 05 Y -61173124 04 Z -24105883 05  
 INC -13514175 03 LAN -21640519 03 APF -23658779 03  
 MX -41082255 00 MY -56769796 00 WZ -70885411 00  
 QX -44416788 00 QY -80956431 00 QZ -38840984 00  
 BX -86743101 00 BY -25013427-01 BZ -49342078 00  
 SXI -26238659 00 SYI -82285879 00 SZI -50404540 00  
 SXO -59806759 00 SYO -75971682 00 SZO -25523606 00  
 ETE -31364342 03 ETS -46579462 02 ETC -26212929 03

DX -29682299 01 DY -54592814 01 DZ -26192343 01  
 MX -44016288 00 MY -80956431 00 MZ -38840984 00  
 PX -79436250 00 PY -14941416 00 PZ -58878147 00  
 RX -15312781 00 RY -48022248 00 RZ -86567711 00  
 DAI -30268004 02 KAI -25231415 03  
 DAO -14787573 02 KAO -23178931 03

T VECTOR IN ECLIPTIC PLANE

BTC -41042657 05 BRC -28986852 05 B -50738202 05  
 625535030676 625730425255 621606475633 601700261755  
 620900500 2337000

FHA -14515891 03  
 602465443457 575673744666  
 000000000000

EARTH  
 INITIAL  
 VENUS  
 END

END TRAJECTORY (SFPRD) 016441 6



C. Check case 3 is an Earth-Mars trajectory made during the design phase of the Mariner C mission. The spacecraft injects near the Earth on November 11, 1964 and encounters Mars 258.97 days later with a miss of 236,205 km. A minimum print was requested. Earth and Mars oblateness perturbations were included.

JPL TECHNICAL MEMORANDUM NO. 33-199

START TRAJECTORY (SFPRO) 000000 G

CASE 1 EBSYS-JPTRAJ-SFPRO 041765

1

EARTH - MARS CHECK 3

DOUBLE PRECISION EPHemeris TAPE - EPHEM1 S/C EPHemeris WRITTEN 016324G 041765 RUNID=(TRAJ03)

GME .3966063 06 J .16234500-02 H -.57499999-05 D .78749999-05 RE .63781650 04 REM .63783112 04
G .66709998-19 A .88781796 29 H .888800194 29 C .888836976 29 DME .41780741-02 AU .14959850 09
GMM .44026293 04 GMS .13271411 12 GMV .32476627 06 GMA .42971367 05 GMC .37918700 05 GMJ .12670935 00
EGM .39660320 06 MGM .44027779 04 JA .29200000-02 HA .00000000 00 DA .00000000 00 RA .34170000 04

INJECTION CONDITIONS 1950.0 MARS 235677237016202605402000 J.D.= 2438711.19601670 NOV. 11,1964 16 39 23.043

GEOCENTRIC XG .542060d7 04 YO .17802719 04 ZO .32653654 04 DXO-.27051733 01 UYO .11088835 02 DZO .78981014 00
CARTESIAN TC .59961042 05 GHA .30069470 03 GHO .50164659 02
DATE OF RUN 041765G 016450 EARTH IS THE CENTRAL BODY FOR INTEGRATION COWELL EQUATIONS OF MOTION

0 DAYS 0 HRS. 0 MIN. 0.000 SEC. 235677237016202605402000 J.D.= 2438711.19601670 NOV. 11,1964 16 39 23.043

GEOCENTRIC

EQUATORIAL COORDINATES

X .54194663 04 Y .17978477 04 Z -.32577224 04 DX -.27422009 01 DY .11080006 02 DZ .78601700 00
R .69738098 04 DEL -.29706737 02 RA .18520879 02 V .11441330 02 PTH .19036053 01 AZ .84370138 02
R .85738098 04 LAT -.29706739 02 LON .77658181 02 VE .11027283 02 PLE .19751097 01 AZE .84157781 02
XS -.76461613 08 YS -.10304310 04 ZS -.44685764 08 UXS .23091572 02 DYS -.17704550 02 DZS -.76783641 01
XM .25334946 06 YM -.26971397 06 ZM -.14600498 06 DXM .71534795 00 DYM .62824798 00 DZM .20905980 00
XT -.20584371 09 YT .93772019 08 ZT .48581444 08 DXT .23641340 01 DYT .25932608 02 DZT .10896690 02
RS .14806638 09 VS .30093671 02 RM .40100812 06 VM .97676315 00 RT .73139467 09 VT .28279808 02
GED -.29874523 02 ALI .20090686 03 LOS .28618862 03 RAS .22688352 03 RAM .31376712 03 LOM .13072418 02
DUT .35000000 02 DT .75000000 01 DM .38005918 00 SHA .53646702 04 DES .-17565394 02 DEM .-21351886 02
CGL .12196124 03 MCL .40307905 02 ICL .22181517 03

GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235677237005202701106200 J.D.= 2438711.19360542 NOV. 11,1964 16 38 47.509
SMA -.41317204 05 ECC .11587348 01 H .24217761 05 SLR .-14176526 05 APO .00000000 00 RCA .65670528 04
WH .31039069 01 C3 .96347346 01 C1 .75171617 05 TFP .35534115 02 TF .-41127447-03 LTF .-23138793-01
TA .35463218 01 MTA .14965626 03 EA .96198518 00 MA .15275302 00

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE

X .54194663 04 Y .17978477 04 Z -.32577224 04 DX -.27422009 01 DY .11080006 02 DZ .78601700 00
INC .30187602 02 LAN .97102443 02 APF .27620986 03 MX .-86438362 00 MY .05986647 00 MZ .85208402-01
WX .49897654 00 WY .62172189-01 WZ .86438362 00 PX .83934327 00 PY .21358915 00 PZ .-49988249 00
QX .-21570175 00 QY .97494321 00 QZ .56391739-01 RX .-43039015 00 RY .15917508 00 RZ .-88849737 00
BX .23787206 00 BY .94928832 00 BZ .-20559325 00 TX .34687610 00 TY .93791097 00 TZ .00000000 00
SXI .61539222 00 SYI .67685773 00 SZI .-40342572 00 DAI .-23823625 02 RAI .47723203 02
SXD .-83331314 00 SYD .30819850 00 SZD .45888167 00 DAO .27314968 02 RAO .15970383 03

BTQ .22883279 05 BRQ .79281447 04 H .24217761 05 THA .19109164 02 T VECTOR IN EARTH EQUATOR PLANE

ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET

X .-43063933 03 Y .54988291 04 Z .-35769763 04 DX .-10319328 02 DY .29379116 01 DZ .-39729283 01
INC .39497020 02 LAN .28258649 03 APF .23526778 03 MX .-90025614 00 MY .-28472205 00 MZ .-32935052 00
WX .-43063933 00 WY .46828726 00 WZ .77165765 00 PX .-98681145-02 PY .89249492 00 PZ .-52271127 00
QX .-90258240 00 QY .-23243893 00 QZ .-36237736 00 RX .-12453859 00 RY .-23734787 00 RZ .-96340854 00
BX .-70382110 00 BY .23005198 00 BZ .-57680204 00 TX .-88550390 00 TY .46463196 00 TZ .00000000 00
SXI .-40641443 00 SYI .61825264 00 SZI .-63417330 00 DAI .-39358695 02 RAI .12690694 03
SXD .-44763639 00 SYD .-89310201 00 SZD .26803707 00 DAO .155947494 02 RAO .24231359 03

CASE 1 EBSYS-JPTRAJ-SFPRO 041765

2

EARTH - MARS CHECK 3

BTQ .24169739 05 BRQ .-19243946 04 B .24217764 05 THA .35639111 03 T VECTOR IN ORBIT PLANE OF TARGET

0 DAYS 0 HRS. 5 MIN. 50.668 SEC. 23567723714620233032710 J.D.= 2438711.19807535 NOV. 11,1964 16 45 13.711

START OF VIEW PERIOD

41 WOODNER HABECL

R .73104551 04 LAT .-21913748 02 LON .11117700 03
MIN .58444723 01 HA .77346002 02 DEC .10776721 02
CKC .65138162 02 CKM .34355178 03 CKT .16468715 03
DT .47407177 01 DHA .-17165033 00 DDL .-53962399-01
ET .21866374 00 RGI .42680964 04 DRG .-37157797 01
RDI .63726349 04 PHI .-31711875 02 THL .13688727 03
DT .10239246 01 RFB .96004999 09 RFI .96004999 09
BFI .38100655 05 FI .67100654 05 F2 .76201310 05
DI .22366685 04 D2 .25400947 04 DDP .18460417 03

0 DAYS 0 HRS. 13 MIN. 25.629 SEC. 235677237330202126047771 J.D.= 2438711.20334111 NOV. 11,1964 16 52 48.672

EXTREM ELEVATION

41 WOODNER HABECL

R .94767954 04 LAT .-94729852 01 LON .13634373 03
MIN .13427128 02 HA .13039093 01 DEC .24102885 02
CKC .28622479 03 CKM .17883042 03 CKT .76638563-01
DT .22378596 00 DHA .-93410073-01 DDL .20182813-02
ET .21866374 00 RGI .42680964 04 DRG .66632083 01
RDI .63726349 04 PHI .-31711875 02 THL .13688727 03
DT .14236855 01 RFB .96004999 09 RFI .96004999 09
BFI .11318145 05 FI .67100654 05 F2 .14267627 06
DI .33466045 04 D2 .47558757 04 DDP .42574607 02

0 DAYS 0 HRS. 58 MIN. 23.941 SEC. 235677240572702912631072 J.D.= 2438711.23456694 NOV. 11,1964 17 37 46.584

START OF VIEW PERIOD

11 GOLDSTONE HABECL

R .25274955 05 LAT .14065439 02 LON .16718489 03
MIN .58392355 02 HA .88099518 02 DEC .59881711 01
CKC .24029951 03 CKM .154869310 03 CKT .34016476 03
DT .37327592 00 DHA .-66494237-02 DDL .50537278-02
ET .46343370 00 RGI .29170307 02 DRG .91428878 01
RDI .63726349 04 PHI .-31711875 02 THL .24315082 03
DT .80623455 01 RFB .96004999 09 RFI .96004999 09
BFI .66667469 05 FI .67100654 05 F2 .13293698 06
DI .31823163 04 D2 .44312992 04 DDP .94743906 00

0 DAYS 1 HRS. 7 MIN. 51.639 SEC. 235677241010202927173207 J.D.= 2438711.24114214 NOV. 11,1964 17 47 14.682

EXTREM ELEVATION

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

185YS-JPTRAJ-SFPRO 041765

3

EARTH - MARS

CHECK 3

41 WOOMERA HADEC

R .28707454 05	LAT .15541228 02	LON .16789739 03	ELE .22755152 02	AZI .37068277 02
MN .67860642 02	HA .32202550 03	DEC .25395915 02	PSS .10124796 03	PSM .17504134 03
CKC .26584786 03	CKM .18416428 03	CKT .56930040 01	DEL .00000000 00	DAZ -.82009333-03
UT .11310107 01	DHA .68746103-03	DDE .43157301-03	DOR-.37371986-03	SLS .18027062 03
ET .11212885 01	RGE .25634663 05	DRG .56449693 01	DDR-.11071971-09	PUL .29053117 03
ROI .63726039 04	PHI-.31211875 02	THI .13688727 03	SPS .78742311 02	FA .96004999 09
DT .85507955-01	RFB .96004999 09	KF1 .96004999 09	RF2 .29668212 08	PRA .13256807 03
BF1 .68077345 05	F1 .97077345 05	F2 .13615469 06	XA .29668770 08	DF2-.23935872 01
D1 .32359115 04	D2 .45384897 04	DOP-.23934626 01	DF1-.11967936 01	

0 DAYS 1 HRS. 51 MIN. 34.505 SEC.

2356772422302023C6063004 J.D.= 2438711.27149938 NOV. 11,1964 18 30 57.548

EXTREME ELEVATION

11 GOLDSTONE HADEC

R .42487724 05	LAT .19425995 02	LON .16569189 03	ELE .12627887 02	AZI .27947768 03
MIN .11157508 03	HA .84894975 02	DEC .14911680 02	PSS .10374106 03	PSM .16946661 03
CKC .25409903 03	CKM .17205290 03	CKT .35393420 03	DEL-.14525590-02	UAZ .18500019-02
UT .18598624 01	DHA .10307962-02	DDE .15055734-02	DDR-.73492546-04	SLS .18427255 03
ET .18498624 01	RGE .40637238 05	DRG .90797076 01	SPS .76193669 02	PUL .13164146 03
ROI .63720340 04	PHI .35208070 02	THI .24315082 03	RF2 .29668212 08	FA .96004999 09
DT .13555121 00	RFB .96004999 09	KF1 .96004999 09	XA .29668714 08	PRA .12692068 03
BF1 .66267162 05	F1 .95267162 05	F2 .13253432 06	DF1-.23535118 00	DF2-.47070237 00
D1 .31195720 04	D2 .44178108 04	DOP-.47067785 00		

0 DAYS 2 HRS. 38 MIN. 51.168 SEC.

235677243535202433042177 J.D.= 2438711.30433114 NOV. 11,1964 19 18 14.211

END OF VIEW PERIOD

11 GOLDSTONE HADEC

R .56233558 05	LAT .21395650 02	LON .15885759 03	ELE .10214350 02	AZI .28479461 03
MIN .15885280 03	HA .90000000 02	DEC .17913106 02	PSS .98374648 02	PSM .17578290 03
CKC .25879639 03	CKM .17637449 03	CKT .35863128 03	DEL-.14525590-02	UAZ .18989237-02
UT .26475468 01	DHA .23622032-02	DDE .74183679-03	DDR-.66289583-04	SLS .18686220 03
ET .26378245 01	RGE .54752837 05	DRG .48764806 01	SPS .81604387 02	PUL .13024477 03
ROI .63720340 04	PHI .35208070 02	THI .24315082 03	RF2 .29668212 08	FA .96004999 09
DT .18263578 00	RFB .96004999 09	KF1 .96004999 09	XA .29668694 08	PRA .13366765 03
BF1 .65616351 05	F1 .94616351 05	F2 .13123270 06	DF1-.21228454 00	DF2-.42456909 00
D1 .31538783 04	D2 .43744234 04	DOP-.42454698 00		

0 DAYS 4 HRS. 29 MIN. 10.329 SEC.

23567724672420257454010 J.D.= 2438711.38094179 NOV. 11,1964 21 08 33.372

EXTREME ELEVATION

CASE 1

185YS-JPTRAJ-SFPRO 041765

4

EARTH - MARS

CHECK 3

41 WOOMERA HADEC

R .85487236 05	LAT .23475263 02	LON .13715056 03	ELE .31683818 02	AZI .29615789 00
MIN .26917214 03	HA .35971709 03	DEC .27103681 02	PSS .90910393 02	PSM .16914906 03
CKC .27083620 03	CKM .18762835 03	CKT .10658889 02	DEL .00000000 00	DAZ-.46172515-02
UT .44862023 01	DHA .38428194-02	DDE .16976693-04	DDR-.26138638-04	SLS .19038816 03
ET .44764801 01	RGE .82168376 05	DRG .42691754 01	SPS .69057811 02	PUL .25090216 03
ROI .63726039 04	PHI-.31211875 02	THI .13688727 03	RF2 .29668212 08	FA .96004999 09
DT .27408416 00	RFB .96004999 09	KF1 .96004999 09	XA .29668634 08	PRA .14534215 03
BF1 .63671529 05	F1 .92671528 05	F2 .12734306 06	DF1-.63705892-01	DF2-.16741179 00
D1 .30890509 04	D2 .42447685 04	DOP-.16740307 00		

0 DAYS 9 HRS. 4 MIN. 44.114 SEC.

235677256771202624036402 J.D.= 2438711.57230505 NOV. 12,1964 01 44 07.157

END OF VIEW PERIOD

41 WOOMERA HADEC

R .15188983 06	LAT .25186489 02	LON .73711471 02	ELE .49999998 01	AZI .30547913 03
MIN .54473522 03	HA .69239299 02	DEC .26701548 02	PSS .87980697 02	PSM .16881881 03
CKC .27158268 03	CKM .18681885 03	CKT .11375078 02	DEL-.27576970-02	DAZ-.22765480-02
UT .90789203 01	DHA .39964068-02	UDE-.40932680-04	SPS .51204038-05	SLS .19568520 03
ET .90691981 01	RGE .19120170 06	DRG .41318458 01	RF2 .29668212 08	PUL .19781903 03
ROI .63726039 04	PHI-.31211875 02	THI .13688727 03	XA .29668634 08	FA .96004999 09
DT .50435451 00	RFB .96004999 09	KF1 .96004999 09	DF1-.16397487-01	PRA .14889937 03
BF1 .63231746 05	F1 .92231746 05	F2 .12646349 06	DF2-.32794974-01	
D1 .30743915 04	D2 .42154498 04	DOP-.32793267-01		

0 DAYS 16 HRS. 3 MIN. 35.643 SEC.

235677273204202527632767 J.D.= 2438711.86317923 NOV. 12,1964 08 42 58.686

START OF VIEW PERIOD

11 GOLDSTONE HADEC

R .24440763 06	LAT .26013783 02	LON .33179259 03	ELE .14232336 02	AZI .68933612 02
MIN .96359403 03	HA .27000000 03	DEC .25240923 02	PSS .82303859 02	PSM .16597682 03
CKC .27250371 03	CKM .18602131 03	CKT .12250009 02	DEL .31787964-02	DAZ .20088750-02
UT .16059900 02	DHA .41205723-02	DDE .68656901-04	DDR-.61114379-05	SLS .19979772 03
ET .16050178 02	RGE .24276298 06	DRG .32367789 01	SPS .97603013 02	POL .87337137 01
ROI .63720340 04	PHI .35208070 02	THI .24315082 03	RF2 .29668212 08	FA .96004999 09
DT .80977002 00	RFB .96004999 09	KF1 .96004999 09	XA .29668532 08	PRA .15540360 03
BF1 .60365400 05	F1 .89365400 05	F2 .12073080 06	DF1-.19571156-01	DF2-.39142312-01
D1 .29788467 04	D2 .40243600 04	DOP-.39140274-01		

0 DAYS 22 HRS. 2 MIN. 24.581 SEC.

235677305612202717777777 J.D.= 2438712.11235677 NOV. 12,1964 14 41 47.625

EXTREME ELEVATION

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRD 041765

5

EARTH - MARS CHECK 3

11 GOLDSTONE HADEC  
 R .32048308 06 LAT .26332138 02  
 MIN .13224097 04 HA .38004100-01  
 CKC .27334355 03 CKM .18574581 03  
 UT .22040161 02 DHA .42092378-02  
 ET .22030439 02 RGE .31388890 06  
 RDI .63720340 04 PHI .35208070 02  
 DT .10470205 01 RFB .96004999 09  
 BFI .61119920 05 F1 .90119919 05  
 D1 .36039973 04 D2 .40746613 04

LON .24311272 03  
 DEC .26152673 02 ELE .80944529 02 AZI .18024147 03  
 CKT .13050181 02 PSS .82989944 02 PSM .16826951 03  
 DDE .13282553-04 DEL .35948373-09 UAZ .21997915-01  
 DRG .34723908 01 DDR .21062289-04 SLS .20202959 03  
 TH1 .24315062 03 SPS .96889440 02 PUL .66385270 02  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .12223984 06 XA .29668955 08 PRA .15531430 03  
 DDP .13487195 00 DF1 .67449487-01 UF2 .13489898 00

1 DAYS 0 HRS. 52 MIN. 28.433 SEC.

235677312601202674677771 J.D.= 2438712.23045689 NOV. 12,1964 17 31 51.476

START OF VIEW PERIOD

41 WOOMERA HADEC  
 R .35544450 06 LAT .26433460 02  
 MIN .14924738 04 HA .29510273 03  
 CKC .27469251 03 CKM .18664314 03  
 UT .24874564 02 DHA .41802313-02  
 ET .24864642 02 RGE .35482739 06  
 RDI .63726039 04 PHI .31211875 02  
 DT .11035999 01 RFB .96004999 09  
 BFI .59493593 05 F1 .88993999 05  
 D1 .29664532 04 D2 .39995733 04

LON .20089603 03  
 DEC .27079432 02 ELE .49999998 01 AZI .54032984 02  
 CKT .14480262 02 PSS .82417746 02 PSM .16635982 03  
 DDE .28888848-04 DEL .28754132-02 UAZ .23724553-02  
 DRG .31208777 01 DDR .78710615-05 SLS .20309429 03  
 TH1 .13688727 03 SPS .97440075 02 PUL .29644058 03  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .11998720 06 XA .29668520 08 PRA .15661926 03  
 DDP .50537749-01 DF1 .25270190-01 UF2 .50540381-01

1 DAYS 4 HRS. 1 MIN. 3.336 SEC.

235677320216202457600002 J.D.= 2438712.36141635 NOV. 12,1964 20 40 26.373

END OF VIEW PERIOD

11 GOLDSTONE HADEC  
 R .39419704 06 LAT .26523594 02  
 MIN .16810555 04 HA .90000001 02  
 CKC .27325794 03 CKM .18475267 03  
 UT .28017541 02 DHA .41408669-02  
 ET .28007647 02 RGE .39249569 06  
 RDI .61720340 04 PHI .35208070 02  
 DT .13022245 01 RFB .96004999 09  
 BFI .61993470 05 F1 .90993469 05  
 D1 .30331156 04 D2 .41328980 04

LON .15399668 03  
 DEC .26046246 02 ELE .14664581 02 AZI .29176807 03  
 CKT .12924667 02 CKT .12924667 02 PSM .17032008 03  
 DDE .12825492-04 DEL .14849765-02 UAZ .20478740-02  
 DRG .37451721 01 DDR .24046908-05 SLS .20397077 03  
 TH1 .24315062 03 SPS .96617079 02 PUL .12391140 03  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .12398694 06 XA .29668582 08 PRA .19526003 03  
 DDP .15401954-01 DF1 .17701378-02 UF2 .15402758-01

1 DAYS 5 HRS. 9 MIN. 45.876 SEC.

23567732225202165500004 J.D.= 2438712.40913101 NOV. 12,1964 21 49 08.919

EXTREME ELEVATION

CASE 1

IBSYS-JPTRAJ-SFPRD 041765

6

EARTH - MARS CHECK 3

41 WOOMERA HADEC  
 R .46018349 06 LAT .26551961 02  
 MIN .17497666 04 HA .35999566 03  
 CKC .27478627 03 CKM .18612316 03  
 UT .27162743 02 DHA .42130407-02  
 ET .29193620 02 RGE .40462016 06  
 RDI .63726039 04 PHI .31211875 02  
 DT .13503345 01 RFB .96004999 09  
 BFI .60881121 05 F1 .889881121 05  
 D1 .29960373 04 D2 .40587414 04

LON .13689154 03  
 DEC .27314896 02 ELE .31473229 02 AZI .13986227-01  
 CKT .14443382 02 PSS .83007551 02 PSM .16707163 03  
 DDE .28465302-06 DEL .16655452-10 UAZ .14198915-02  
 DRG .33978217 01 DDR .23483918-04 SLS .20424931 03  
 TH1 .13688727 03 SPS .96836862 02 PUL .24569043 03  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .12176224 06 XA .29668548 08 PRA .15622513 03  
 DDP .15040110 00 DF1 .75204466-01 UF2 .15040894 00

1 DAYS 9 HRS. 27 MIN. 13.599 SEC.

235677331653202122170003 J.D.= 2438712.58742410 NOV. 13,1964 02 06 36.642

END OF VIEW PERIOD

41 WOOMERA HADEC  
 R .46018387 06 LAT .26647141 02  
 MIN .20072266 04 HA .64841681 02  
 CKC .27453583 03 CKM .18533242 03  
 UT .31653777 02 DHA .41746027-02  
 ET .33444555 02 RGE .45981469 06  
 RDI .63726039 04 PHI .31211875 02  
 DT .15337765 01 RFB .96004999 09  
 BFI .61798903 05 F1 .90798903 05  
 D1 .36768601 04 D2 .41199269 04

LON .72732435 02  
 DEC .27141081 02 ELE .49999998 01 AZI .30604596 03  
 CKT .14166138 02 PSS .83354659 02 PSM .16852825 03  
 DDE .18834210-04 DEL .20749412-02 UAZ .23617951-02  
 DRG .36844154 01 DDR .91405363-05 SLS .20534573 03  
 TH1 .13688727 03 SPS .96468474 02 PUL .19491262 03  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .12359761 06 XA .29668576 08 PRA .15592088 03  
 DDP .58541843-01 DF1 .29272446-01 UF2 .58544892-01

1 DAYS 10 HRS. 8 MIN. 43.704 SEC.

235677345461202537472725 J.D.= 2438712.66674475 NOV. 13,1964 08 48 06.747

START OF VIEW PERIOD

11 GOLDSTONE HADEC  
 R .54102141 06 LAT .26746517 02  
 MIN .27494434 04 HA .27000000 03  
 CKC .27494434 03 CKM .18460343 03  
 UT .44014947 02 DHA .41658876-02  
 ET .44013570 02 RGE .51935789 06  
 RDI .63720340 04 PHI .35208070 02  
 DT .17991040 01 RFB .96004999 09  
 BFI .59971118 05 F1 .88573318 05  
 D1 .29502449 04 D2 .39715565 04

LON .33253338 03  
 DEC .26399349 02 ELE .14853435 02 AZI .67923391 02  
 CKT .14129508 02 PSS .81891759 02 PSM .16919265 03  
 DDE .23677451-04 DEL .31668868-02 UAZ .20418418-02  
 DRG .29894372 01 DDR .12459483-05 SLS .20673161 03  
 TH1 .24315062 03 SPS .97901433 02 PUL .74912276 01  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .11914664 06 XA .29668507 08 PRA .15767635 03  
 DDP .79770265-02 DF1 .39887210-02 UF2 .79774418-02

1 DAYS 22 HRS. 6 MIN. 31.686 SEC.

23567736050202535277760 J.D.= 2438713.11521677 NOV. 13,1964 14 45 54.729

EXTREME ELEVATION

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRD 041765

7

EARTH - MARKS CHECK 3

11 GOLDSTONE HADEC

R .61220466 06 LAT .26815268 02  
 MIN .27652981 04 HA .91304778-02  
 CKC .27475741 03 CKM .18424525 03  
 UT .46108601 02 DHA .42056489-02  
 ET .46099079 02 RGE .60590158 06  
 RDI .63720340 04 PHI .35208070 02  
 DT .20210698 01 RFB .96004999 09  
 BF1 .60579085 05 F1 .89579085 05  
 D1 .29859695 04 02 .40386057 04

LON .24314178 03  
 DEC .26727319 02  
 CKT .14302104 02  
 DDE .33135784-05  
 DRG .33035058 01  
 THI .24315082 03  
 RFI .96004999 09  
 F2 .12115817 06  
 DDP .15229521 00  
 ELE .81519237 02  
 PSS .82526114 02  
 DEL .11191100-09  
 DOR .23779668-04  
 SPS .97241184 02  
 RF2 .29668212 08  
 XA .29668538 08  
 DF1 .76151572-01  
 AZI .18009867 03  
 PSM .16828738 03  
 DAZ .14261885-01  
 SLS .20774211 03  
 POL .65427679 02  
 FA .96004999 09  
 PRA .15736204 03  
 DF2 .15230315 00

2 DAYS 0 HRS. 54 MIN. 22.017 SEC.

235677364776202207477757 J.D.= 2438713.23177151 NOV. 13,1964 17 33 45.060

START OF VIEW PERIOD

41 WOOMERA HADEC

R .64562124 06 LAT .26841987 02  
 MIN .29363669 04 HA .29520998 03  
 CKC .27443256 03 CKM .18467486 03  
 UT .48906115 02 DHA .41861815-02  
 ET .48896393 02 RGE .64483460 06  
 RDI .63720340 04 PHI .31211875 02  
 DT .21509366 01 RFB .96004999 09  
 BF1 .59525952 05 F1 .88525952 05  
 D1 .29508650 04 02 .39683968 04

LON .20118667 03  
 DEC .27197779 02  
 CKT .14958194 02  
 GDE .15260463-04  
 DRG .29746462 01  
 THI .13688727 03  
 RFI .96004999 09  
 F2 .11905190 06  
 DDP .64556316-01  
 ELE .49999998 01  
 PSS .82339999 02  
 DEL .28824943-02  
 DOR .10079948-04  
 SPS .97412441 02  
 RF2 .29668212 08  
 XA .29668505 08  
 DF1 .32279839-01  
 AZI .53880752 02  
 PSM .16644544 03  
 DAZ .23658362-02  
 SLS .20826304 03  
 POL .29601863 03  
 FA .96004999 09  
 PRA .15797221 03  
 DF2 .64559678-01

2 DAYS 4 HRS. 4 MIN. 31.028 SEC.

23567737244220241110000/ J.D.= 2438713.36382026 NOV. 13,1964 20 43 54.071

END OF VIEW PERIOD

11 GOLDSTONE HADEC

R .66294925 06 LAT .26868908 02  
 MIN .31245171 04 HA .90000001 02  
 CKC .27457440 03 CKM .18355329 03  
 UT .52075785 02 DHA .41656561-02  
 ET .52066562 02 RGE .68126687 06  
 RDI .63720340 04 PHI .35208070 02  
 DT .22724614 01 RFB .96004999 09  
 BF1 .61598746 05 F1 .90598746 05  
 D1 .30194582 04 02 .41065831 04

LON .15364048 03  
 DEC .26594136 02  
 CKT .14078366 02  
 DDE .10705148-04  
 DRG .36219128 01  
 THI .24315082 03  
 RFI .96004999 09  
 F2 .12319749 06  
 DDP .51955020-02  
 ELE .14957446 02  
 PSS .82411585 02  
 DEL .28824943-02  
 DOR .10079948-04  
 SPS .9626515 02  
 RF2 .29668212 08  
 XA .29668570 08  
 DF1 .25778852-02  
 AZI .29224703 03  
 PSM .16690853 03  
 DAZ .20480711-02  
 SLS .20876041 03  
 POL .12333810 03  
 FA .96004999 09  
 PRA .15711345 03  
 DF2 .51557705-02

2 DAYS 5 HRS. 11 MIN. 30.249 SEC.

235677374417202245277777 J.D.= 2438713.41033903 NOV. 13,1964 21 50 53.292

EXTREME ELEVATION

CASE 1

IBSYS-JPTRAJ-SFPRD 041765

8

EARTH - MARKS CHECK 3

41 WOOMERA HADEC

R .69612972 06 LAT .26877650 02  
 MIN .31795641 04 HA .35999965 03  
 CKC .27444756 03 CKM .18433708 03  
 UT .51191735 02 DHA .42052850-02  
 ET .51182013 02 RGE .69276233 06  
 RDI .63720340 04 PHI .31211875 02  
 DT .23108727 01 RFB .96004999 09  
 BF1 .60904785 05 F1 .89504785 05  
 D1 .29836428 04 02 .40336524 04

LON .13688761 03  
 DEC .27325044 02  
 CKT .14943884 02  
 DDE .12114746-04  
 DRG .32803041 01  
 THI .13688727 03  
 RFI .96004999 09  
 F2 .12100957 06  
 DDP .16041870 00  
 ELE .31463082 02  
 PSS .82832090 02  
 DEL .13744012-09  
 DOR .25048085-04  
 SPS .96901625 02  
 RF2 .29668212 08  
 XA .29668536 08  
 DF1 .86213527-01  
 AZI .98911702-02  
 PSM .16507589 03  
 DAZ .16097312-03  
 SLS .20890800 03  
 POL .24525889 03  
 FA .96004999 09  
 PRA .15764285 03  
 DF2 .16042705 00

2 DAYS 9 HRS. 28 MIN. 45.473 SEC.

235677404042202102034011 J.D.= 2438713.58898745 NOV. 14,1964 02 08 08.516

END OF VIEW PERIOD

41 WOOMERA HADEC

R .74666870 06 LAT .26908131 02  
 MIN .34487579 04 HA .64773729 02  
 CKC .27526443 03 CKM .18362572 03  
 UT .57479297 02 DHA .41823622-02  
 ET .57469575 02 RGE .74608631 06  
 RDI .63720340 04 PHI .31211875 02  
 DT .24866757 01 RFB .96004999 09  
 BF1 .61489115 05 F1 .90489115 05  
 D1 .30163038 04 02 .40992743 04

LON .72537816 02  
 DEC .27215641 02  
 CKT .14731305 02  
 DDE .12114746-04  
 DRG .35876784 01  
 THI .13688727 03  
 RFI .96004999 09  
 F2 .12297823 06  
 DDP .65991006-01  
 ELE .49999998 01  
 PSS .83187426 02  
 DEL .28809855-02  
 DOR .10303963-04  
 SPS .96525558 02  
 RF2 .29668212 08  
 XA .29668566 08  
 DF1 .32997221-01  
 AZI .30614233 03  
 PSM .16358040 03  
 DAZ .23613363-02  
 SLS .20954885 03  
 POL .19451012 03  
 FA .96004999 09  
 PRA .15735832 03  
 DF2 .65994443-01

2 DAYS 16 HRS. 7 MIN. 34.266 SEC.

23567741760202247463471 J.D.= 2438713.86594108 NOV. 14,1964 08 46 57.309

START OF VIEW PERIOD

11 GOLDSTONE HADEC

R .82469330 06 LAT .26947403 02  
 MIN .38475711 04 HA .27000000 03  
 CKC .27522743 03 CKM .18332088 03  
 UT .64126184 02 DHA .41727100-02  
 ET .64116462 02 RGE .82301849 06  
 RDI .63720340 04 PHI .35208070 02  
 DT .27452938 01 RFB .96004999 09  
 BF1 .59433594 05 F1 .88333594 05  
 D1 .29444531 04 02 .39555730 04

LON .33274504 03  
 DEC .26719997 02  
 CKT .14648416 02  
 DDE .14238938-04  
 DRG .79145792 01  
 THI .24315082 03  
 RFI .96004999 09  
 F2 .11866719 06  
 DDP .34203030-02  
 ELE .15024580 02  
 PSS .82427984 02  
 DEL .31608802-02  
 DOR .53405270-06  
 SPS .97255899 02  
 RF2 .29668212 08  
 XA .29668500 08  
 DF1 .17102406-02  
 AZI .67642751 02  
 PSM .16352204 03  
 DAZ .20452045-02  
 SLS .21040226 03  
 POL .73158019 01  
 FA .96004999 09  
 PRA .15837187 03  
 DF2 .34204811-02

2 DAYS 27 HRS. 5 MIN. 32.164 SEC.

235677432171202632437763 J.D.= 2438714.11452786 NOV. 14,1964 14 44 55.207

EXTREME ELEVATION

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

9

EARTH - PAKS CHECK 3

11 GOLDSTONE

HADEC  
 R .89444021 06 LAT .26976256 02  
 MIN .42055360 04 HA .39176941-02  
 CKC .27533934 03 CKM .18304828 03  
 UT .70092266 02 DHA .41995586-02  
 ET .70082563 02 RGE .88813430 06  
 RDI .63720340 04 PHI .35208070 02  
 DT .29624967 01 RFB .96004999 09  
 BF1 .60381397 05 F1 .89381397 05  
 D1 .29749378 04 D2 .40254238 04

LN .24314693 03  
 DFC .26917398 02  
 CKT .14718894 02  
 UDE .14488960-05  
 DRG .32417615 01  
 THI .24315082 03  
 RFI .96004999 09  
 F2 .12076721 06  
 DDP .15549792 00  
 ELC .81709312 02  
 PSS .82969162 02  
 DEL .20570073-09  
 DNR .24279745-04  
 SPS .96689264 02  
 RF2 .29668212 08  
 XA .29668532 08  
 DFI .77753010-01  
 AZI .18011787 03  
 PSM .16034027 03  
 DAZ .53296082-02  
 SLS .21106364 03  
 PUL .65298115 02  
 FA .96004999 09  
 PRA .15810419 03  
 DF2 .15550602 00

3 DAYS 0 HRS. 52 MIN. 41.624 SEC.

235677437105202125277757 J.D. = 2438714.23060957 NOV. 14, 1964 17 32 04.667

START OF VIEW PERIOD

41 WOOMERA

HADEC  
 R .92922655 06 LAT .26988064 02  
 MIN .43726436 04 HA .29524460 03  
 CKC .27579576 03 CKM .18333511 03  
 UT .72878227 02 DHA .41854944-02  
 ET .72868504 02 RGE .92635169 06  
 RDI .64726039 04 PHI .31211875 02  
 DT .30899762 01 RFB .96004999 09  
 BF1 .99343705 05 F1 .88343705 05  
 D1 .29447901 04 D2 .39562470 04

LN .20130071 03  
 DEC .27235779 02  
 CKT .15156079 02  
 DDE .10429267-04  
 DRG .29177366 01  
 THI .13688727 03  
 RFI .96004999 09  
 F2 .11868741 06  
 DDP .67632326-01  
 ELE .49999498 01  
 PSS .82889736 02  
 DEL .28832519-02  
 DNR .10560242-04  
 SPS .96754037 02  
 RF2 .29668212 08  
 XA .29668500 08  
 DFI .33817924-01  
 AZI .53831702 02  
 PSM .15861467 03  
 DAZ .23618971-02  
 SLS .21142955 03  
 PUL .29602014 03  
 FA .96004999 09  
 PRA .15850378 03  
 DF2 .67635848-01

3 DAYS 4 HRS. 3 MIN. 37.572 SEC.

235677444565202116600000 J.D. = 2438714.36320156 NOV. 14, 1964 20 43 00.615

END OF VIEW PERIOD

11 GOLDSTONE

HADEC  
 R .96398117 06 LAT .27000445 02  
 MIN .45636261 04 HA .90000001 02  
 CKC .27518521 03 CKM .18253723 03  
 UT .76080435 02 DHA .41717661-02  
 ET .76050712 02 RGE .96230477 06  
 RDI .63720340 04 PHI .35208070 02  
 DT .32099027 01 RFB .96004999 09  
 BF1 .61432838 05 F1 .90432838 05  
 D1 .30144279 04 D2 .40955225 04

LN .15349812 03  
 DEC .26805975 02  
 CKT .14523080 02  
 DDE .84921185-05  
 DRG .35701049 01  
 THI .24315082 03  
 RFI .96004999 09  
 F2 .12286568 06  
 DDP .26184988-02  
 ELE .15070415 02  
 PSS .83346239 02  
 DEL .21551930-02  
 DNR .40885746-06  
 SPS .96283332 02  
 RF2 .29668212 08  
 XA .29668565 08  
 DFI .13093176-02  
 AZI .29243257 03  
 PSM .15714345 03  
 DAZ .20475617-02  
 SLS .21116032 03  
 PUL .13276842 03  
 FA .96004999 09  
 PRA .15787574 03  
 DF2 .26186352-02

3 DAYS 5 HRS. 9 MIN. 58.328 SEC.

235677446530202257400000 J.D. = 2438714.40927512 NOV. 14, 1964 21 49 21.371

EXTREME ELEVATION

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

10

EARTH - PAKS CHECK 3

41 WOOMERA

HADEC  
 R .97584275 06 LAT .27004495 02  
 MIN .46299720 04 HA .81634521-03  
 CKC .27580179 03 CKM .18309037 03  
 UT .77166200 02 DHA .41993533-04  
 ET .77156477 02 RGE .97350128 06  
 RDI .63726039 04 PHI .31211875 02  
 DT .32472502 01 RFB .96004999 09  
 BF1 .60344143 05 F1 .89344143 05  
 D1 .29781381 04 D2 .40229429 04

LN .13688646 03  
 DEC .27323316 02  
 CKT .15131911 02  
 DDE .52880588-07  
 DRG .32301408 01  
 THI .13688727 03  
 RFI .96004999 09  
 F2 .12068829 06  
 DDP .16283569 00  
 ELE .31464810 02  
 PSS .83309580 02  
 DEL .91200913-10  
 DNR .25425385-04  
 SPS .96315704 02  
 RF2 .29668212 08  
 XA .29668531 08  
 DFI .61421787-01  
 AZI .35998601 03  
 PSM .15612227 03  
 DAZ .26416352-03  
 SLS .21186080 03  
 PUL .24524955 03  
 FA .96004999 09  
 PRA .15824327 03  
 DF2 .16284357 00

3 DAYS 9 HRS. 27 MIN. 19.246 SEC.

235677456154202445014002 J.D. = 2438714.58798946 NOV. 15, 1964 02 06 42.289

END OF VIEW PERIOD

41 WOOMERA

HADEC  
 R .10266695 07 LAT .27019067 02  
 MIN .48873207 04 HA .64749066 02  
 CKC .27566471 03 CKM .18271435 03  
 UT .81455345 02 DHA .41831765-02  
 ET .81445622 02 RGE .10260944 07  
 RDI .63726039 04 PHI .31211875 02  
 DT .34226821 01 RFB .96004999 09  
 BF1 .61446190 05 F1 .90346349 03  
 D1 .30115450 04 D2 .40897566 04

LN .72447009 02  
 DFC .27242672 02  
 CKT .14964693 02  
 DDE .89877241-05  
 DRG .35430975 01  
 THI .13688727 03  
 RFI .96004999 09  
 F2 .12269270 06  
 DDP .68092126-01  
 ELE .49999998 01  
 PSS .83636687 02  
 DEL .28822286-02  
 DNR .10632036-04  
 SPS .95968071 02  
 RF2 .29668212 08  
 XA .29668562 08  
 DFI .34047836-01  
 AZI .30617727 03  
 PSM .15358703 03  
 DAZ .23595091-02  
 SLS .21231782 03  
 PUL .14648753 03  
 FA .96004999 09  
 PRA .15800364 01  
 DF2 .68095672-01

3 DAYS 16 HRS. 5 MIN. 2.258 SEC.

235677471672202246410435 J.D. = 2438714.86418172 NOV. 15, 1964 08 44 25.301

START OF VIEW PERIOD

11 GOLDSTONE

HADEC  
 R .11034953 07 LAT .27038592 02  
 MIN .52850375 04 HA .27000000 03  
 CKC .27562786 03 CKM .18232844 03  
 UT .88083959 02 DHA .41749724-02  
 ET .88074236 02 RGE .11018178 07  
 RDI .63720340 04 PHI .35208070 02  
 DT .36752679 01 RFB .96004999 09  
 BF1 .99712500 05 F1 .88212500 05  
 D1 .29404193 04 D2 .39475054 04

LN .33284732 03  
 DFC .26888758 02  
 CKT .14981046 02  
 DDE .10160559-04  
 DRG .28767908 01  
 THI .24315082 03  
 RFI .96004999 09  
 F2 .11847516 06  
 DDP .19639313-02  
 ELE .15103862 02  
 PSS .83170108 02  
 DEL .31572498-02  
 DNR .30665202-06  
 SPS .96405841 02  
 RF2 .29668212 08  
 XA .29668566 08  
 DFI .98201679-03  
 AZI .67512398 02  
 PSM .15277855 03  
 DAZ .20460240-02  
 SLS .21293626 03  
 PUL .73800364 01  
 FA .96004999 09  
 PRA .15872239 03  
 DF2 .19640336-02

3 DAYS 22 HRS. 3 MIN. 10.498 SEC.

235677504266202305237764 J.D. = 2438715.11288820 NOV. 15, 1964 14 42 33.541

EXTREME ELEVATION

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

11

EARTH - MARS

CHECK 3

11 GOLDSTONE

HADEC

R .11725092 07 LAT .27053517 02  
 MIN .56431749 04 HA .20637512-02  
 CKC .27570884 03 CKM .18211132 03  
 UT .94052915 02 DHA .41954327-02  
 ET .94043192 02 RGE .11662020 07  
 RDI .63720340 04 PHI .35208070 02  
 DT .38900304 01 RFB .96004999 09  
 BF1 .60274224 05 F1 .89274223 05  
 D1 .29758074 04 D2 .40182815 04

LON .24314876 03  
 DEC .27009111 02 ELE .81801029 02 AZI .18010445 03  
 CKT .14917629 02 PSS .83650535 02 PSM .14917093 03  
 DDE .76892019 06 DEL .19799240-09 DAZ .32243126-02  
 CRG .32083073 01 DDR .24440798-04 SLS .21342954 03  
 THI .24315082 03 SPS .95900162 02 POL .65371784 02  
 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .12054845 06 XA .29668529 08 PRA .15849979 03  
 DDP .15652937 00 DF1 .78268762-01 DF2 .15653753 00

4 DAYS 0 HRS. 49 MIN. 59.273 SEC.

235677511174202450337774 J.D.= 2438715.22873051 NOV. 15,1964 17 29 22.316

START OF VIEW PERIOD

41 WOODPERA

HADEC

R .12046053 07 LAT .27059740 02  
 MIN .58099878 04 HA .29525787 03  
 CKC .27605468 03 CKM .18232648 03  
 UT .9683129 02 DHA .41844575-02  
 ET .96823407 02 RGE .12040332 07  
 RDI .63726039 04 PHI .31211875 02  
 DT .40162218 01 RFB .96004999 09  
 BF1 .59242138 05 F1 .8824138 05  
 D1 .29414046 04 D2 .39494759 04

LON .20136612 03  
 DEC .27250272 02 ELE .49999998 01 AZI .53812901 02  
 CKT .15245643 02 PSS .83619936 02 PSM .14740866 03  
 DDE .79146735-05 DEL .28834233-02 DAZ .23594401-02  
 DRG .28860205 01 DDR .10732553-04 SLS .21370684 03  
 THI .13688727 03 SPS .95916197 02 POL .29616003 03  
 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .11848428 06 XA .29668497 08 PRA .15879782 03  
 DDP .68735882-01 DF1 .34369731-01 DF2 .68739461-01

4 DAYS 4 HRS. 1 MIN. 23.821 SEC.

235677516663202556500003 J.D.= 2438715.36165351 NOV. 15,1964 20 40 46.864

END OF VIEW PERIOD

11 GOLDSTONE

HADEC

R .12413979 07 LAT .27066371 02  
 MIN .60013969 04 HA .90000001 02  
 CKC .27558286 03 CKM .18170615 03  
 UT .10002328 03 DHA .41741730-02  
 ET .10001356 03 RGE .12397196 07  
 RDI .63720340 04 PHI .35208070 02  
 DT .41352589 01 RFB .96004999 09  
 BF1 .61337163 05 F1 .90337162 05  
 D1 .30112387 04 D2 .40891441 04

LON .15342067 03  
 DEC .26915433 02 ELE .15128727 02 AZI .29252852 03  
 CKT .14751010 02 PSS .84309684 02 PSM .14531381 03  
 DDE .69903057-05 DEL .31540240-02 DAZ .20471923-02  
 DRG .35402285 01 DDR .25897748-06 SLS .21396054 03  
 THI .24315082 03 SPS .95512328 02 POL .12335923 03  
 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .12267433 06 XA .29668562 08 PRA .15830255 03  
 DDP .16586030-02 DF1 .82934471-03 DF2 .16586894-02

4 DAYS 5 HRS. 7 MIN. 24.359 SEC.

235677520621202663377770 J.D.= 2438715.40749308 NOV. 15,1964 21 46 47.402

EXTREME ELEVATION

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

12

EARTH - MARS

CHECK 3

41 WOODPERA

HADEC

R .12540775 07 LAT .27068539 02  
 MIN .60074059 04 HA .14438629-02  
 CKC .27606114 03 CKM .18213410 03  
 UT .10112343 03 DHA .41954022-02  
 ET .10111371 03 RGE .12507388 07  
 RDI .63726039 04 PHI .31211875 02  
 DT .41720148 01 RFB .96004999 09  
 BF1 .60250717 05 F1 .89250717 05  
 D1 .29750239 04 D2 .40167145 04

LON .13688563 03  
 DEC .27316861 02 ELE .31471263 02 AZI .35998601 03  
 CKT .15221409 02 PSS .83992694 02 PSM .14467994 03  
 DDE .93932361-07 DEL .79221064-10 DAZ .46811805-03  
 DRG .32009670 01 DDR .25562354-04 SLS .21403740 03  
 THI .13688727 03 SPS .95525117 02 POL .24537490 03  
 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .12050143 06 XA .29668528 08 PRA .15858497 03  
 DDP .16371230 00 DF1 .81860413-01 DF2 .16372083 00

4 DAYS 9 HRS. 24 MIN. 52.200 SEC.

235677530247202637124003 J.D.= 2438715.58628754 NOV. 16,1964 02 04 15.243

END OF VIEW PERIOD

41 WOODPERA

HADEC

R .13034930 07 LAT .27076465 02  
 MIN .63248899 04 HA .64740068 02  
 CKC .27595513 03 CKM .18183584 03  
 UT .10541450 03 DHA .41829236-02  
 ET .10540477 03 RGE .13029221 07  
 RDI .63726039 04 PHI .31211875 02  
 DT .43460796 01 RFB .96004999 09  
 BF1 .61260001 05 F1 .90260001 05  
 D1 .30086667 04 D2 .40840000 04

LON .72390531 02  
 DEC .27252530 02 ELE .49999998 01 AZI .30619002 03  
 CKT .15084579 02 PSS .84295748 02 PSM .14174575 03  
 DDE .71772316-05 DEL .28827246-02 DAZ .23580114-02  
 DRG .35161334 01 DDR .10760885-04 SLS .21439244 03  
 THI .13688727 03 SPS .95201606 02 POL .19459653 03  
 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .12252000 06 XA .29668559 08 PRA .15838861 03  
 DDP .68917328-01 DF1 .34460459-01 DF2 .68920917-01

4 DAYS 16 HRS. 1 MIN. 58.759 SEC.

235677543754202346520031 J.D.= 2438715.86205789 NOV. 16,1964 08 41 21.802

START OF VIEW PERIOD

11 GOLDSTONE

HADEC

R .13195911 07 LAT .27087178 02  
 MIN .67219792 04 HA .27000000 03  
 CKC .27592510 03 CKM .18152108 03  
 UT .11203299 03 DHA .41759780-02  
 ET .11202326 03 RGE .13779123 07  
 RDI .63720340 04 PHI .35208070 02  
 DT .45962201 01 RFB .96004999 09  
 BF1 .59139327 05 F1 .88135327 05  
 D1 .29378442 04 D2 .39423551 04

LON .33290795 03  
 DEC .26951381 02 ELE .15147867 02 AZI .67439958 02  
 CKT .15006794 02 PSS .83989894 02 PSM .14035385 03  
 DDE .78807291-05 DEL .31551399-02 DAZ .20463603-02  
 DRG .28926666 01 DDR .21236046-06 SLS .21487850 03  
 THI .24315082 03 SPS .95478781 02 POL .75366782 01  
 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .11827065 06 XA .29668494 08 PRA .15894135 03  
 DDP .13600477-02 DF1 .68005925-03 DF2 .13601185-02

4 DAYS 22 HRS. 0 MIN. 15.042 SEC.

235677556352202413000023 J.D.= 2438716.11089747 NOV. 16,1964 14 39 38.086

EXTREME ELEVATION

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

13

EARTH - PAKS

CHECK 3

11 GOLDSTONE

HADEC

R .14461305 07	LAT .27095481 02	LON .24314965 03	ELE .81851663 02	AZI .18010561 03
MIN .70802306 04	HA .11768341-02	DEC .27059747 02	PSS .84428895 02	PSM .13673057 03
CKC .27599038 03	CKM .18134050 03	CKT .15028734 02	DDE .43947608-06	DEL-.75195075-10
UT .11800418 03	DHA .41925622-02	DDE .43947608-06	DRG .31859891 01	DDR .24502991-04
ET .11799445 03	RGE .14418225 07	THI .24315082 03	SPS .95014668 02	SLS .21527231 03
RDI .63720340 04	PHI .35208070 02	RF1 .96004999 09	RF2 .29668212 08	FA .96004999 09
UT .48094016 01	RFB .96004999 09	F2 .12040551 06	XA .29668527 08	PRA .15879324 03
BF1 .60202753 05	F1 .89202753 05	DOP .15692788 00	DF1 .78467929-01	DF2 .15693586 00
DI .29734251 04	D2 .40135168 04			

5 DAYS 0 HRS. 46 MIN. 50.558 SEC.

23567756325520231467773 J.D. = 2438716.22654629 NOV. 16,1964 17 26 13.601

START OF VIEW PERIOD

41 WOOMERA

HADEC

R .14799651 07	LAT .27098950 02	LON .20141163 03	ELE .49999998 01	AZI .53808080 02
MIN .72468425 04	HA .29526128 03	DEC .27254002 02	PSS .84425990 02	PSM .13681875 03
CKC .27627319 03	CKM .18151226 03	CKT .15291316 02	DDE .63735747-05	DEL .28836038-02
UT .12078071 03	DHA .41835653-02	DRG .28644431 01	DDR .10805392-04	SLS .215449576 03
ET .12077098 03	RGE .14793961 07	THI .13688727 03	SPS .95003058 02	PUL .27635915 03
RDI .63726039 04	PHI -.31211875 02	RF1 .96004999 09	RF2 .29668212 08	FA .96004999 09
UT .49447334 01	RFB .96004999 09	F2 .11834608 06	XA .29668495 08	PRA .15899158 03
BF1 .59173039 05	F1 .88173040 05	DOP .69202114-01	DF1 .34602860-01	DF2 .69205719-01
DI .29491013 04	D2 .39448693 04			

5 DAYS 3 HRS. 58 MIN. 34.994 SEC.

235677570751202404623640 J.D. = 2438716.35969950 NOV. 16,1964 20 37 58.037

END OF VIEW PERIOD

11 GOLDSTONE

HADEC

R .15165787 07	LAT .27102664 02	LON .15337178 03	ELE .15162651 02	AZI .29258439 03
MIN .74385832 04	HA .90000000 02	DEC .26979147 02	PSS .84772073 02	PSM .13252556 03
CKC .27589079 03	CKM .18100446 03	CKT .14885581 02	DDE -.59400459-05	DEL-.31540765-02
UT .12396666 03	DHA .41753512-02	DRG .35194556 01	DDR -.19280866-06	SLS .21570175 03
ET .12396666 03	RGE .15148996 07	THI .24315082 03	SPS .94642420 02	PUL .12352103 03
RDI .63720340 04	PHI .35208070 02	RF1 .96004999 09	RF2 .29668212 08	FA .96004999 09
UT .50531603 01	RFB .96004999 09	F2 .12254128 06	XA .29668560 08	PRA .15858780 03
BF1 .61270640 05	F1 .90270639 05	DOP -.12348295-02	DF1 -.61744691-03	DF2 -.12348938-02
DI .30090213 04	D2 .40847093 04			

5 DAYS 5 HRS. 4 MIN. 23.040 SEC.

235677572704202412500263 J.D. = 2438716.4039447 NOV. 16,1964 21 43 46.083

EXTREME ELEVATION

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

14

EARTH - PAKS

CHECK 3

41 WOOMERA

HADEC

R .15291372 07	LAT .27104874 02	LON .13688941 03	ELE .314480617 02	AZI .35999011 03
MIN .75043839 04	HA .18711090-02	DEC .27307508 02	PSS .84766078 02	PSM .13204075 03
CKC .27628241 03	CKM .18135361 03	CKT .15269168 02	DDE -.12168300-06	DEL-.50607362-11
UT .12507306 03	DHA .41926319-02	DRG .31805404 01	DDR .25619655-04	SLS .21576402 03
ET .12506434 04	RGE .15257997 07	THI .13688727 03	SPS .94644705 02	PUL .24555973 03
RDI .63726039 04	PHI -.31211875 02	RF1 .96004999 09	RF2 .29668212 08	FA .96004999 09
UT .56895192 01	RFB .96004999 09	F2 .12037061 06	XA .29668526 08	PRA .15881261 03
BF1 .60149304 05	F1 .89185303 05	DOP .16407928 00	DF1 .62043911-01	DF2 .16408782 00
DI .29728434 04	D2 .40123536 04			

5 DAYS 4 HRS. 21 MIN. 57.444 SEC.

235677602334202076334011 J.D. = 2438716.58426490 NOV. 17,1964 02 01 20.488

END OF VIEW PERIOD

41 WOOMERA

HADEC

R .15762657 07	LAT .27108307 02	LON .72349284 02	ELE .49999998 01	AZI .30619152 03
MIN .77619573 04	HA .64739008 02	DEC .27253690 02	PSS .85050619 02	PSM .12896577 03
CKC .27619665 03	CKM .18110635 03	CKT .15153925 02	DDE -.59948608-05	DEL-.28831068-02
UT .12936595 03	DHA .41824782-02	DRG .34967278 01	DDR .10416942-04	SLS .21605495 03
ET .12935673 03	RGE .15776975 07	THI .13688727 03	SPS .94339828 02	PUL .19476564 03
RDI .63726039 04	PHI -.31211875 02	RF1 .96004999 09	RF2 .29668212 08	FA .96004999 09
UT .52626318 01	RFB .96004999 09	F2 .11234971 06	XA .29668557 08	PRA .15864516 03
BF1 .61197887 05	F1 .90197886 05	DOP .69276344-01	DF1 .34639976-01	DF2 .69279952-01
DI .30065952 04	D2 .40798571 04			

5 DAYS 15 HRS. 59 MIN. 40.185 SEC.

235677616032202635127403 J.D. = 2438716.85975958 NOV. 17,1964 08 38 03.228

START OF VIEW PERIOD

11 GOLDSTONE

HADEC

R .16530599 07	LAT .27114269 02	LON .33294617 03	ELE .15174287 02	AZI .67396431 02
MIN .81586696 04	HA .27000000 02	DEC .27001012 02	PSS .84846303 02	PSM .12701428 03
CKC .27617623 03	CKM .18084006 03	CKT .15082771 02	DDE .44229264-05	DEL-.31537608-02
UT .14597783 03	DHA .41764447-02	DRG .28345617 01	DDR -.17071868-06	SLS .21645511 03
ET .14596810 03	RGE .16521605 07	THI .24315082 03	SPS .94515540 02	PUL .77381206 01
RDI .63720340 04	PHI .35208070 02	RF1 .96004999 09	RF2 .29668212 08	FA .96004999 09
UT .59110134 01	RFB .96004999 09	F2 .11815470 06	XA .29668492 08	PRA .15909732 03
BF1 .59077348 05	F1 .88077347 05	DOP -.10933558-02	DF1 -.54670636-03	DF2 -.10934127-02
DI .29359115 04	D2 .39384899 04			

5 DAYS 21 HRS. 57 MIN. 2.654 SEC.

23567763043220231277767 J.D. = 2438717.10863075 NOV. 17,1964 14 36 25.698

EXTREME ELEVATION



JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

15

EARTH - MARS CHECK 3

11 GOLDSTONE

HADEC	LAT	LON	ELE	AZI
R .17220173 07	.27118853 02	.24315014 03	.81880829 02	.18009742 03
MIN .85170442 04	HA .67710876-03	DFC .27088910 02	P55 .85255432 02	PSM .12349773 03
CKC .27623528 03	CKP .18068667 03	CKT .15097570 02	DEL .43485809-09	DAZ .11463110-02
UT .14195073 03	DHA .41904661-02	DDE .25305560-06	DDR .24529589-04	SLS .21678294 03
ET .14194101 03	RGE .17157089 07	DRG .31686733 01	SPS .94081424 02	PUL .65728611 02
RDI .63720340 04	PHI .35208070 02	THI .24315062 03	RF2 .29668212 08	FA .96004999 09
DT .57229879 01	RFB .96004999 09	RF1 .96004999 09	XA .29668525 08	PRA .15893556 03
BF1 .60147300 05	F1 .89147300 05	F2 .12029460 06	DF1 .78540296-01	DF2 .15708059 00
D1 .29715767 04	D2 .46096200 04	DDP .15707241 00		

6 DAYS 0 HRS. 43 MIN. 28.364 SEC.

23567763532202664037774 J.D.= 2438717.22420609 NOV. 17,1964 17 22 51.407

START OF VIEW PERIOD

41 WOODPEKA

HADEC	LAT	LON	ELE	AZI
R .17536496 07	.27120746 02	.20144727 03	.49999989 01	.53811216 02
MIN .86834726 04	HA .29525906 03	DEC .27251577 02	P55 .85270263 02	PSM .12138887 03
CKC .27647499 03	CKP .18063008 03	CKT .15316646 02	DEL .28838815-02	DAZ .23565152-02
ET .14472494 03	DHA .41828417-02	DDE .53237285-05	DDR .10835699-04	SLS .21697012 03
UT .14471482 03	RGE .17530827 07	DRG .26474364 01	SPS .94052119 02	PUL .29658800 03
RDI .63726633 04	PHI .31211875 02	THI .13688727 03	RF2 .29668212 08	FA .96004999 09
DT .58476534 01	RFB .96004999 09	RF1 .96004999 09	XA .29668493 08	PRA .15913464 03
BF1 .59118571 05	F1 .88118571 05	F2 .11823714 06	DF1 .34700044-01	DF2 .69400088-01
D1 .29372857 04	D2 .39412380 04	DDP .69396474-01		

6 DAYS 3 HRS. 55 MIN. 27.913 SEC.

235677643032202572300001 J.D.= 2438717.35753421 NOV. 17,1964.20 34 50.956

END OF VIEW PERIOD

11 GOLDSTONE

HADEC	LAT	LON	ELE	AZI
R .17901162 07	.27122765 02	.15333804 03	.15163403 02	.29261858 03
MIN .88754650 04	HA .90000004 02	DEC .27018136 02	P55 .85585525 02	PSM .11909069 03
CKC .27615120 03	CKP .18040103 03	CKT .14473005 02	DEL .11523776-02	DAZ .20470050-02
UT .14970442 03	DHA .41760061-02	DDE .51697794-05	DDR .16365443-06	SLS .21714355 03
ET .14791469 03	RGE .17884387 07	DRG .35028172 01	SPS .93722870 02	PUL .12371961 03
RDI .63720340 04	PHI .35208070 02	THI .24315062 03	RF2 .29668212 08	FA .96004999 09
DT .54558887 01	RFB .96004999 09	RF1 .96004999 09	XA .29668558 08	PRA .15878680 03
BF1 .61217456 05	F1 .90217356 05	F2 .12243471 06	DF1 .52472441-03	DF2 .16494488-02
D1 .30072452 04	D2 .40811571 04	DDP .10493941-02		

6 DAYS 5 HRS. 1 MIN. 7.466 SEC.

235677644763202501100004 J.D.= 2438717.40313088 NOV. 17,1964 21 40 30.509

EXTREME ELEVATION

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

16

EARTH - MARS CHECK 3

41 WOODPEKA

HADEC	LAT	LON	ELE	AZI
R .18025666 07	.27123415 02	.13688511 03	.31491988 02	.35998286 03
MIN .89411242 04	HA .21705627-02	DEC .27246136 02	P55 .85586524 02	PSM .11875383 03
CKC .27648742 03	CKP .18069637 03	CKT .15297051 02	DEL .12304112-09	DAZ .57501280-03
UT .14901874 03	DHA .41905914-02	DDE .14103703-06	DDR .25642685-04	SLS .21719589 03
ET .14900901 03	RGE .17992475 07	DRG .31640777 01	SPS .93717686 02	PUL .24575532 03
RDI .63726633 04	PHI .31211875 02	THI .13688727 03	RF2 .29668212 08	FA .96004999 09
DT .60316426 01	RFB .96004999 09	RF1 .96004999 09	XA .29668524 08	PRA .15898082 03
BF1 .60132584 05	F1 .89132564 05	F2 .12026517 06	DF1 .62117663-01	DF2 .16423533 00
D1 .29710661 04	D2 .40088389 04	DDP .16422677 00		

6 DAYS 9 HRS. 18 MIN. 47.968 SEC.

23567765444202601337776 J.D.= 2438717.58207189 NOV. 18,1964 01 58 11.011

END OF VIEW PERIOD

41 WOODPEKA

HADEC	LAT	LON	ELE	AZI
R .18514814 07	.27125778 02	.72315997 02	.50000006 01	.30618634 03
MIN .91987993 04	HA .64742662 02	DEC .27249686 02	P55 .85856675 02	PSM .11554925 03
CKC .27642049 03	CKP .18048694 03	CKT .15197968 02	DEL .28835157-02	DAZ .23559215-02
UT .15331332 03	DHA .41820315-02	DDE .51600804-02	DDR .10838967-04	SLS .21744180 03
ET .15330360 03	RGE .18509151 07	DRG .34807476 01	SPS .93427282 02	PUL .19496676 03
RDI .63726633 04	PHI .31211875 02	THI .13688727 03	RF2 .29668212 08	FA .96004999 09
DT .61739874 01	RFB .96004999 09	RF1 .96004999 09	XA .29668558 08	PRA .15883549 03
BF1 .61146682 05	F1 .90146681 05	F2 .12229336 06	DF1 .34710509-01	DF2 .69421017-01
D1 .30048893 04	D2 .40764454 04	DDP .69417401-01		

6 DAYS 15 HRS. 55 MIN. 13.409 SEC.

235677670107202071654200 J.D.= 2438718.85736634 NOV. 18,1964 08 34 36.452

START OF VIEW PERIOD

11 GOLDSTONE

HADEC	LAT	LON	ELE	AZI
R .14266257 07	.27128880 02	.33297685 03	.15190601 02	.67369535 02
MIN .95952234 04	HA .27000000 03	DEC .27031668 02	P55 .85722325 02	PSM .11301786 03
CKC .27640525 03	CKP .18025791 03	CKT .15133047 02	DEL .31528315-02	DAZ .20468277-02
UT .15920333 03	DHA .41767990-03	DDE .54114368-05	DDR .15435407-06	SLS .21778244 03
ET .15991666 03	RGE .19249464 07	DRG .28191335 01	SPS .93533092 02	PUL .79642848 01
RDI .63720340 04	PHI .35208070 02	THI .24315062 03	RF2 .29668212 08	FA .96004999 09
DT .64209291 01	RFB .96004999 09	RF1 .96004999 09	XA .29668490 08	PRA .15921904 03
BF1 .59027941 05	F1 .88027941 05	F2 .11805588 06	DF1 .49430063-03	DF2 .98860127-03
D1 .29342647 04	D2 .39351961 04	DDP .98854978-03		

6 DAYS 21 HRS. 53 MIN. 40.722 SEC.

235677702507202741740001 J.D.= 2438718.10624357 NOV. 18,1964 14 33 03.765

EXTREME ELEVATION

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRD 041765

17

EARTH - MARS

CHECK 3

11 GOLDSTONE

HADEC

R .19744894 07 LAT .27131180 02  
 MIN .99536785 04 HA .47840333-03  
 CKC .2766159 03 CKM .18012772 03  
 UT .16589464 03 OHA .41888743-02  
 ET .16588492 03 RGE .19881808 07  
 RDI .63720340 04 PHI .35208070 02  
 DT .66318563 01 RFB .96004999 09  
 BFI .60098842 05 F1 .89098842 09  
 D1 .29699614 04 D2 .40065894 04

LON .24315045 03  
 DEC .27105390 02  
 CKT .15144228 02  
 DDE .13811370-06  
 DRG .31535412 01  
 TH1 .24315082 03  
 RFI .96004999 09  
 F2 .12019768 06  
 DDP .15709642 00

ELE .81897302 02  
 PSS .86108977 02  
 DEL-.30551660-09  
 DDR .24529727-04  
 SPS .93121585 02  
 RF2 .29668212 08  
 XA .29668523 08  
 DF1 .78553547-01

AZI .18006187 04  
 PSM .10966609 03  
 DAZ .74887425-03  
 SLS .21806319 03  
 PDL .63951595 02  
 FA .96004999 09  
 PRA .15907782 03  
 DF2 .15710710 00

7 DAYS 0 HRS. 39 MIN. 58.492 SEC.

235677707406202304340006 J.D.= 2438718.22177701 NOV. 18,1964 17 19 21.535

START OF VIEW PERIOD

41 WOOMERA

HADEC

R .20259463 07 LAT .27132100 02  
 MIN .10119475 05 HA .29525336 03  
 CKC .27670706 03 CKM .18025247 03  
 UT .10886624 03 OHA .41822563-02  
 ET .16865652 03 RGE .20253809 07  
 RDI .63720379 04 PHI-.31211875 02  
 DT .67559426 01 RFB .96004999 09  
 BFI .59070372 05 F1 .88070372 05  
 D1 .29356790 04 D2 .39380248 04

LON .20147726 03  
 DEC .27245323 02  
 CKT .15332376 02  
 DDE .45654779-05  
 DRG .28323637 01  
 TH1 .13688727 03  
 RFI .96004999 09  
 F2 .11814674 06  
 DDP .69451083-01

ELE .50000006 01  
 PSS .86136118 02  
 DEL .28842536-02  
 DDR .10844228-04  
 SPS .93080013 02  
 RF2 .29668212 08  
 XA .29668492 08  
 DF1 .34727351-01

AZI .53819299 02  
 PSM .10735308 03  
 DAZ-.23555598-02  
 SLS .21822420 03  
 PDL .29683417 03  
 FA .96004999 09  
 PRA .15924913 03  
 DF2 .69454701-01

7 DAYS 3 HRS. 52 MIN. 10.237 SEC.

2356777151120224362275 J.D.= 2438718.35524628 NOV. 18,1964 20 31 33.280

END OF VIEW PERIOD

11 GOLDSTONE

HADEC

R .20622415 07 LAT .27133055 02  
 MIN .16312170 05 HA .90000000 02  
 CKC .27639738 03 CKM .17988268 03  
 UT .17186951 03 OHA .41784056-02  
 ET .17185978 03 RGE .20606020 07  
 RDI .63720340 04 PHI .35208070 02  
 DT .68734275 01 RFB .96004999 09  
 BFI .61169664 05 F1 .90169664 05  
 D1 .30056554 04 D2 .40779776 04

LON .15331335 03  
 DEC .27042239 02  
 CKT .15034645 02  
 DDE-.45805434-05  
 DRG .34879243 01  
 TH1 .24315082 03  
 RFI .96004999 09  
 F2 .12233933 06  
 DDP-.98974909-03

ELE .15196232 02  
 PPS .8642477 02  
 DEL-.31518799-02  
 DDR-.15454133-06  
 SPS .92737376 02  
 RF2 .29668212 08  
 XA .29668557 08  
 DF1-.4949032-03

AZI .29263973 03  
 PSM .10517403 03  
 DAZ .20470861-02  
 SLS .21837395 03  
 PDL .12393944 03  
 FA .96004999 09  
 PRA .15694653 03  
 DF2-.4880063-03

7 DAYS 4 HRS. 57 MIN. 43.627 SEC.

235677717040202525600000 J.D.= 2438718.40077164 NOV. 18,1964 21 37 06.670

EXTREME ELEVATION

CASE 1

IBSYS-JPTRAJ-SFPRD 041765

18

EARTH - MARS

CHECK 3

41 WOOMERA

HADEC

R .20746700 07 LAT .27133355 02  
 MIN .10377727 05 HA .23555755-02  
 CKC .27668641 03 CKM .18013950 03  
 UT .17296212 03 OHA .41784056-02  
 ET .17295239 03 RGE .20713328 07  
 RDI .63720379 04 PHI-.31211875 02  
 DT .69092214 01 RFB .96004999 09  
 BFI .60085139 05 F1 .89085139 05  
 D1 .29695046 04 D2 .40056759 04

LON .13688492 03  
 DEC .27283404 02  
 CKT .15315345 02  
 DDE-.15319623-06  
 DRG .31442621 01  
 TH1 .13688727 03  
 RFI .96004999 09  
 F2 .12017028 06  
 DDP .16426327 00

ELE .31504720 02  
 PPS .86436288 02  
 DEL-.11807980-04  
 DDR-.25648383-04  
 SPS .92763773 02  
 RF2 .29668212 08  
 XA .29668554 08  
 DF1 .82135910-01

AZI .35998601 03  
 PSM .10486251 03  
 DAZ-.76516017-03  
 SLS .21841907 03  
 PDL .24600884 03  
 FA .96004999 09  
 PRA .15911463 03  
 DF2 .16427182 00

7 DAYS 9 HRS. 15 MIN. 29.816 SEC.

23567772647320215602400/ J.D.= 2438718.57977847 NOV. 19,1964 01 54 52.860

END OF VIEW PERIOD

41 WOOMERA

HADEC

R .21233569 07 LAT .27134417 02  
 MIN .10639497 05 HA .64749279 02  
 CKC .27663773 03 CKM .17996030 03  
 UT .17296212 03 OHA .41816311-02  
 ET .17296212 03 RGE .21227920 07  
 RDI .63720379 04 PHI-.31211875 02  
 DT .70808708 01 RFB .96004999 09  
 BFI .61099682 05 F1 .90099682 05  
 D1 .30033294 04 D2 .40733255 04

LON .72287455 02  
 DEC .27242439 02  
 CKT .19228876 02  
 DDE-.45366699-05  
 DRG .34661338 01  
 TH1 .13688727 03  
 RFI .96004999 09  
 F2 .12219978 06  
 DDP .69444634-01

ELE .49999998 01  
 PPS .86693101 02  
 DEL-.28839776-02  
 DDR .10843219-04  
 SPS .92484802 02  
 RF2 .29668212 08  
 XA .29668554 08  
 DF1 .34724125-01

AZI .30617697 03  
 PSM .10166801 03  
 DAZ-.23551692-02  
 SLS .21863222 03  
 PDL .19518656 03  
 FA .96004999 09  
 PRA .15898663 03  
 DF2 .69448251-01

7 DAYS 15 HRS. 51 MIN. 41.750 SEC.

235677742162202145377624 J.D.= 2438718.85491658 NOV. 19,1964 08 31 04.793

START OF VIEW PERIOD

11 GOLDSTONE

HADEC

R .21981118 07 LAT .27135709 02  
 MIN .11031696 05 HA .27000000 03  
 CKC .27662407 03 CKM .17976446 03  
 UT .16386159 03 OHA .41769853-02  
 ET .16386187 03 RGE .21964327 07  
 RDI .63720340 04 PHI .35208070 02  
 DT .71265091 01 RFB .96004999 09  
 BFI .58981576 05 F1 .87881576 05  
 D1 .29377191 04 D2 .39321050 04

LON .33249832 03  
 DEC .27050507 02  
 CKT .15169596 02  
 DDE .46710593-05  
 DRG .28004653 01  
 TH1 .24315082 03  
 RFI .96004999 09  
 F2 .11796315 06  
 DDP-.97562954-03

ELE .15200625 02  
 PPS .86609951 02  
 DEL .31521988-02  
 DDR-.15233668-06  
 SPS .92539486 02  
 RF2 .29668212 08  
 XA .29668489 08  
 DF1-.48784018-03

AZI .67353007 02  
 PSM .98542518 02  
 DAZ .20470748-02  
 SLS .21892843 03  
 PDL .82051343 01  
 FA .96004999 09  
 PRA .15932036 03  
 DF2-.97568036-03

7 DAYS 21 HRS. 50 MIN. 12.919 SEC.

235677754563202773200010 J.D.= 2438719.10388845 NOV. 19,1964 14 29 35.963

EXTREME ELEVATION

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

19

EARTH - MARS CHECK 3

11 GOLDSTONE HADEC

R .22656760 07	LAT .27136557 02	LON .24315064 03	ELE .81405787 02	AZI .18010136 03
MIN .11390215 05	HA .17929077-03	DEC .27113869 02	PSS .86679190 02	PSM .95387049 02
CKC .27667954 03	CKM .17965651 03	CKT .15179027 02	DEL-.10351005-09	DAZ-.28407902-03
UT .18983692 03	DHA .41876294-02	DDE .64847653-07	DDR .24523613-04	SLS .21917381 03
ET .18982719 03	RGE .22593672 07	DRG .31390873 01	SPS .92145549 02	PDL .66189221 02
RDI .63720340 04	PHI .35208070 02	THI .24315082 03	RF2 .29668212 08	FA .96004999 09
DT .75364367 01	RFB .96004999 09	RF1 .96004999 09	F2 .12010511 06	PKA .15919545 03
BF1 .60052555 05	F1 .89052554 05	F2 .12010511 06	KA .29668522 08	DF1 .78533969-01
DI .29684145 04	D2 .40035037 04	DOP .15705976 00	DF1 .78533969-01	DF2 .15706794 00

8 DAYS 0 HRS. 36 MIN. 23.896 SEC. 235677761460202570177775 J.D.= 2438719.21929327 NOV. 19,1964 17 15 46.939

START OF VIEW PERIOD

41 WOOMERA HADEC

R .22969674 07	LAT .27136857 02	LON .20150360 03	ELE .49999998 01	AZI .53830444 02
MIN .11556398 05	HA .29524548 03	DEC .27236702 02	PSS .87015392 02	PSM .92896017 02
CKC .27686606 03	CKM .17976919 03	CKT .15344140 02	DEL-.28846964-02	DAZ-.23547991-02
UT .19260683 03	DHA .41817816-02	DDE .39948818-05	DDR .10840326-04	SLS .21931503 03
ET .19259691 03	RGE .22964037 07	DRG .28117836 01	SPS .92094659 02	PDL .29709064 03
RDI .63726039 04	PHI-.31211875 02	THI .13688727 03	RF2 .29668212 08	FA .96004999 09
DT .76597974 01	RFB .96004999 09	RF1 .96004999 09	KA .29668490 08	PRA .15934607 03
BF1 .59023938 05	F1 .88023938 05	F2 .11804788 06	DF1 .34714861-01	UF2 .69429722-01
DI .29341312 04	D2 .39349292 04	DOP .69426107-01		

8 DAYS 3 HRS. 48 MIN. 45.876 SEC. 235677767166202165500003 J.D.= 2438719.35288100 NOV. 19,1964 20 28 08.919

END OF VIEW PERIOD

11 GOLDSTONE HADEC

R .23331682 07	LAT .27137135 02	LON .15329449 03	ELE .15204013 02	AZI .29265256 03
MIN .11748765 05	HA .90000001 02	DEC .27058665 02	PSS .47290124 02	PSM .90926720 02
CKC .27662855 03	CKM .17944771 03	CKT .15081764 02	DEL-.41131604-05	DAZ-.20472416-02
UT .19581274 03	DHA .41766600-02	DDE-.41131604-05	DDR-.19604168-06	SLS .21944674 03
ET .19580302 03	RGE .23314890 07	DRG .34734682 01	SPS .91806421 02	PDL .12417268 03
RDI .63720340 04	PHI .35208070 02	THI .24315082 03	RF2 .29668212 08	FA .96004999 09
DT .77770090 01	RFB .96004999 09	RF1 .96004999 09	F2 .12224674 06	PKA .15907836 03
BF1 .61123370 05	F1 .90123370 05	F2 .12224674 06	DF1-.49970501-03	UF2-.99941002-03
DI .30041123 04	D2 .40748913 04	DOP-.99935797-03		

8 DAYS 4 HRS. 54 MIN. 14.575 SEC. 235677771114202317077777 J.D.= 2438719.39835206 NOV. 19,1964 21 33 37.618

EXTREME ELEVATION

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

20

EARTH - MARS CHECK 3

41 WOOMERA HADEC

R .23454852 07	LAT .27137215 02	LON .13688484 03	ELE .31518204 02	AZI .35998286 03
MIN .11814243 05	HA .24299621-02	DEC .27264920 02	PSS .87299450 02	PSM .90578669 02
CKC .27688480 03	CKM .17967574 03	CKT .15329562 02	DEL .19129320-09	DAZ-.64444699-03
UT .19690404 03	DHA .41878039-02	DDE-.15831487-06	DDR .25644941-04	SLS .21948635 03
ET .19689432 03	RGE .23421475 07	DRG .31348238 01	SPS .91792957 02	PDL .24625335 03
RDI .63726039 04	PHI-.31211875 02	THI .13688727 03	RF2 .29668212 08	FA .96004999 09
DT .78125622 01	RFB .96004999 09	RF1 .96004999 09	KA .29668522 08	PRA .15922678 03
BF1 .60038401 05	F1 .89038901 05	F2 .12007780 06	DF1 .62124887-01	DF2 .16424977 00
DI .29679634 04	D2 .40025934 04	DOP .16424122 00		

8 DAYS 9 HRS. 12 MIN. 6.066 SEC. 235700000550202215773777 J.D.= 2438719.57742024 NOV. 20,1964 01 51 29.109

END OF VIEW PERIOD

41 WOOMERA HADEC

R .23939653 07	LAT .27137453 02	LON .72262183 02	ELE .50000015 01	AZI .30616509 03
MIN .12072101 05	HA .64757668 02	DEC .27233245 02	PSS .67549217 02	PSM .87477823 02
CKC .27686192 03	CKM .17952359 03	CKT .15253265 02	DEL-.28844844-02	DAZ-.23545443-02
UT .20120168 03	DHA .41812866-02	DDE-.40502518-05	DDR .10836800-04	SLS .21967438 03
ET .20119196 03	RGE .23934015 07	DRG .34517393 01	SPS .91523142 02	PDL .19541823 03
RDI .63726039 04	PHI-.31211875 02	THI .13688727 03	RF2 .29668212 08	FA .96004999 09
DT .79835269 01	RFB .96004999 09	RF1 .96004999 09	KA .29668553 08	PRA .15911262 03
BF1 .61053786 05	F1 .90053786 05	F2 .12210757 06	DF1 .34703570-01	DF2 .69407140-01
DI .30017928 04	D2 .40702524 04	DOP .69403525-01		

8 DAYS 15 HRS. 48 MIN. 6.917 SEC. 235700014234202372736454 J.D.= 2438719.85243009 NOV. 20,1964 08 27 29.960

START OF VIEW PERIOD

11 GOLDSTONE HADEC

R .24688412 07	LAT .27137607 02	LON .33301502 03	ELE .15206599 02	AZI .67343161 02
MIN .12468115 05	HA .27000000 03	DEC .27061132 02	PSS .87505281 02	PSM .83777677 02
CKC .27683927 03	CKM .17935673 03	CKT .15199000 02	DEL .31517699-02	DAZ .20473360-02
UT .20780192 03	DHA .41771128-02	DDE .41091324-05	DDR-.15857773-06	SLS .21993626 03
ET .20779219 03	RGE .24666621 07	DRG .27901535 01	SPS .91538713 02	PDL .84555372 01
RDI .63720340 04	PHI .35208070 02	THI .24315082 03	RF2 .29668212 08	FA .96004999 09
DT .82778880 01	RFB .96004999 09	RF1 .96004999 09	KA .29668487 08	PKA .15940844 03
BF1 .58935136 05	F1 .87935136 05	F2 .11787027 06	DF1-.50782641-03	DF2-.10156528-02
DI .29311712 04	D2 .39290090 04	DOP-.10155999-02		

8 DAYS 18 HRS. 36 MIN. 50.283 SEC. 23570002117202251644633 J.D.= 2438719.96959869 NOV. 20,1964 11 16 13.327

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRN 041765

21

EARTH - PARS

CHECK 3

GEOCENTRIC

EQUATORIAL COORDINATES

X -20809419 07	Y 78698492 06	Z 11403225 07	DX -26177298 01	DY 94365922 00	DZ 14259753 01
R 25000000 07	DEC 27137601 02	RA 15928403 03	VE 16222060 03	PTH 89205767 02	AZ 90115152 02
R -24999999 07	LAT -27137601 02	LON -29073523 03	VE -16222060 03	PTE -11043101 01	AZE 26999996 03
XS -77915722 08	YS -11520235 09	ZS -44957800 08	DXS -25786643 02	DYS -14308895 02	DZS -62037552 01
XM 12583806 06	YM 31244563 06	ZM 12704644 06	UXM -10238458 01	GYM 10328885 00	DZM 23776494 00
XT -20267688 09	YT 74862852 08	ZT 40625872 08	UXT 58881486 01	DYT -23873869 02	OZT -10057389 02
RS 14777761 09	VS 30136058 04	RM 35997762 06	VM 10939728 01	RT 21984912 09	VT 26566576 02
GED 27295870 02	ALT 24936262 07	LUS 73742065 01	HAS 23992802 03	RAM 68062793 02	LDM 19550898 03
DUT 35000000 02	DF 15360000 05	DR 31264243 03	SHA -24960716 07	DES -19758764 02	DEM 20665352 02
GCL 27685530 03	MCL 17933773 03	TCL 15223058 02			

GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE	235677234006202455644633 J.D. = 2438711.12252729	NOV. 11, 1964	14 56 26.358
SMA -42166391 05	ECC 13033514 01	B 35230037 05	SLR 29448734 05
VH 30753022 01	C3 94575268 01	C1 10834336 06	TFP 16438697 06
TA 13193707 03	MTA 14010763 03	EA 275941866 03	MA 31956874 04

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE

X -26809419 07	Y 78698492 06	Z 11403225 07	DX -26177298 01	DY 94365922 00	DZ 14259753 01
INC 27140333 07	LAN 69031556 04	APF 31091752 03	MX -35458424 00	MY -93499826 00	MZ -17866665-02
WX 42201672 08	WY -16327490 00	WZ 48989185 00	PX 66231199 00	PY 37094129 00	PZ -34467795 00
QX -23788140 00	QY -91417625 00	QZ 29875404 00	KX -42905386 00	KY 15460601 00	RZ -88994929 00
BX 34292617 00	BY 49932690 00	BZ 81626506-02	TX 33900407 00	TY 94078491 00	TZ 00000000 00
SXI 48997169 00	SYI 87090792 00	SZI 72450767-01	UAI -41777423 01	RAI 60838228 02	
SXO -83225687 00	SYO 30169643 00	SZO 45605947 00	DAU 27133124 02	RAO 16018379 03	

T VECTOR IN EARTH EQUATOR PLANE

BTQ 31435160 05	BRQ 15905195 05	B 35230037 05	THA 26837963 02		
X -11312736 07	Y -21303847 07	Z 65702387 06	DX -13774467 01	DY -26789233 01	DZ 83810340 00
INC 27442597 02	LAN 21047333 03	APF 27536925 03	MX 86049492 00	MY -33987433 00	MZ 37957866 00
WX -23413705 00	WY 39790916 00	WZ 88707048 00	PX -21792566 00	PY 86772248 00	PZ -44675051 00
QX -94748307 00	QY -29789062 00	QZ -11645919 00	RX -12256340 00	RY -23843148 00	RZ -96339431 00
BX -86671441 00	BY 32792556 00	BZ -37586079 00	TX 88937854 00	TY 45717543 00	TZ 00000000 00
SXI -71485443 00	SYI 44747915 00	SZI -61746561 00	DAI -24676742 02	RAI 14850550 03	
SXO -44684021 00	SYO -85682050 00	SZO 26808834 00	DAO 15550542 02	RAO 24279500 03	

T VECTOR IN ORBIT PLANE OF TARGET

8 DAYS 18 HRS. 36 MIN. 50.283 SEC.	235700021177202251644633 J.D. = 2438719.96959869	NOV. 20, 1964	11 16 13.327
CHANGE OF PHASE OCCURS AT THIS POINT	SUN IS THE CENTRAL BODY FOR INTEGRATION	COWELL EQUATIONS OF MOTION	
8 DAYS 18 HRS. 36 MIN. 50.283 SEC.	235700021177202251644633 J.D. = 2438719.96959869	NOV. 20, 1964	11 16 13.327
***** S/C DISCONTINUITY STOP			
8 DAYS 18 HRS. 36 MIN. 50.283 SEC.	235700021177202251644633 J.D. = 2438719.96959869	NOV. 20, 1964	11 16 13.327

CASE 1

IBSYS-JPTRAJ-SFPRN 041765

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EARTH - PARS

CHECK 3

HELIOCENTRIC

ECLIPTIC COORDINATES

X 75834779 08	Y 12674386 09	Z 73327900 06	DX -28404373 02	DY 17028954 02	DZ 93162262 00
R 14770056 09	LAT 28445432 00	LON 59106609 02	V 33130776 02	PTH 58065999-01	AZ 88388930 02
RE -77915722 08	YE 12556816 09	ZE 13965000 03	DXE -25786643 02	DYE -15959867 02	DZE -12002567-02
XS -12476316 09	YS 21041414 07	ZS 74879929 07	DXS -19898495 02	DYS -10308557 02	DZS 4673591 00
XM 75410806-04	YM 58180174 02	ZM 17533010 01	UXM 12066543 03	GYM 24473665 09	DZM 22411812 02
XT 91281439 02	YT 96903388 00	YT 81749463 02	UXT 82792833 01	DYT 89955339 02	OPY 81765380 02
LTE 75410806-04	LBE 58180174 02	LTI 17533010 01	LOT 12066543 03	MST 24473665 09	VST 22411812 02
FSP 91281439 02	FSP 96903388 00	SEP 81749463 02	EPM 82792833 01	EMP 89955339 02	MEP 81765380 02
MPS 99954670 02	MSP 94382735 03	SMP 79521691 02	SEM 16855798 03	EMS 11393339 02	ESM 27088088-01
EPT 16331898 03	ETP 18701907 06	TEP 16493999 02	TPS 81760879 02	TSP 61563839 02	STP 36675276 02
SET 80900794 02	STE 36599970 02	EST 62499229 02	RPM 24742260 07	RPT 21745316 09	SPN 91135265 02
GCL 83114691 02	GCT 27833776 03	SIP 81759689 02	CPT 83250368 02	SIN 83244977 02	
REP 29000006 07	VHP 31267244 01	CPE 82997981 02	CPS 99625016 02		

HELIOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE	235700005055202204544633 J.D. = 2438719.68135459	NOV. 20, 1964	04 21 09.037
SMA 18975202 09	ECC 22161495 00	B 18503364 09	SLR 18043270 09
VH 21110448 02	CS -64940812 04	C1 48938615 10	TFP 24940290 05
TA 32007375 00	MTA 18000000 03	EA 25549432 00	MA 194887295 00

ALL VECTORS REFERENCED TO ECLIPTIC PLANE

X 75834779 08	Y 12674386 09	Z 73327900 06	DX -28404373 02	DY 17028954 02	DZ 93162262 00
INC 16360055 01	LAN 49096194 02	APF 96943779 01	MX -85785656 00	MY 51311951 00	MZ 28114365-01
WX 21577669 01	WY -18693866 01	WZ 99959237 00	PX 31821992 00	PY 85523332 00	PZ 48074970-02
QX -85497458 00	QY 51740434 00	QZ 28141647-01	RX 24913702-02	RY 41115811-02	RZ -99998794 00
BX 85497501 00	BY -51790521 00	BZ -28141661-01	TX 85524362 00	TY -51822615 00	TZ 00000000 00
DAP 27545128 00	RAP 58786660 02				

T VECTOR IN ECLIPTIC PLANE

BTG 18496337 09	BRC 52072106 07	B 18503360 09	THA 16126311 01		
X -12881438 09	Y 72256614 08	Z -80702950 05	DX -16237118 02	DY -28879102 02	DZ -12250912 00
INC 12409112 00	LAN 32230397 03	APF 18808731 03	MX -48920510 00	MY -87216093 00	MZ -36971695-02
WX -22852750-02	WY -29572244-02	WZ 99999302 00	PX -86941883 00	PY 49407454 00	PZ -52577550-03
QX -49406954 00	QY 86941397 00	QZ -37001628-02	RX 45711940-03	RY -25977245-03	RZ -99999937 00
BX 49406978 00	BY 86941439 00	BZ 37001646-02	TX 49407485 00	TY 86941937 00	TZ 00000000 00
DAP -30126256-01	RAP 15039123 03				

T VECTOR IN ORBIT PLANE OF TARGET

BTU 18503337 09	BRU 68465451 06	B 18503359 09	THA 35978799 03		
252 DAYS 17 HRS. 35 MIN. 56.663 SEC.	235724105159202732310324 J.D. = 2438963.92731141	JULY 22, 1965	10 15 19.706		

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

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EARTH - MARS CHECK 3

HELIOCENTRIC

ECLIPTIC COORDINATES

X -14180703 09	Y -18080550 09	Z -35318550 06	DX -16289199 02	DY -13676693 02	DZ -60002750 00
R -22978248 09	LAT -88067603-01	LON -23189265 03	V -21277922 02	PTH -19117819 01	AZ -91613891 02
XE -74579964 08	YE -13242883 09	ZE -20050000 03	OXE -23477438 02	DYE -14502661 02	DZE -89901685-03
XT -14380243 09	YT -18092580 09	ZT -29060300 06	OXT -19907202 02	DYT -13014897 02	DYT -76160681 00
LTE -75584905-04	LOE -29938691 03	LTT -72045688-01	LOT -23152181 03	RST -23111333 09	VST -23796308 02
EPS -39290480 02	ESP -67494281 02	SEP -73215237 02	EPM -41964682-01	EMP -25186631 02	MEP -15476932 03
MPS -39248762 02	MSP -67636768 02	SMP -73114467 02	SEM -81746242 02	EMS -98117059 02	ESM -14230920 00
EPF -17065762 03	ETP -92592157 01	TEP -82755473-01	TPS -13152909 03	TSP -37121615 00	STP -48099716 02
SET -73133797 02	STE -39001090 02	EST -67865112 02	RPM -22207495 09	RPT -20000010 07	SPN -39288832 02
GCE -25662492 03	GCT -81135149 02	SIP -13143232 03	CPT -69055774 02	SIN -88959000 02	
REP -22172902 09	VEP -29645552 02	CPE -90548312 02	CPS -81532245 02		

HELIOCENTRIC CONIC

EP0CH OF PERICENTER PASSAGE	235700004656202372310324 J.D.= 2438719.72289301 NOV. 20,1964 05 20 57.956
SMA -18694964 09	ECC -21854539 00
VH -21223477 02	C3 -70237821 03
TA -17313131 03	MTA -18000000 03
B -18438207 09	SLR -17992501 09
APO -23024371 09	RCA -14765556 09
CI -48865721 10	TFP -21099262 06
EA -17142858 03	MA -16956232 03
TF -85288772 01	PER -51847363 03
TFI -25273329 03	

ALL VECTORS REFERENCED TO ECLIPTIC PLANE

X -14180703 09	Y -18080550 09	Z -35318550 06	DX -16289199 02	DY -13676693 02	DZ -60002750 00
INC -16162292 01	LAN -48770085 02	APF -99924950 01	MX -78657053 00	MY -61685783 00	MZ -28163934-01
WX -21212796-01	WY -18589970-01	WZ -99960213 00	PX -51863737 00	PY -85498018 00	PZ -48942541-02
QX -85473099 00	QY -51832719 00	QZ -27777473-01	RX -25383747-02	RY -41845408-02	RZ -99999790 00
BX -86473110 00	BY -51832726 00	BZ -27777977-01	TX -85499051 00	TY -51864363 00	TZ -00000000 00
DAP -28042110 00	RAP -58758687 02				

BTC -18431093 09 BRC -51218220 07

H -18438208 09 THA -15917862 01 T VECTOR IN ECLIPTIC PLANE

ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET

X -18467587 09	Y -13672896 09	Z -16276000 05	DX -13224495 02	DY -16668987 02	DZ -86889505-01
INC -23638124 00	LAN -32447736 03	APF -18587607 03	MX -59503176 00	MY -80369177 00	MZ -40881908-02
WX -23756955-02	WY -33278210-02	WZ -99999163 00	PX -86909271 00	PY -49464883 00	PZ -41860045-03
QX -49466329 00	QY -86908642 00	QZ -40673197-02	RX -36380267-03	RY -20706026-03	RZ -99999498 00
BX -49466335 00	BY -86908654 00	BZ -40673203-02	TX -49464693 00	TY -86909289 00	TZ -00000000 00
DAP -23985062-01	RAP -15035340 03				

BTD -18438054 09 BRD -74994092 06

B -18438207 09 THA -35976695 03 T VECTOR IN ORBIT PLANE OF TARGET

252 DAYS 17 HRS. 35 MIN. 56.663 SEC.	235724105155202732310324 J.D.= 2438963.92731141 JULY 22,1965 10 15 19.706
CHANGE OF PHASE OCCURS AT THIS POINT	MARS IS THE CENTRAL BODY FOR INTEGRATION COWELL EQUATIONS OF MOTION
252 DAYS 17 HRS. 35 MIN. 56.562 SEC.	235724105155202715400605 J.D.= 2438963.92731024 JULY 22,1965 10 15 19.605
***** S/C DISCONTINUITY=R STUP	
252 DAYS 20 HRS. 48 MIN. 8.447 SEC.	235724112660202676637777 J.D.= 2438964.06078114 JULY 22,1965 13 27 31.491

END OF VIEW PERIOD

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EARTH - MARS CHECK 3

41 WOODMERA

HADEC

R -22190329 09	LAT -50951153 01	LON -49656887 02	ELE -50000015 01	AZI -26706465 03
MIN -36412814 06	HA -87231815 02	DEC -50942717 01	PSS -15232307 03	PSM -15232307 03
CKC -10136622 03	CKM -18000759 03	CKT -24824382 01	DEL -35621011-02	DAZ -21483052-02
UT -60688022 04	DHA -41720441-02	UDE -26955391-05	DDR -00000000 00	SLS -25901732 03
ET -60687924 04	RGE -22190273 09	DRG -15503473 02	SPS -39277244 02	PDL -73453400 02
RDI -63726639 04	PHI -31211875 02	THI -13688727 03	RF1 -96004999 09	FA -96004999 09
DT -74018774 03	RFB -96004999 09	RF2 -29668212 08	XA -29669746 08	PRA -19162357 03
BFI -99648038 05	F1 -12864804 06	F2 -19929608 06		
D1 -42882674 04	U2 -66432025 04			

253 DAYS 2 HRS. 33 MIN. 2.735 SEC.

235724124746202343477774 J.D.= 2438964.30029836 JULY 22,1965 19 12 25.778

START OF VIEW PERIOD

11 GOLDSTONE

HADEC

R -22221582 09	LAT -51510810 01	LON -32331955 03	ELE -49999998 01	AZI -99907570 02
MIN -36447304 06	HA -27982994 03	DEC -51520449 01	PSS -73072565 02	PSM -15092180 03
CKC -10135190 03	CKM -18000785 03	CKT -24315460 01	DEL -33563979-02	DAZ -24589006-02
UT -60745505 04	DHA -41720528-02	DDE -27125325-05	DDR -00000000 00	SLS -25902954 03
ET -60745408 04	RGE -22221527 09	DRG -14723647 02	SPS -39247306 02	PDL -25988379 03
RDI -63720340 04	PHI -35208070 02	THI -24315082 03	RF1 -96004999 09	FA -96004999 09
DT -74123025 03	RFB -96004999 09	RF2 -29668212 08	XA -29669669 08	PRA -19175124 03
BFI -97150736 05	F1 -12615074 06	F2 -19430147 06		
D1 -42050245 04	U2 -64767157 04			

253 DAYS 7 HRS. 53 MIN. 11.378 SEC.

235724136250202465710775 J.D.= 2438964.52262061 JULY 23,1965 00 32 34.421

EXTREME ELEVATION

11 GOLDSTONE

HADEC

R -22250566 09	LAT -52030169 01	LON -24318039 03	ELE -49587638 02	AZI -17995005 03
MIN -36479319 06	HA -35997042 03	DEC -52040806 01	PSS -72987776 02	PSM -14781557 03
CKC -10133864 03	CKM -18000815 03	CKT -23811683 01	DEL -22889545-10	DAZ -58297472-02
UT -60798864 04	DHA -41721307-02	DDE -27033631-05	DDR -00000000 00	SLS -25904070 03
ET -60798766 04	RGE -22250061 09	DRG -15083386 02	SPS -39232628 02	PDL -26956085 03
RDI -63720340 04	PHI -35208070 02	THI -24315082 03	RF1 -96004999 09	FA -96004999 09
DT -74218272 03	RFB -96004999 09	RF2 -29668212 08	XA -29669704 08	PRA -19186593 03
BFI -98302758 05	F1 -12730276 06	F2 -19660552 06		
D1 -42434253 04	U2 -65535172 04			

253 DAYS 9 HRS. 9 MIN. 3.198 SEC.

235724140432202436657776 J.D.= 2438964.57530371 JULY 23,1965 01 48 26.241

START OF VIEW PERIOD

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CASE 1

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EARTH - MARS

CHECK 3

41 WOOMERA HADEC  
 R .22257431 09 LAT-.52153224 01  
 MIN .36486904 06 HA .27269581 03  
 CKC .10133162 03 CKM .16000436 03  
 UT .60811507 04 UHA .41720369-02  
 ET .60811409 04 RGE .22257376 09  
 ROI .63726639 04 PHI-.31211875 02  
 DT .74242604 03 RFB .96004999 09  
 BFI .97028825 05 F1 .12602882 06  
 D1 .42007608 04 D2 .64685883 04

LON .22419005 03  
 DEC-.52144831 01 ELE .49999998 01 AZI .93076060 02  
 CKT .23648736 01 PSS .72966246 02 PSM .14715206 03  
 UDE-.27125488-05 DEL .35644173-02 DAZ-.21428804-02  
 DRG .14685578 02 DDR .00000000 00 SLS .25904354 03  
 TH1 .13688727 03 SPS .3911182 02 POL .91733430 02  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .19405765 06 XA .29669665 08 PRA .19189484 03

253 DAYS 13 HRS. 13 MIN. 16.001 SEC.

235724147551202605600012 J.D.= 2438964.74489635 JULY 23,1965 05 52 39.045

END OF VIEW PERIOD

11 GOLDSTONE HADEC  
 R .22279522 09 LAT-.52549323 01  
 MIN .36511326 06 HA .80094039 02  
 CKC .10132503 03 CKM .18000814 03  
 UT .60852210 04 UHA .41720462-02  
 ET .60852113 04 RGE .22279466 09  
 ROI .63720340 04 PHI .35208070 02  
 DT .74316291 03 RFB .96004999 09  
 BFI .99454611 05 F1 .12845481 06  
 D1 .42818270 04 D2 .66303207 04

LON .16305810 03  
 DEC-.52558945 01 ELE .49999998 01 AZI .25996342 03  
 CKT .23270621 01 PSS .72899894 02 PSM .14400506 03  
 UDE-.26939067-05 DEL-.35582485-02 DAZ .24551777-02  
 DRG .15443135 02 DDR .00000000 00 SLS .25905216 03  
 TH1 .24315082 03 SPS .39199973 02 POL .27142240 03  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .19890962 06 XA .29669740 08 PRA .19198067 03

253 DAYS 14 HRS. 57 MIN. 53.500 SEC.

235724152613202105357776 J.D.= 2438964.81755257 JULY 23,1965 07 37 16.543

EXTREME ELEVATION

41 WOOMERA HADEC  
 R .22288981 09 LAT-.52718965 01  
 MIN .36521788 06 HA .19067764-01  
 CKC .10131710 03 CKM .14000466 03  
 UT .60869647 04 UHA .41721309-02  
 ET .60869549 04 RGE .22288408 09  
 ROI .63726339 04 PHI-.31211875 02  
 DT .74346117 03 RFB .96004999 09  
 BFI .98249830 05 F1 .12724983 06  
 D1 .42416609 04 D2 .65499886 04

LON .13686820 03  
 DEC-.52711830 01 ELE .64059294 02 AZI .35993943 03  
 CKT .23050893 01 PSS .72874101 02 PSM .14386849 03  
 UDE-.27026796-05 DEL .00001197-09 DAZ-.68033495-02  
 DRG .15066858 02 DDR .00000000 00 SLS .25905565 03  
 TH1 .13688727 03 SPS .39191260 02 POL .89493473 02  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .19849966 06 XA .29669702 08 PRA .14201994 03

253 DAYS 20 HRS. 46 MIN. 51.018 SEC.

235724164775202407640005 J.D.= 2438965.05988497 JULY 23,1965 13 26 14.061

END OF VIEW PERIOD

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

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EARTH - MARS

CHECK 3

41 WOOMERA HADEC  
 R .22120515 09 LAT-.53284824 01  
 MIN .36526685 06 HA .87372351 02  
 CKC .10130216 03 CKM .16000498 03  
 UT .60927808 04 UHA .41720295-02  
 ET .60927710 04 RGE .22320459 09  
 ROI .63726639 04 PHI-.31211875 02  
 DT .74453027 03 RFB .96004999 09  
 BFI .99471058 05 F1 .12884706 06  
 D1 .42023686 04 D2 .66314039 04

LON .49516322 02  
 DEC-.53276431 01 ELE .49999998 01 AZI .26679148 03  
 CKT .22402073 01 PSS .72778185 02 PSM .13964886 03  
 UDE-.26925118-05 DEL-.35611789-02 DAZ-.21468091-02  
 DRG .15448209 02 DDR .00000000 00 SLS .25908813 03  
 TH1 .13688727 03 SPS .39165357 02 POL .73681145 02  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .19894212 06 XA .29669740 08 PRA .19214517 03

254 DAYS 2 HRS. 31 MIN. 52.648 SEC.

235724177064202730377762 J.D.= 2438965.29948715 JULY 23,1965 19 11 15.691

START OF VIEW PERIOD

11 GOLDSTONE HADEC  
 R .22151664 09 LAT-.53844130 01  
 MIN .36991187 06 HA .28000084 03  
 CKC .10127760 03 CKM .18000477 03  
 UT .60989512 04 UHA .41720385-02  
 ET .60989514 04 RGE .22351600 09  
 ROI .63720340 04 PHI .45208070 02  
 DT .74556431 03 RFB .96004999 09  
 BFI .96794918 05 F1 .12597424 06  
 D1 .41991639 04 D2 .64649945 04

LON .32314865 03  
 DEC-.53853718 01 ELE .49999998 01 AZI .10019747 03  
 CKT .21710913 01 PSS .72687777 02 PSM .13792965 03  
 UDE-.27101580-05 DEL .33533756-02 DAZ .24603748-02  
 DRG .14668745 02 DDR .00000000 00 SLS .25908024 03  
 TH1 .24315082 03 SPS .39135161 02 POL .26007100 03  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .19394984 06 XA .29669663 08 PRA .19227316 03

254 DAYS 7 HRS. 51 MIN. 20.365 SEC.

235724210354202664217003 J.D.= 2438965.52133574 JULY 24,1965 00 30 43.408

EXTREME ELEVATION

11 GOLDSTONE HADEC  
 R .22180491 09 LAT-.54361876 01  
 MIN .36623131 06 HA .45997031 03  
 CKC .10127415 03 CKM .18000901 03  
 UT .61038555 04 UHA .41721157-02  
 ET .61038458 04 RGE .22379997 09  
 ROI .63720340 04 PHI .35208070 02  
 DT .74651626 03 RFB .96004999 09  
 BFI .98125046 05 F1 .12712505 06  
 D1 .42375015 04 D2 .65416647 04

LON .24318051 03  
 DEC-.54372505 01 ELE .49354668 02 AZI .17995054 03  
 CKT .21019275 01 PSS .72603317 02 PSM .13492730 03  
 UDE-.27006008-05 DEL-.98184116-11 DAZ .58515787-02  
 DRG .15027892 02 DDR .00000000 00 SLS .25909127 03  
 TH1 .24315082 03 SPS .39111274 02 POL .26952741 03  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .19625009 06 XA .29669688 08 PRA .19238790 03

254 DAYS 9 HRS. 6 MIN. 38.984 SEC.

235724212526202320203761 J.D.= 2438965.57362994 JULY 24,1965 01 46 01.627

START OF VIEW PERIOD

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CASE 1

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EARTH - PARS CHECK 3

41 WOODMERA HADEC  
 R .22387270 09 LAT-.54483905 01 LON .22433043 03  
 MIN .36630664 06 HA .27255943 03 DEC-.54475556 01 ELE .49999998 01 AZI .93348863 02  
 CKC .10126712 03 CKM .18000120 03 CKT .20809614 01 PSS .72581971 02 PSM .13402082 03  
 UT .61051106 04 DHA .41720220-02 DDE-.27101585-05 DEL .55634509-02 DAZ--21413905-02  
 ET .61051009 04 RGE .22387214 09 DRG .14630046 02 DDR .00000000 00 SLS .25909407 03  
 RDI .63726039 04 PHI-.31211875 02 TH1 .13688727 03 SPS .39104820 02 POL .91716475 02  
 DT .74675698 03 RFB .96004999 09 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 BF1 .96850492 05 F1 .12585099 06 F2 .19370198 06 XA .29669659 08 PRA .19241666 03  
 D1 .41950330 04 D2 .64567327 04

254 DAYS 13 HRS. 10 MIN. 44.147 SEC. 235724221643202630300001 J.D.= 2438965.74313878 JULY 24,1965 05 50 07.190

END OF VIEW PERIOD

11 GOLDSTONE HADEC  
 R .22409268 09 LAT-.54879406 01 LON .16322890 03  
 MIN .36655073 06 HA .79923233 02 DEC-.54888988 01 ELE .49999998 01 AZI .25967385 03  
 CKC .10126036 03 CKM .18000493 03 CKT .20267591 01 PSS .72515782 02 PSM .13099539 03  
 UT .61091788 04 DHA .41720318-02 DDE-.26907913-05 DEL-.33551914-02 DAZ .24566514-02  
 ET .61091691 04 RGE .22409213 09 DRG .15387134 02 DDR .00000000 00 SLS .25910260 03  
 RDI .63720340 04 PHI .35208070 02 TH1 .24315082 03 SPS .34067423 02 POL .27140619 03  
 DT .74749077 03 RFB .96004999 09 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 BF1 .99275675 05 F1 .12827547 06 F2 .19655095 06 XA .29669734 08 PRA .19250268 03  
 D1 .42758492 04 D2 .66183650 04

254 DAYS 14 HRS. 56 MIN. 2.565 SEC. 235724224717202315700000 J.D.= 2438965.81626862 JULY 24,1965 07 35 25.608

EXTREME ELEVATION

41 WOODMERA HADEC  
 R .22418754 09 LAT-.55050018 01 LON .13686837 03  
 MIN .36665604 06 HA .18896103-01 DEC-.55042957 01 ELE .64292408 02 AZI .35993943 03  
 CKC .10125234 03 CKM .18000145 03 CKT .19971409 01 PSS .72489845 02 PSM .13086637 03  
 UT .61109339 04 DHA .41721157-02 DDE-.26999805-05 DEL-.13091981-09 DAZ-.68518993-02  
 ET .61109242 04 RGE .22418179 09 DRG .15011266 02 DDR .00000000 00 SLS .25910607 03  
 RDI .63726639 04 PHI-.31211875 02 TH1 .13688727 03 SPS .39078574 02 POL .84526518 02  
 DT .74788487 03 RFB .96004999 09 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 BF1 .98071868 05 F1 .12707187 06 F2 .19614373 06 XA .29669697 08 PRA .19254228 03  
 D1 .42357289 04 D2 .65381244 04

254 DAYS 20 HRS. 45 MIN. 33.855 SEC. 235724237112202163040006 J.D.= 2438966.05899188 JULY 24,1965 13 24 56.899

END OF VIEW PERIOD

CASE 1

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EARTH - PARS CHECK 3

41 WOODMERA HADEC  
 R .22450220 09 LAT-.55616181 01 LON .49375904 02  
 MIN .36700556 06 HA .87512761 02 DEC-.55607848 01 ELE .49999998 01 AZI .26651861 03  
 CKC .10123713 03 CKM .18000131 03 CKT .19048104 01 PSS .72393953 02 PSM .12651462 03  
 UT .61167593 04 DHA .41720146-02 DDE-.26893160-05 DEL-.35601767-02 DAZ-.21453148-02  
 ET .61167496 04 RGE .22450164 09 DRG .15392162 02 DDR .00000000 00 SLS .25911846 03  
 RDI .63726039 04 PHI-.31211875 02 TH1 .13688727 03 SPS .39052349 02 POL .73912042 02  
 DT .74885677 03 RFB .96004999 09 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 BF1 .99291578 05 F1 .12829158 06 F2 .19858315 06 XA .29669734 08 PRA .19266803 03  
 D1 .42763859 04 D2 .66194385 04

255 DAYS 2 HRS. 30 MIN. 42.900 SEC. 235724251203202370577774 J.D.= 2438966.29867990 JULY 24,1965 19 10 05.943

START OF VIEW PERIOD

11 GOLDSTONE HADEC  
 R .22481265 09 LAT-.56175112 01 LON .32297761 03  
 MIN .36735071 06 HA .28017189 03 DEC-.56184664 01 ELE .49999998 01 AZI .10048723 03  
 CKC .10122234 03 CKM .18000146 03 CKT .18047165 01 PSS .72303607 02 PSM .12437647 03  
 UT .61225118 04 DHA .41720239-02 DDE-.27076060-05 DEL .33502689-02 DAZ .24618467-02  
 ET .61225020 04 RGE .22481210 09 DRG .14612896 02 DDR .00000000 00 SLS .25913046 03  
 RDI .63720340 04 PHI .35208070 02 TH1 .24315082 03 SPS .39021894 02 POL .26024150 03  
 DT .74889234 03 RFB .96004999 09 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 BF1 .96796669 05 F1 .12579607 06 F2 .19359214 06 XA .29669657 08 PRA .19279636 03  
 D1 .41932023 04 D2 .64530712 04

255 DAYS 7 HRS. 49 MIN. 29.659 SEC. 235724262461202131662746 J.D.= 2438966.52005442 JULY 25,1965 00 28 52.702

EXTREME ELEVATION

11 GOLDSTONE HADEC  
 R .22509912 09 LAT-.56691218 01 LON .24318063 03  
 MIN .3676949 06 HA .35997019 03 DEC-.56701830 01 ELE .44121735 02 AZI .17994908 03  
 CKC .10120872 03 CKM .18000167 03 CKT .17029284 01 PSS .72219482 02 PSM .12149973 03  
 UT .61278247 04 DHA .41721004-02 DDE-.26976829-05 DEL .13411688-10 DAZ .56486290-02  
 ET .61278149 04 RGE .22509430 09 DRG .14471395 02 DDR .00000000 00 SLS .25914136 03  
 RDI .63720340 04 PHI .35208070 02 TH1 .24315082 03 SPS .38997811 02 POL .26944589 03  
 DT .75083168 03 RFB .96004999 09 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 BF1 .97944120 05 F1 .12694412 06 F2 .19588824 06 XA .29669693 08 PRA .19291114 03  
 D1 .42314706 04 D2 .65296079 04

255 DAYS 9 HRS. 4 MIN. 14.308 SEC. 23572426462202254740001 J.D.= 2438966.57196008 JULY 25,1965 01 43 37.351

START OF VIEW PERIOD

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

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EARTH - MARKS

CHECK 3

41 WOODMERA

HADEC

R .22596625 09 LAT-.56812215 01  
 MIN .36774423 06 HA .27241521 03  
 CKC .10120167 03 CKM .17999787 03  
 UT .61290705 04 DHA .41720070-02  
 ET .61290608 04 RGE .22516570 03  
 RDI .63726339 04 PHI-.31211875 02  
 DT .75107182 03 RFB .96004999 09  
 BFI .96671083 05 F1 .12567108 06  
 D1 .41690360 04 D2 .64447388 04

LON .22447066 03  
 DEC-.56803907 01 ELE .50000006 01 AZI .93621360 02  
 CKT .16737451 01 PSS .72198318 02 PSM .12038231 03  
 DDE-.27075786-05 DEL .35624047-02 DAZ-.21399029-02  
 DRG .14573867 02 DDR .00000000 00 SLS .25914411 03  
 TH1 .13688727 03 SPS .38991341 02 POL .91700554 02  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .19334216 06 XA .29669654 08 PRA .19293977 03

255 DAYS 13 HRS. 8 MIN. 12.560 SEC.

23572427373520215200004 J.D.= 2438966.74138430 JULY 25,1965 05 47 35.604

END OF VIEW PERIOD

11 GOLDSTONE

HADEC

R .22598950 09 LAT-.57207093 01  
 MIN .36798821 06 HA .29752271 02  
 CKC .10119473 03 CKM .18000157 03  
 UT .61331367 04 DHA .41720172-02  
 ET .61331270 04 RGE .22538475 09  
 RDI .65720360 04 PHI .35208070 02  
 DT .75180249 03 RFB .96004999 09  
 BFI .99073683 05 F1 .12680387 06  
 D1 .42697690 04 D2 .66062447 04

LON .16339985 03  
 DEC-.57216614 01 ELE .49999998 01 AZI .25938443 01  
 CKT .15903113 01 PSS .72132295 02 PSM .11750772 03  
 DDE-.26875000-05 DEL-.33520501-02 UAZ .24581280-02  
 DRG .15330363 02 DDR .00000000 00 SLS .25915255 03  
 TH1 .24315082 03 SPS .38973755 02 POL .27139048 03  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .19818734 06 XA .29669729 08 PRA .19302597 03

255 DAYS 14 HRS. 54 MIN. 11.935 SEC.

235724277023202575200003 J.D.= 2438966.81498817 JULY 25,1965 07 33 34.979

EXTREME ELEVATION

41 WOODMERA

HADEC

R .22598042 09 LAT-.57378617 01  
 MIN .36809419 06 HA .18724441-01  
 CKC .10118664 03 CKM .17999810 03  
 UT .61349631 04 DHA .41721002-02  
 ET .61349434 04 RGE .22547466 09  
 RDI .63726339 04 PHI-.31211875 02  
 DT .75107182 03 RFB .96004999 09  
 BFI .97890700 05 F1 .12689070 06  
 D1 .42296960 04 D2 .65260466 04

LON .13686655 03  
 DEC-.57371650 01 ELE .64525279 02 AZI .35994148 03  
 CKT .15467979 01 PSS .72106214 02 PSM .11736926 03  
 DDE-.26968983-05 DEL-.36576903-10 DAZ-.71421167-02  
 DRG .14954714 02 DDR .00000000 00 SLS .25915602 03  
 TH1 .13688727 03 SPS .38964770 02 POL .89478590 02  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .19578140 06 XA .29669691 08 PRA .19306591 03

255 DAYS 20 HRS. 44 MIN. 16.963 SEC.

23572431127202000640006 J.D.= 2438967.05810192 JULY 25,1965 13 23 40.006

END OF VIEW PERIOD

CASE 1

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EARTH - MARKS

CHECK 3

41 WOODMERA

HADEC

R .22579439 09 LAT-.57945079 01  
 MIN .36844428 06 HA .87653023 02  
 CKC .10117116 03 CKM .17999794 03  
 UT .61607379 04 DHA .41719994-02  
 ET .61607281 04 RGE .22579483 04  
 RDI .63726339 04 PHI-.31211875 02  
 DT .75107182 03 RFB .96004999 09  
 BFI .99103407 05 F1 .12810941 06  
 D1 .42703135 04 D2 .66072937 04

LON .49235635 02  
 DEC-.57936797 01 ELE .49999998 01 AZI .76624606 03  
 CKT .14037477 01 PSS .72010344 02 PSM .11295041 03  
 DDE-.26859302-05 DEL-.35590949-02 DAZ-.71438221-02  
 DRG .15335276 02 DDR .00000000 00 SLS .25916831 03  
 TH1 .13688727 03 SPS .38938225 02 POL .74149100 02  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .19821881 06 XA .29669729 08 PRA .19319218 03

256 DAYS 2 HRS. 24 MIN. 33.494 SEC.

23572432322202104600004 J.D.= 2438967.29787658 JULY 25,1965 19 08 56.537

START OF VIEW PERIOD

11 GOLDSTONE

HADEC

R .22815377 09 LAT-.58503542 01  
 MIN .36878952 06 HA .28034310 03  
 CKC .10115614 03 CKM .17999810 03  
 UT .61666424 04 DHA .41720042-02  
 ET .61666327 04 RGE .22610322 09  
 RDI .63726339 04 PHI .35208070 02  
 DT .75107182 03 RFB .96004999 09  
 BFI .98614919 05 F1 .12561494 06  
 D1 .41871666 04 D2 .64409959 04

LON .32240641 03  
 DEC-.58513094 01 ELE .50000024 01 AZI .10077684 03  
 CKT .12445347 01 PSS .71920073 02 PSM .11031216 03  
 DDE-.27048434-05 DEL .33476781-02 DAZ .24633162-07  
 DRG .14556335 02 DDR .00000000 00 SLS .25918020 03  
 TH1 .24315082 03 SPS .38907508 02 POL .26041654 03  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .19327988 06 XA .29669652 08 PRA .19332086 03

256 DAYS 7 HRS. 47 MIN. 39.258 SEC.

23572433456520246445001 J.D.= 2438967.51877663 JULY 26,1965 00 27 02.301

EXTREME ELEVATION

11 GOLDSTONE

HADEC

R .22638855 09 LAT-.59018007 01  
 MIN .36813765 06 HA .35997006 03  
 CKC .10114234 03 CKM .17999834 03  
 UT .61517941 04 DHA .41720849-02  
 ET .61517664 04 RGE .22683375 09  
 RDI .61720360 04 PHI .35208070 02  
 DT .75107182 03 RFB .96004999 09  
 BFI .97763048 05 F1 .12676105 06  
 D1 .42254349 04 D2 .65175365 04

LON .24318075 03  
 DEC-.59028611 01 ELE .48889057 02 AZI .17994908 03  
 CKT .10783801 01 PSS .71836273 02 PSM .10757185 03  
 DDE-.26445318-05 DEL-.41294189-10 DAZ .56133654-02  
 DRG .14914852 02 DDR .00000000 00 SLS .25919097 03  
 TH1 .24315082 03 SPS .38883219 02 POL .26943663 03  
 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 F2 .19552610 06 XA .29669688 08 PRA .19343569 03

256 DAYS 9 HRS. 1 MIN. 50.376 SEC.

235724336716702265537775 J.D.= 2438967.57029421 JULY 26,1965 01 41 13.419

START OF VIEW PERIOD



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EARTH - PARS CHECK 3

41 WOOMERA HADEC  
 R .22645494 09 LAT-.59137963 01 LON .22461074 03  
 MIN .36918183 06 HA .27227514 03 CEC-.59129698 01 ELE .49999981 01 AZI .93893530 02  
 CKC .10113527 03 CKM .17999455 03 CKT .10326734 01 PSS .71815287 02 PSM .10627989 03  
 UT .61530305 04 DHA .41719918-02 DDE-.27047700-05 DEL .35612792-02 DAZ-.21384176-02  
 ET .61530208 04 RGE .22645438 09 DRG .14517195 02 DDR .00000000 00 SLS .25919368 03  
 RDI .63726039 04 PHI-.31211875 02 TH1 .13688727 03 SPS .38876736 02 PDL .91684270 02  
 DT .75537139 03 RFB .96004999 09 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 BF1 .96489597 05 F1 .12548960 06 F2 .19297919 06 XA .29669648 08 PRA .19346416 03  
 D1 .41829865 04 D2 .64326398 04

256 DAYS 13 HRS. 5 MIN. 41.247 SEC. 235724346030202045120004 J.D.= 2438967.73963299 JULY 26,1965 05 45 04.290

END OF VIEW PERIOD

11 GOLDSTONE HADEC  
 R .22667304 09 LAT-.59532184 01 LON .16357095 03  
 MIN .36942568 06 HA .79581171 02 DEC-.59541661 01 ELE .49999998 01 AZI .25909518 03  
 CKC .10112817 03 CKM .17999826 03 CKT .88914591 00 PSS .71749432 02 PSM .10359304 03  
 UT .61570945 04 DHA .41720025-02 DDE-.26839704-05 DEL-.33488249-02 DAZ .74596025-02  
 ET .61570846 04 RGE .22667248 09 DRG .15273411 02 DDR .00000000 00 SLS .25920204 03  
 RDI .63720340 04 PHI .35208070 02 TH1 .24315082 03 SPS .38858962 02 PDL .27137481 03  
 DT .75609791 03 RFB .96004999 09 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 BF1 .96911291 05 F1 .12791129 06 F2 .19782258 06 XA .29669723 08 PRA .19355056 03  
 D1 .42637096 04 D2 .65940860 04

256 DAYS 14 HRS. 52 MIN. 21.613 SEC. 235724351130202124017777 J.D.= 2438967.81371130 JULY 26,1965 07 31 44.656

EXTREME ELEVATION

41 WOOMERA HADEC  
 R .22676641 09 LAT-.59704612 01 LON .13686872 03  
 MIN .36933235 06 HA .18548965-01 DEC-.59647739 01 ELE .64757886 02 AZI .35993705 03  
 CKC .10111599 03 CKM .17999482 03 CKT .81630646 00 PSS .71723207 02 PSM .10341586 03  
 UT .61588725 04 DHA .41720849-02 DDE-.26936668-05 DEL .16343477-10 DAZ-.66853434-02  
 ET .61588628 04 RGE .22676264 09 DRG .14898024 02 DDR .00000000 00 SLS .25920549 03  
 RDI .63726339 04 PHI-.31211875 02 TH1 .13688727 03 SPS .38849640 02 PDL .89425796 02  
 DT .75639666 03 RFB .96004999 09 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 BF1 .97709156 05 F1 .12670916 06 F2 .19541831 06 XA .29669686 08 PRA .19359083 03  
 D1 .42236385 04 D2 .65139437 04

256 DAYS 20 HRS. 43 MIN. 0.361 SEC. 235724363343202661200003 J.D.= 2438968.05721509 JULY 26,1965 13 22 23.385

END OF VIEW PERIOD

CASE 1

IBSYS-JPTRAJ-SFPRD 041765

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EARTH - PARS CHECK 3

41 WOOMERA HADEC  
 R .22708170 09 LAT-.60271267 01 LON .49095526 02  
 MIN .36988300 06 HA .87793124 02 DEC-.60263065 01 ELE .49999998 01 AZI .26597385 03  
 CKC .10110425 03 CKM .17999469 03 CKT .56300309 00 PSS .71627355 02 PSM .99010180 02  
 UT .61647166 04 DHA .41719842-02 DDE-.26822633-05 DEL-.35579342-02 DAZ-.21423318-02  
 ET .61647069 04 RGE .22708114 09 DRG .15278661 02 DDR .00000000 00 SLS .25921769 03  
 RDI .63726039 04 PHI-.31211875 02 TH1 .13688727 03 SPS .38822967 02 PDL .74406202 02  
 DT .75746106 03 RFB .96004999 09 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 BF1 .98928744 05 F1 .12792874 06 F2 .19785749 06 XA .29669723 08 PRA .19371764 03  
 D1 .42642914 04 D2 .65952495 04

257 DAYS 2 HRS. 28 MIN. 24.431 SEC. 235724375440202674477765 J.D.= 2438968.29707722 JULY 26,1965 19 07 47.474

START OF VIEW PERIOD

11 GOLDSTONE HADEC  
 R .22739604 09 LAT-.60829331 01 LON .32263508 03  
 MIN .37022840 06 HA .28051444 03 DEC-.60838782 01 ELE .49999998 01 AZI .10106625 03  
 CKC .10108903 03 CKM .17999491 03 CKT .26823988 00 PSS .71537145 02 PSM .95817155 02  
 UT .61764733 04 DHA .41719946-02 DDE-.27017472-05 DEL .33436043-02 DAZ .24647831-02  
 ET .61764636 04 RGE .22739648 09 DRG .14500871 02 DDR .00000000 00 SLS .25922947 03  
 RDI .63720340 04 PHI .35208070 02 TH1 .24315082 03 SPS .38791985 02 PDL .26059010 03  
 DT .75848956 03 RFB .96004999 09 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 BF1 .96437322 05 F1 .12543732 06 F2 .19287464 06 XA .29669647 08 PRA .19384665 03  
 D1 .41812440 04 D2 .64291547 04

257 DAYS 7 HRS. 45 MIN. 49.168 SEC. 235724406672202033001742 J.D.= 2438968.51750244 JULY 27,1965 00 25 12.211

EXTREME ELEVATION

11 GOLDSTONE HADEC  
 R .22767314 09 LAT-.61341979 01 LON .24318066 03  
 MIN .37054582 06 HA .35996945 03 DEC-.61352575 01 ELE .48656662 02 AZI .17995104 03  
 CKC .10107503 03 CKM .17999521 03 CKT .35994583 03 PSS .71453669 02 PSM .93220413 02  
 UT .61757635 04 DHA .41720697-02 DDE-.26910134-05 DEL .14947115-10 DAZ .58009966-02  
 ET .61757538 04 RGE .22766835 09 DRG .14859462 02 DDR .00000000 00 SLS .25924012 03  
 RDI .63720340 04 PHI .35208070 02 TH1 .24315082 03 SPS .38767490 02 PDL .26939843 03  
 DT .75941978 03 RFB .96004999 09 RF1 .96004999 09 RF2 .29668212 08 FA .96004999 09  
 BF1 .97545731 05 F1 .12658573 06 F2 .19517146 06 XA .29669682 08 PRA .19396152 03  
 D1 .42195243 04 D2 .65057153 04

257 DAYS 8 HRS. 59 MIN. 26.791 SEC. 235724411012202352554002 J.D.= 2438968.56863233 JULY 27,1965 01 38 49.834

START OF VIEW PERIOD

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CASE 1

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EARTH - MARS

CHECK 3

41 WOOMERA

HADEC

R .22773877 09 LAT-.61460876 01  
 MIN .37061944 06 HA .27213523 03  
 CKC .10106795 03 CKM .17999145 03  
 UT .61769907 04 DHA .41719769-02  
 ET .61769809 04 RGE .22773822 09  
 RDI .63726039 04 PHI-.31211875 02  
 DT .75965282 03 RFB .96004999 09  
 BF1 .96313914 05 F1 .12531391 06  
 D1 .41771304 04 D2 .64209275 04

LON .22475066 03  
 DEC-.61452671 01  
 CKT .35985860 03  
 DDE-.27015633-05  
 DRG .14462334 02  
 TH1 .13688727 03  
 RFI .96004999 09  
 F2 .19262783 06  
 ELE .50000015 01  
 PSS .71432870 02  
 DEL .35600750-02  
 DDR .00000000 00  
 SPS .38761001 02  
 RFD .29668212 08  
 XA .29669642 08  
 AZI .94165340 02  
 PSM .91809677 02  
 DAZ-.21369352-02  
 SLS .25924278 03  
 POL .91669417 02  
 FA .96004999 09  
 PRA .19398985 03

257 DAYS 13 HRS. 3 MIN. 10.208 SEC.

235724420122202240120004 J.D.= 2438968.73788485 JULY 27,1965 05 42 33.251

END OF VIEW PERIOD

11 GOLUSTONF

HADEC

R .22795597 09 LAT-.61854380 01  
 MIN .37086316 06 HA .79409941 02  
 CKC .10106668 03 CKM .17999520 03  
 UT .61810527 04 DHA .41719883-02  
 ET .61810429 04 RGE .22795541 09  
 RDI .63720340 04 PHI-.35208070 02  
 DT .76037731 03 RFB .96004999 09  
 BF1 .98735680 05 F1 .12773568 06  
 D1 .42578560 04 D2 .65823786 04

LON .16374217 03  
 DEC-.61863808 01  
 CKT .35955821 03  
 DDE-.26800011-05  
 DRG .15218574 02  
 TH1 .24315082 03  
 RFI .96004999 09  
 F2 .19747136 06  
 ELE .49999998 01  
 PSS .71367167 02  
 DEL-.33455168-02  
 DDR .00000000 00  
 SPS .38743028 02  
 RFD .29668212 08  
 XA .29669717 08  
 AZI .25880613 03  
 PSM .89337630 02  
 DAZ .24610751-02  
 SLS .25925106 03  
 POL .27135987 03  
 FA .96004999 09  
 PRA .19407642 03

257 DAYS 14 HRS. 50 MIN. 31.595 SEC.

235724423234202521600002 J.D.= 2438968.81243794 JULY 27,1965 07 29 54.639

EXTREME ELEVATION

41 WOOMERA

HADEC

R .22805160 09 LAT-.62027670 01  
 MIN .37097052 06 HA .18933054 02  
 CKC .10105243 03 CKM .17999181 03  
 UT .61828420 04 DHA .41720700-02  
 ET .61828323 04 RGE .22804582 09  
 RDI .63726639 04 PHI-.31211875 02  
 DT .76067888 03 RFB .96004999 09  
 BF1 .97536416 05 F1 .12653642 06  
 D1 .42178805 04 D2 .65024277 04

LON .13688690 03  
 DEC-.62020900 01  
 CKT .35940538 03  
 DDE-.26899514-05  
 DRG .14844082 02  
 TH1 .13688727 03  
 RFI .96004999 09  
 F2 .19507283 06  
 ELE .64990204 02  
 PSS .71340796 02  
 DEL-.24406805-10  
 DDR .00000000 00  
 SPS .38733765 02  
 RFD .29668212 08  
 XA .29669680 08  
 AZI .35994148 03  
 PSM .89086203 02  
 DAZ-.72411993-02  
 SLS .25925451 03  
 POL .89385862 02  
 FA .96004999 09  
 PRA .19411704 03

257 DAYS 20 HRS. 41 MIN. 43.979 SEC.

235724435460202602777777 J.D.= 2438969.05633128 JULY 27,1965 13 21 07.023

END OF VIEW PERIOD

CASE 1

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EARTH - MARS

CHECK 3

41 WOOMERA

HADEC

R .22836427 09 LAT-.62594465 01  
 MIN .37132172 06 HA .87933054 02  
 CKC .10104642 03 CKM .17999176 03  
 UT .61886454 04 DHA .41719760-02  
 ET .61886856 04 RGE .22836371 09  
 RDI .63726639 04 PHI-.31211875 02  
 DT .76173924 03 RFB .96004999 09  
 BF1 .98759861 05 F1 .12775986 06  
 D1 .42586620 04 D2 .65839907 04

LON .48955591 02  
 DEC-.62586278 01  
 CKT .35883276 03  
 DDE-.26779876-05  
 DRG .15226125 02  
 TH1 .13688727 03  
 RFI .96004999 09  
 F2 .19751977 06  
 ELE .50000015 01  
 PSS .71244948 02  
 DEL-.35566459-02  
 DDR .00000000 00  
 SPS .38706555 02  
 RFD .29668212 08  
 XA .29669671 08  
 AZI .26570202 03  
 PSM .84787424 02  
 DAZ-.21408440-02  
 SLS .25926661 03  
 POL .74651913 02  
 FA .96004999 09  
 PRA .19424435 03

258 DAYS 2 HRS. 27 MIN. 15.688 SEC.

235724447557202535477767 J.D.= 2438969.29628160 JULY 27,1965 19 06 38.731

START OF VIEW PERIOD

11 GOLUSTONF

HADEC

R .22869164 09 LAT-.63151851 01  
 MIN .37166725 06 HA .28068589 03  
 CKC .10102096 03 CKM .17999209 03  
 UT .61946543 04 DHA .41719814-02  
 ET .61946444 04 RGE .22867109 09  
 RDI .63720340 04 PHI-.35208070 02  
 DT .76276454 03 RFB .96004999 09  
 BF1 .98276639 05 F1 .12576664 06  
 D1 .41758874 04 D2 .64184426 04

LON .32246364 03  
 DEC-.63161260 01  
 CKT .35810162 03  
 DDE-.26978192-05  
 DRG .14450695 02  
 TH1 .24315082 03  
 RFI .96004999 09  
 F2 .19255328 06  
 ELE .49999998 01  
 PSS .71154778 02  
 DEL .33404494-02  
 DDR .00000000 00  
 SPS .38675299 02  
 RFD .29668212 08  
 XA .29669641 08  
 AZI .10135544 03  
 PSM .81037152 02  
 DAZ .24662474-02  
 SLS .25927829 03  
 POL .26075745 03  
 FA .96004999 09  
 PRA .19437368 03

258 DAYS 7 HRS. 43 MIN. 59.367 SEC.

235724460776202564372773 J.D.= 2438969.51623160 JULY 28,1965 00 23 22.410

EXTREME ELEVATION

11 GOLUSTONF

HADEC

R .22895314 09 LAT-.63602562 01  
 MIN .37188378 06 HA .35996985 03  
 CKC .10100683 03 CKM .17999250 03  
 UT .61997130 04 DHA .41720570-02  
 ET .61997231 04 RGE .22894842 09  
 RDI .63720340 04 PHI-.35208070 02  
 DT .76318962 03 RFB .96004999 09  
 BF1 .97430544 05 F1 .12643059 06  
 D1 .42153531 04 D2 .64953728 04

LON .24318096 03  
 DEC-.63673148 01  
 CKT .35721029 03  
 DDE-.26861629-05  
 DRG .14411037 02  
 TH1 .24315082 03  
 RFI .96004999 09  
 F2 .19486119 06  
 ELE .48424605 02  
 PSS .71071588 02  
 DEL .43513814-10  
 DDR .00000000 00  
 SPS .38650588 02  
 RFD .29668212 08  
 XA .29669677 08  
 AZI .17995054 03  
 PSM .78579584 02  
 DAZ .57040999-02  
 SLS .25928882 03  
 POL .26935263 03  
 FA .96004999 09  
 PRA .19448854 03

258 DAYS 8 HRS. 57 MIN. 3.536 SEC.

235724463106202512044003 J.D.= 2438969.56697429 JULY 28,1965 01 36 26.579

START OF VIEW PERIOD

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

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EARTH - MARS CHECK 3

41 WOOMERA HADEC  
 R .22901813 09 LAT-.63780340 01 LON .22489038 03  
 MIN .37205705 06 HA .27199552 03 DEC-.63772187 01 ELE .50000015 01 AZI .94436723 02  
 CKC .10099973 03 CKM .17998877 03 CKT .35695931 03 PSS .71050949 02 PSM .77111682 02  
 UT .62009508 04 DHA .41719646-02 DDE-.26971364-05 DEL .35587945-02 DAZ-.21354581-02  
 ET .62009411 04 RGE .22901757 09 DRG .14414524 02 ODR .00000000 00 SLS .25929144 03  
 RDI .63726639 04 PHI-.31211875 02 TH1 .13688727 03 SPS .38644083 02 PDL .91653873 02  
 DT .76392028 03 RFB .96004999 09 RFI .96004999 09 SPS .38644083 02 PDL .91653873 02  
 BFI .96160807 05 F1 .12516081 06 F2 .19232161 06 RF2 .29668212 08 FA .96004999 09  
 D1 .41720269 04 D2 .64107204 04 F2 .19232161 06 XA .29669638 08 PRA .19451672 03

258 DAYS 13 HRS. 0 MIN. 39.423 SEC.

235724472214202473560011 J.D.= 2438969.73613966 JULY 28,1965 05 40 02.467

END OF VIEW PERIOD

11 GOLDSTONE HADEC  
 R .22923452 09 LAT-.64172905 01 LON .16391347 03  
 MIN .37230065 06 HA .79238632 02 DEC-.64182296 01 ELE .49999998 01 AZI .25851737 03  
 CKC .10099232 03 CKM .17999260 03 CKT .35598391 03 PSS .70985358 02 PSM .74874780 02  
 UT .62050109 04 DHA .41719776-02 DDE-.26744588-05 DEL-.33421293-02 DAZ .24625483-02  
 ET .62050010 04 RGE .22923397 09 DRG .15171733 02 ODR .00000000 00 SLS .25929964 03  
 RDI .63720340 04 PHI-.35208070 02 TH1 .24315062 03 TH1 .24315062 03 SPS .38625912 02 PDL .27134472 03  
 DT .76464210 03 RFB .96004999 09 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 BFI .98585165 05 F1 .12758517 06 F2 .19717033 06 XA .29669712 08 PRA .19460342 03  
 D1 .42528389 04 D2 .65723443 04 F2 .19717033 06 XA .29669712 08 PRA .19460342 03

258 DAYS 14 HRS. 48 MIN. 41.842 SEC.

235724475341202161220001 J.D.= 2438969.81116765 JULY 28,1965 07 28 04.885

EXTREME ELEVATION

41 WOOMERA HADEC  
 R .22933046 09 LAT-.64346955 01 LON .13686908 03  
 MIN .37240669 06 HA .18184662-01 DEC-.64340279 01 ELE .65222141 02 AZI .35999406 03  
 CKC .10098398 03 CKM .17998926 03 CKT .35544931 03 PSS .70958811 02 PSM .74514401 02  
 UT .62068115 04 DHA .41720594-02 DDE-.26844723-05 DEL-.68334116-10 DAZ-.71845382-02  
 ET .62068018 04 RGE .22932467 09 DRG .14797811 02 ODR .00000000 00 SLS .25930308 03  
 RDI .63726639 04 PHI-.31211875 02 TH1 .13688727 03 SPS .38616503 02 PDL .89344693 02  
 DT .76494466 03 RFB .96004999 09 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 BFI .97388238 05 F1 .12638824 06 F2 .19477648 06 XA .29669676 08 PRA .19464435 03  
 D1 .42129412 04 D2 .64925492 04 F2 .19477648 06 XA .29669676 08 PRA .19464435 03

258 DAYS 20 HRS. 40 MIN. 27.799 SEC.

2357245075202553700001 J.D.= 2438970.05544957 JULY 28,1965 13 19 50.843

END OF VIEW PERIOD

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

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EARTH - MARS CHECK 3

41 WOOMERA HADEC  
 R .22964264 09 LAT-.64913383 01 LON .48815693 02  
 MIN .37276646 06 HA .88072745 02 DEC-.64905263 01 ELE .49999998 01 AZI .26543071 03  
 CKC .10096774 03 CKM .17996935 03 CKT .35306893 03 PSS .70862842 02 PSM .70414719 02  
 UT .62126743 04 DHA .41719626-02 DDE-.26712658-05 DEL-.35553872-02 DAZ-.21393608-02  
 ET .62126645 04 RGE .22964209 09 DRG .15178249 02 ODR .00000000 00 SLS .25931510 03  
 RDI .63726639 04 PHI-.31211875 02 TH1 .13688727 03 SPS .38588459 02 PDL .74492898 02  
 DT .76600344 03 RFB .96004999 09 RFI .96004999 09 RF2 .29668212 08 FA .96004999 09  
 BFI .98606545 05 F1 .12760655 06 F2 .19721309 06 XA .29669713 08 PRA .19477205 03  
 D1 .42535515 04 D2 .65737697 04 F2 .19721309 06 XA .29669713 08 PRA .19477205 03

258 DAYS 23 HRS. 17 MIN. 28.762 SEC.

235724514260202747055042 J.D.= 2438970.16448848 JULY 28,1965 15 56 51.805

GEOCENTRIC

EQUATORIAL COORDINATES

X -.22069152 09 Y -.58437119 08 Z -.26078223 08 DX -.67759749 01 DY -.26997936 02 DZ -.12361472 02  
 R .22478189 09 DEC .19483103 03 RA .19483103 03 V .30456663 02 PTH .29023969 02 AZ .11381592 03  
 R .22478189 09 LAT .65166083 01 LON .95120270 01 VE .16623345 05 PTE .50932720-01 AZE .26996292 03  
 XS -.87878015 08 YS .11366779 09 ZS .49293696 08 DXS -.23821953 02 DYS -.15721360 02 DZS -.68170658 01  
 XM -.21864600 06 YM .24773850 06 ZM .13595025 06 UXM -.87000689 00 DYM -.64006138 00 DZM -.21841982 00  
 XT -.22073127 09 YT -.98214939 08 ZT -.26008592 08 DXT -.31068879 01 DYT -.26372385 02 DZT -.12262985 02  
 RS .15189727 09 VS .29344829 02 RM .35729807 06 VM .11015571 01 RT .22975578 09 VT .29249551 02  
 GED -.65606317 01 ALI .22977551 09 LOS .30238905 03 RAS .12770806 03 RAM .13143081 03 LOM .30611180 03  
 DUT .35000000 02 DT .95999999 03 OR .14776626 02 SHA -.21702920 09 DES .18936493 02 DEM .22364368 02  
 CCL .10096657 03 MCL .17998949 03 TCL .35149954 03

HELIOCENTRIC

ECLIPTIC COORDINATES

X -.13281351 09 Y -.18788445 09 Z -.67584600 06 DX .17045978 02 DY -.12551548 02 DZ -.60018480 00  
 R .23008792 09 LAT .16829842 00 LON .23474391 03 V .21177038 02 PTH .11137503 01 AZ .91621096 02  
 XE .87878015 08 YE .12389606 09 ZE .33300000 03 DXE .23821953 02 DYE .17135739 02 DZE .62513351-03  
 XT -.13285326 09 YT .18765291 09 ZT .70036300 06 DXT .20715065 02 DYT .11938455 02 DZT .75871021 00  
 LTE -.12560788-03 LOE .30534763 03 LTI .17452641 00 LTV .23470252 03 RST .2292193 09 VST .23921042 02  
 EPS .36574496 02 ESP .70603794 02 SEP .70821708 02 EPM .83050964-01 EPP .11152291 03 P .63942209 02  
 MPS .38491877 02 MSP .70597944 02 SMP .70910179 02 SEM .46866878 01 EMS .17510180 03 ESM .98911702-02  
 EPT .83624309 02 ETP .96317149 02 EEP .58097472-01 TPS .49330583 02 TSP .41964682-01 STP .13462755 03  
 SET .70763497 02 STE .38591306 02 SEP .70645197 02 EST .70645197 02 RPM .22965057 09 RPT .23620497 06 SPN .38572905 02  
 GCE .25903442 03 GCT .70538979 02 SIP .44511159 02 CPT .69922116 02 SIN .69102693 02  
 REP .22478189 09 VEP .30456663 02 CPE .89749999 02 CPS .81061030 02

AROCENTRIC

ECLIPTIC COORDINATES

X .39749151 05 Y -.23154230 06 Z .24514323 05 DX -.36690870 01 DY -.61309294 00 DZ .15852540 00  
 R .23620496 06 DEC .59571193 01 RA .27974108 03 V .37233336 01 PTH .14331472-07 AZ .27245343 03  
 ALT .23282697 06 SHA .16810431 06 ALP .17384013 03 DR .16537543-07 UP .90316174-03 ASD .81942291 00  
 HSE .32142550 03 SVL .60343030 01 HNG .45014140 02 SIA .82804886 02

JPL TECHNICAL MEMORANDUM NO. 33-199

CASE 1

IBSYS-JPTRAJ-SFPRO 041765

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EARTH - MARS

CHECK 3

AREOCENTRIC EQUATORIAL COORDINATES

X .22979118 06	Y .29207460 05	Z .46213904 05	DX .71223004 00	DY -.33713025 01	DZ -.14107658 01
R .23620497 06	DEC .11282797 02	RA .72437015 01	V .37233335 01	PTH .28662945-06	AZ .24727144 03
K .23620497 06	LAT .11282797 02	LOA .30645975 03	VP .19905394 02	PTP .71843381-06	AZP .26585560 03
RAE .10944998 03	DEL .23958425 02	RAS .14884074 03	DES .13037049 02	LOE .48666033 02	LOS .87856794 02

AREOCENTRIC CONIC

EPOCH OF PERICENTR PASSAGE	235724514260202747020726 J.D.= 2438970.1644888	JULY 28, 1965	15 56 51.805
SMA -.31836703 04	ECC .75192653 02	B .23936746 06	SLR .17997083 08
VH .36741412 01	C3 .13499314 02	C1 .87946988 06	TFP .42952848-03
TA .25613208-05	MFA .90762007 02	EA .00000000 00	MA .28401568-04
ZAE .17354659 03	ZAP .13547478 03	ZAC .91406690 02	DEF .15241199 01

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE

X .39749151 05	Y -.22218080 06	Z -.69631051 05	DX -.36690070 01	DY -.62555059 00	DZ -.98487204-01
INC .16278397 03	LAN .18477665 03	APF .26487261 03	MX -.98543065 00	MY -.16800820 00	MZ -.26451349-01
WX -.24664413-01	WY .29494718 00	WZ -.95519564 00	PX .16828246 00	PY -.94062713 00	PZ -.29479079 00
QX -.98543064 00	QY -.16800820 00	QZ -.26451351-01	RX .29570185-01	RY .54843099-02	RZ -.99953872 00
BX .11137297 00	BY -.93830958 00	BZ -.29441294 00	TX -.18058620 00	TY .98355917 00	TZ .00000000 00
SX1 -.98310547 00	SY1 -.18050290 00	SZ1 -.30369485-01	DA1 -.17403100 01	KA1 .19040390 03	
SX0 -.98758150 00	SY0 -.19548378 00	SZ0 -.22528538-01	DA0 -.12908989 01	KA0 .18894714 03	
ET1 .13245197 03	ETS .15412666 03	ETC .23280338 03			

ALL VECTORS REFERENCED TO ORBIT PLANE OF TARGET

X .22979118 06	Y .45471979 05	Z .30349612 05	DX .71222989 00	DY -.36536678 01	DZ .81561729-01
INC .17251061 03	LAN .91436507 02	APF .80324851 02	MX .19128822 00	MY -.98128942 00	MZ .21905565-01
WX .13030142 00	WY .32675759-02	WZ -.79146904 00	PX .97284652 00	PY .19251069 00	PZ .12848846 00
QX .19128823 00	QY -.98128942 00	QZ .21905566-01	RX .48232219-02	RY -.23114559-01	RZ -.99972117 00
BX .97021651 00	BY .20554400 00	BZ .12818577 00	TX .97891536 00	TY -.20426632 00	TZ .00000000 00
SX1 .20420937 00	SY1 -.97864240 00	SZ1 .23612419-01	DA1 .13530169 01	KA1 .28178655 03	
SX0 .17833326 00	SY0 -.98376287 00	SZ0 .20194839-01	DA0 .11571570 01	KA0 .28027481 03	
ETE .15684928 03	ETS .17862398 03	ETC .25730070 03			

ALL VECTORS REFERENCED TO AREOCENTRIC EQUATOR PLANE

X .22979118 06	Y .29207449 05	Z .46213904 05	DX .71222989 00	DY -.33713025 01	DZ -.14107658 01
INC .15475849 03	LAN .16220799 03	APF .15268954 03	MX .19128822 00	MY -.90545272 00	MZ -.37889858 00
WX .13030142 00	WY .40603604 00	WZ -.90451990 00	PX .97284651 00	PY .12365298 00	PZ .19565170 00
QX .19128823 00	QY -.90545272 00	QZ -.37889858 00	KX -.82930786-01	KY .36701005 00	KZ -.92651284 00
BX .97021651 00	BY .13568382 00	BZ .20067343 00	TX -.97940813 00	TY -.22040640 00	TZ .00000000 00
SX1 .20420936 00	SY1 -.90372816 00	SZ1 -.37626306 00	DA1 -.22102400 02	KA1 .28273290 03	
SX0 .17833326 00	SY0 -.90701412 00	SZ0 -.38146707 00	DA0 -.22424586 02	KA0 .28112333 03	
ETE .16199127 03	ETS .18376597 03	ETC .26244269 03			

ALL VECTORS REFERENCED TO TRUE TARGET EQU. PLANE

BTT -.23368591 06	BRT -.51844599 05	B .23936746 06	THA .19250882 03	T VECTOR IN TRUE TARGET EQU. PLANE
215522623366	213675042633	614640127306	602532206172	204542657366
	641101116		3923043	200624303772
				000000000000
220457633266	622662154022	621420194524	602725735144	600471673266
				575575031600
				235724514260
				20274055042

END TRAJECTORY (SFPRC) 016542 6

D. Check case 4 is an Earth-Moon trajectory with a minimum print requested. The spacecraft injects near the Earth on August 6, 1963 and impacts the Moon after a 66.37-hour flight time.

JPL TECHNICAL MEMORANDUM NO. 33-199

START TRAJECTORY (SFPRD) 016543 G

CASE 1 IBSYS-JPTRAJ-SFPRD 041765

1

EARTH-MOON CHECK 4

DOUBLE PRECISION EPHEMERIS TAPE - EPHEM1  
S/C EPHEMERIS WRITTEN 016353G 041765 RUNID=(TRAJ04)

G .39860063 06 J .16234500-02 H -.57499999-05 D -.78749999-05 RE .63781650 04 REM .63783112 04  
G .66709998-19 A .88781796 79 B .88800194 29 C .88836976 29 DME .41780741-07 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

INJECTION CONDITIONS 1950.0 MOON 235631122755202732375600 J.D.= 2438248.21175586 AUG. 6,1963 17 04 55.707

GEOCENTRIC X0-.61143780 04 Y0-.23438636 04 Z0-.54566108 03 DX0 .35295397 01 DY0-.88027116 01 DZ0-.54594941 01  
CARTESIAN T0 .61495706 05 GHA .21074440 03 GHD .31361078 03  
DATE OF RUN 041765G 016553 EARTH IS THE CENTRAL BODY FOR INTEGRATION COWELL EQUATIONS OF MOTION

0 DAYS 0 HRS. 0 MIN. 0.000 SEC. 235631122755202732375600 J.D.= 2438248.21175586 AUG. 6,1963 17 04 55.707

GEOCENTRIC EQUATORIAL COORDINATES  
X -.61066757 04 Y -.23620296 04 Z -.55352188 03 DX .35627327 01 DY -.87922516 01 DZ -.54547870 01  
R .65709252 04 DEC -.48322111 01 RA .20114620 03 V .10943100 02 PTH .16181000 01 AZ .11987157 03  
R .65709251 04 LAT -.48322111 01 LON .35040180 03 VE .10531934 02 PTE .16812886 01 AZC .12116592 03  
XS -.10447122 09 YS .10094874 09 ZS .43774450 08 DXS -.21109203 02 DYS -.18709376 02 DZS -.81139760 01  
XM .32552845 06 YM -.16238938 06 ZM -.94397182 05 DXM .48530280 00 DYM .87985646 00 DZM .30392424 00  
XT .32552845 06 YT -.16238938 06 ZT -.94397182 05 DXT .48530280 00 DYT .87985646 00 DZT .30392424 00  
RS .15172701 09 VS .29350908 02 RM .37583228 06 VM .10447791 01 RT .37583228 06 VT .10447791 01  
GED -.48649840 01 ALT .19287213 03 LOS .28523794 03 RAS .13598239 03 RAM .33348775 03 LOM .12274335 03  
DUT .35000000 02 DT .75000000 01 UR .30900500 00 SHA .-60875954 04 DES .16768649 02 DEM .-14546660 02  
CCL .78939548 02 MCL .18709179 03 TCL .18709179 03

GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235631122755202732375600 J.D.= 2438248.2113583H AUG. 6,1963 17 04 21.364  
SMA .25371170 06 FCC .97412174 00 B .57344925 05 SLR .12461326 05 APJ .50085777 06 RCA .65656162 04  
VH .14350904 00 C3 .-15107770 01 CL .17877622 05 TFP .34342858 02 TF .95396826-02 PER .21196803 05  
TA .32791989 01 MTA .18000000 03 EA .37554599 00 MA .97211426-02 C3J .-19874077 01 TFI .00000000 00

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE  
X -.61066757 04 Y -.23620296 04 Z -.55352188 03 DX .35627327 01 DY -.87922516 01 DZ -.54547870 01  
INC .30224249 02 LAN .12802531 02 APF .18635416 03 MX .35195159 00 MY .-19361762 00 MZ .-49628737 00  
WX .11154605 00 WY .-49087135 00 WZ .86600182 00 PX .-94759842 00 PY .-31348205 00 PZ .-55711693-01  
QX .29821515 00 QY .-81288025 00 QZ .-50029331 00 RX .52894320-01 KY .17491783-01 RZ .-99844687 00  
BX .-29821515 00 BY .81288026 00 BZ .50029332 00 TX .-31396969 00 TY .94943301 00 TZ .00000000 00  
DAP .-31936974 01 RAP .19829862 03

BTO .56783066 05 BRT .-80009983 04 B .57344925 05 THA .32992908 03 T VECTOR IN EARTH EQUATOR PLANE  
BTO .56783066 05 BRT .-80009983 04 B .57343984 05 THA .35197955 03 T VECTOR IN ORBIT PLANE OF TARGET

CASE 1 IBSYS-JPTRAJ-SFPRD 041765

2

EARTH-MOON CHECK 4

HELIOCENTRIC EQUATORIAL COORDINATES  
X .10446511 09 Y .-10095110 09 Z .-43775003 08 DX .24671935 02 DY .99171245 01 DZ .26591889 01  
R .15172454 09 LAT .-16769149 02 LON .31598005 03 V .26723118 02 PTH .21102723 02 AZ .76838918 02  
XE .10447122 09 YE .-10094874 09 ZE .-43774450 08 DXE .21109203 02 DYE .18709376 02 DZE .81139760 01  
XT .10479674 09 YT .-10111112 09 ZT .-43968847 08 DXT .21594505 02 DYT .19584232 02 DZT .84179002 01  
LTE .-16768649 02 LOE .31598239 03 LTE .-16764967 02 LTO .16102545 03 RST .15208646 09 VST .30346692 01  
EPS .-11211025 03 ESP .98911702-02 SEP .67887145 02 EPM .50291134 02 EMP .77056544 00 MPT .12893820 03  
MPS .16224048 03 MSP .44234658-01 SMP .17715845 02 SEM .16300448 03 EMS .16954125 02 ESM .40178123-01  
RPM .37999636 06 SPN .36028888 02 SIP .16197841 03 CPT .96371983 02 SIN .96109912 02  
GCE .28106645 03 GCT .28815224 03 CPE .84669921 02 CPS .77642693 02  
REP .65709252 04 VEP .10943100 02

2 DAYS 10 HRS. 26 MIN. 41.238 SEC. 235631271546202170747003 J.D.= 2438250.64695538 AUG. 9,1963 03 31 36.945  
CHANGE OF PHASE OCCURS AT THIS POINT MOON IS THE CENTRAL BODY FOR INTEGRATION COWELL EQUATIONS OF MOTION

2 DAYS 10 HRS. 26 MIN. 41.238 SEC. 235631271546202170747003 J.D.= 2438250.64695538 AUG. 9,1963 03 31 36.945  
\*\*\*\*\* S/C DISCONTINUITY=R STOP

2 DAYS 10 HRS. 26 MIN. 41.238 SEC. 235631271546202170747003 J.D.= 2438250.64695538 AUG. 9,1963 03 31 36.945

GEOCENTRIC EQUATORIAL COORDINATES  
X .33731393 06 Y .62030703 05 Z .-75559509 04 DX .83209578 00 DY .28275367 00 DZ .66862292-01  
R .34305333 06 DEC .-12620747 01 RA .10420049 02 V .88136461 00 PTH .79945668 02 AZ .56020466 02  
R .34305333 06 LAT .-12620747 01 LON .60359662 00 VE .24897456 02 PTE .19979127 01 AZC .27019802 03  
XS .-10882430 09 YS .96928550 09 ZS .42031009 08 DXS .-20283164 02 DYS .-19499616 02 DZS .-84560510 01  
XM .36799422 06 YM .38832118 06 ZM .-18535277 05 DXM .-97790682-01 DYM .97846287 00 DZM .39709176 00  
XT .36799422 06 YT .38832118 06 ZT .-18535277 05 DXT .-97790682-01 DYT .97846287 00 DZT .39709176 00  
RS .15167224 09 VS .29365511 06 RM .37050132 06 VM .10604878 01 RT .37050132 06 VT .10604878 01  
GED .-12706726 01 ALT .33667513 06 LOS .12849246 03 RAS .13830891 03 RAM .60237696 01 LOM .95620131 03  
DUT .35000000 02 DT .12000000 03 UR .86782420 00 SHA .27545618 06 DES .16088259 02 DEM .-28675644 01  
CCL .25989520 03 MCL .95146835 01 TCL .95146835 01

GEOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 23563112607420214547003 J.D.= 2438248.28649031 AUG. 6,1963 18 52 32.763  
SMA .25765472 06 FCC .98634146 00 B .42439093 05 SLR .69902918 04 APJ .51178426 06 RCA .35191793 04  
VH .10313960 00 C3 .-15470370 01 CL .52785743 05 TFP .20394418 06 TF .17946268 01 PIR .21602795 05  
TA .17330692 03 MTA .18000000 03 EA .10963569 03 MA .56408823 02 C3J .-20625021 01 TFI .58444788 02

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE  
X .33731393 06 Y .62030703 05 Z .-75559509 04 DX .83209578 00 DY .28275367 00 DZ .66862292-01  
INC .34000142 02 LAN .12291775 02 APF .18443371 03 MX .-13787150 00 MY .81778769 00 MZ .55876084 00  
WX .11904706 00 WY .-54637588 00 WZ .82903568 00 PX .-36050819 00 PY .-27687319 00 PZ .-43229019-01  
QX .25149897 00 QY .-79114927 00 QZ .-55752134 00 RX .41560678-01 RY .11893616-01 RZ .-49906291 00  
BX .-25149897 00 BY .79114927 00 BZ .55752134 00 TX .-27513038 00 TY .96140692 00 TZ .00000000 00  
DAP .-24776118 01 RAP .19596978 03

BTO .35214662 05 BRT .-23682852 05 B .42439093 05 THA .32607941 03 T VECTOR IN EARTH EQUATOR PLANE

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EARTH-MOON

CHECK 4

HELIOCENTRIC

EQUATORIAL COORDINATES

X	.10716161 09	Y	-.96866519 0a	Z	-.42038645 08	DX	-.21095260 02	DY	-.19782370 02	DZ	-.85229133 01
R	.15187702 09	LAT	-.16068951 02	LOX	.31841518 03	V	.30149497 02	PTH	.35350583 00	AZ	-.72784577 02
ME	.10882430 09	YE	-.96928590 08	ZE	-.42031089 08	DXE	.20263164 02	DYE	.19499616 02	DZE	-.84560510 01
MT	-.10919230 09	YI	-.31830891 03	ZI	-.42049624 06	DXT	.20165373 02	DYT	.20478079 02	DZT	-.88531429 01
LTE	-.166188259 02	LDE	-.96889718 08	LTT	-.16088927 02	LDT	.31841635 03	RST	.15191690 09	VST	.30072780 02
EPS	.53309240 02	ESP	.10397499 00	SEP	-.12658684 03	EPN	.13094632 03	EMP	.44376237 02	MEP	.46774429 01
MPS	.17268139 03	MSP	.27453512-18	SMP	.43174719 01	SEM	-.13126360 03	EMS	-.48631356 02	ESM	-.10514460 00
RPM	.39999998 05	SPN	.52243945 02	SIP	.17319097 03	CPT	-.10027956 03	SIN	.97789149 02		
GCE	.10410479 03	GCT	.29361948 03	CPE	.93813447 02	CPS	.77962564 02				
REP	.34305333 06	VEP	-.88136461 00								

SELENOCENTRIC

EQUATORIAL COORDINATES

X	-.30680285 05	Y	.23198585 05	Z	.10979326 05	DX	-.92988647 00	DY	-.69570920 00	DZ	-.33022947 00
R	.39949998 05	DEC	.15931216 02	RA	.14290562 03	V	-.12073739 01	PTH	-.89713068 02	AZ	-.28162652 03
R	.39949998 05	LAT	.19721915 01	LOX	.31342552 03	VP	.12126119 01	PTP	-.84666754 02	ASP	-.26956365 03
LTS	.68027659 00	LNS	.30930468 03	LTE	.64762768 01	LNE	.35771092 03				
ALT	.36261908 05	SHA	-.30113121 04	ALP	.16060174 02	DR	-.12073587 01	DP	-.86493654-05	ASD	-.24904141 01
HGE	.30669076 03	SVL	.71320920 00	HNG	.17574058 03	SIA	.12845590 03				

SELENOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235631307501202703147003 J.D. = 2438250.97712412 AUG. 9, 1963 11 27 03.525

SMA	-.40430050 04	ECC	.10014713 01	B	.21933919 03	SLR	.11905448 02	APD	.00000000 00	RCA	.59483483 01
WH	-.11011903 01	C3	.12126201 01	CL	.24159470 03	TFP	-.28526580 05	TF	.66368837 02	LTF	.66367338 02
TA	-.17659406 03	MTA	.17689390 03	EA	-.17634126 03	MA	-.44517467 03	C3J	-.20625021 01	TFI	.58444788 02
ZAE	-.13592348 03	ZAP	.17538636 03	ZAC	.10020075 03	DEF	.17378768 03	IR	.41322112 04	GP	.13820333 01

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE

X	-.30680285 05	Y	.23198585 05	Z	.10979326 05	DX	-.92988647 00	DY	-.69570920 00	DZ	-.33022947 00
INC	.16032753 03	LAN	.19605032 03	APF	.23137774 03	MX	.63472325 00	MY	.74773151 00	MZ	.19374390 00
WX	-.92875261-01	WY	-.32282394 00	WZ	-.94163243 00	PX	.60336104 00	PY	-.53451788 00	PZ	-.26248813 00
AX	-.38803500 00	OY	-.78086932 00	OZ	-.20970842 00	RX	-.21900350 00	RY	-.16377081 00	RZ	-.96188179 00
BX	.63085499 00	BY	.75093867 00	BZ	-.19522498 00	TX	-.59887180 00	TY	-.80084492 00	TZ	.00000000 00
SXI	.77031014 00	SVI	-.57604387 00	SZI	-.27346556 00	DAI	-.15870591 02	NAI	.32321085 03		
SXD	-.83404353 00	SYD	.49142138 00	SZD	.25073945 00	DAO	.14521272 02	RAO	.14949326 03		
ETE	.19264150 03	ETS	.31222767 01	ETC	-.29697475 03						

T VECTOR IN EARTH EQUATOR PLANE

BTU	-.21477405 03	HRU	-.44517288 02	B	.21933919 03	THA	.19171016 03			
BTO	-.21915344 03	BRD	-.90285067 01	B	.21933933 03	THA	.17764090 03			

ALL VECTORS REFERENCED TO TRUE TARGET EQU. PLANE

X	.34622685 05	Y	-.19983999 05	Z	.13765780 04	DX	-.10420426 01	DY	-.60835829 00	DZ	-.42408749-01
INC	.17160407 03	LAN	.19652162 03	APF	.34292925 03	MX	.49907035 00	MY	-.85486463 00	MZ	-.14212150 00
WX	-.41584238-01	WY	.14019165 00	WZ	-.98928273 00	PX	-.83440279 00	PY	-.54949130 00	PZ	-.42794766-01
AX	-.3495927 00	OY	-.82368209 00	OZ	-.13982661 00	RX	.30357878-01	RY	.17732608-01	RZ	-.99938177 00
BX	.50357635 00	OY	-.85221201 00	BZ	-.14193504 00	TX	-.50437699 00	TY	.86348356 00	TZ	.00000000 00

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EARTH-MOON

CHECK 4

SXI	-.86244973 00	SVI	-.50406518 00	SZI	-.35157448-01	DAI	-.20147871 01	RAI	-.21029000 03
SXD	.80340555 00	SYD	.59330378 00	SZD	.50306413-01	DAO	.28635607 01	KAO	.36445351 02
ETE	.17276643 03	ETS	.34324716 03	ETC	.27710467 03				

BTT

BTT	-.21711745 03	BRT	.31151411 01	B	.21934083 03	THA	.17183508 03			
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2 DAYS 18 HRS. 14 MIN. 47.467 SEC. 235631307323202626217311 J.D. = 2438250.97202747 AUG. 9, 1963 11 19 43.174

GEOCENTRIC

EQUATORIAL COORDINATES

X	-.36277700 06	Y	-.67175656 05	Z	-.68605143 04	DX	.18221274 01	DY	-.55879889 00	DZ	-.31984808 00
R	.36900784 06	DEC	-.10652918 01	RA	.10490673 02	V	.19325390 01	PTH	.61328497 02	AZ	.25187967 03
R	.36900783 06	LAT	-.10652918 01	LOX	.24327888 03	VE	.27838229 02	PTE	.34919521 01	AZE	.26940535 03
XS	-.10393180 09	YS	.96379418 0a	ZS	-.1792963 08	DXS	-.20147588 02	DYS	-.19630223 02	DZS	-.85007954 01
XM	.36410058 06	YM	.66155687 05	ZM	-.73387963 04	DXM	-.17937539 00	DYM	.96620799 00	DZM	.39978709 00
XT	.36410058 06	YT	.66155687 05	ZT	-.73387963 04	DXT	-.17937539 00	DYT	.96620799 00	DZT	.39978709 00
RS	.15166480 09	VS	.29367794 02	RM	.37013466 06	VM	.10609256 01	RT	.37013466 06	VT	.10609256 01
GED	-.10725498 01	ALV	.36262964 06	LMS	.11455612 02	KAS	.13861840 03	NAM	.10298081 02	LOM	-.24313529 03
DUT	.35000000 02	UT	.30000000 02	DLR	.11695806 01	SHA	.29561149 06	DES	.15995471 02	DEM	-.11360978 01
CCL	.25600418 03	WCL	.11460551 02	TCL	.11460551 02						

HELIOCENTRIC

EQUATORIAL COORDINATES

X	.10975450 09	Y	-.96312243 08	Z	-.41799823 08	DX	.21969716 02	DY	.19044225 07	DZ	-.81809474 01
R	.15188895 09	LAT	-.15974251 02	LOX	.31673228 03	V	.30203953 02	PTH	.29378265 01	AZ	.72734667 02
XE	.10939180 09	YE	-.96379418 0a	ZE	-.41792963 08	DXE	.20147588 02	DYE	.19630223 02	DZE	.85007954 01
XT	.10975590 09	YI	-.31831263 0a	ZI	-.41800302 08	DXT	.19968213 02	DYT	.20569232 02	DZT	.89005826 01
LTE	-.15975471 02	LDE	.31861840 03	LTT	-.15974251 02	LDT	.31873232 02	RST	.15188768 09	VST	.30017382 02
EPS	.53123580 02	ESP	.11168705 00	SEP	.12676490 03	EPN	.13031147 03	EMP	.49483367 02	MEP	.20522700 00
MPS	.17649157 03	MSP	.27453512-18	SMP	.35083802 01	SEM	.12697004 03	EMS	.52918404 02	ESM	-.11146784 00
RPM	.17380899 04	SPN	.52133219 02	SIP	.86491569 02	CPT	.10046924 03	SIN	.10469241 02		
GCE	.10399562 03	GCT	.29545637 03	CPE	.93699617 02	CPS	.78005014 02				
REP	.36900784 06	VEP	.19329390 01								

SELENOCENTRIC

EQUATORIAL COORDINATES

X	-.13236605 04	Y	.10199644 04	Z	.47628197 03	DX	.20015028 01	DY	-.15250069 01	DZ	-.71963517 00
R	.17380899 04	DEC	.15972547 02	RA	.14238165 03	V	.26171614 01	PTH	-.89698277 02	AZ	.27232310 03
R	.17380898 04	LAT	.18427696 01	LOX	.30865416 03	VP	.26171886 01	PTP	-.89600169 02	ASP	-.25699724 03
LTS	.68990118 00	LNS	.30533973 03	LTE	.68009133 01	LNE	.35906582 03				
ALT	-.45776367 04	SHA	.10636159 03	ALP	-.17841798 02	DR	-.26171252 01	DP	.45415473-03	ASD	.90000000 02
HGE	.30687642 03	SVL	.69668271 00	HNG	.17656135 03	SIA	.40311468 02				

SELENOCENTRIC CONIC

EPOCH OF PERICENTER PASSAGE 235631307506202557040111 J.D. = 2438250.97734800 AUG. 9, 1963 11 27 22.868

SMA	-.40580137 04	ECC	.10000144 01	B	.21826327 02	SLK	.11697804 00	APD	.00000000 00	RCA	.58488602-01
WH	-.10915200 01	C3	.12081352 01	CL	.23947860 02	TFP	-.4969361 03	TF	.66374210 02	LTF	.66374195 02
TA	-.17926753 03	MTA	.17969241 03	EA	-.51297603 02	MA	-.71340369 01	C3J	-.20830222 01	TFI	.66245518 02
ZAE	-.13043467 03	ZAP	.17606694 03	ZAC	.10029423 03	DEF	.17936447 03	IR	.41385194 04	GP	-.13916920 01

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EARTH-MOON

CHECK 4

ALL VECTORS REFERENCED TO EARTH EQUATOR PLANE

X	-13235805	04	Y	-16199694	04	Z	-47828197	03	DX	-20015028	01	DY	-15250069	01	DZ	-71963517	00
INC	-16384507	03	LAN	-22399531	03	APF	-26120797	04	MX	-61867379	00	MY	-78456081	00	MZ	-38965625	-01
WX	-19302659	00	WY	-19991755	00	WZ	-96051286	00	PX	-76936109	00	PY	-57675598	00	PZ	-27465616	00
QX	-60888781	00	QY	-79199797	00	QZ	-42474812	-01	RX	-21901752	00	RY	-16610380	00	RZ	-96147844	00
BX	-61306750	00	BY	-78896549	00	BZ	-41008683	-01	TX	-60427698	00	TY	-79677433	00	TZ	-00000000	00
SXI	-76608134	00	SYI	-58099930	00	SZI	-27488024	00	DAI	-15954877	02	RAI	-32282316	03			
SXD	-77261865	00	SYD	-57249603	00	SZD	-27442416	00	DAO	-15927699	02	RAO	-14346224	03			
ETE	-19274747	03	ETS	-84490378	00	ETC	-29680645	03									

BTO	-21762616	02	BRO	-92905826	00	B	-21782637	02	THA	-18244448	03	T VECTOR IN EARTH EQUATOR PLANE			
OTO	-21339009	02	ORO	-43456509	01	O	-21777688	02	THA	-16848969	03	T VECTOR IN ORBIT PLANE OF TARGET			

ALL VECTORS REFERENCED TO TRUE TARGET EQU. PLANE

X	-15113746	04	Y	-85649227	03	Z	-55891532	02	DX	-22691506	01	DY	-13010370	01	DZ	-88264561	-01
INC	-16297650	03	LAN	-20366310	03	APF	-39311024	04	MX	-47900394	00	MY	-82580294	00	MZ	-29807107	00
WX	-12032760	00	WY	-27459414	00	WZ	-95612808	00	PX	-86336763	00	PY	-50329218	00	PZ	-35963861	-01
QX	-49007664	00	QY	-81943721	00	QZ	-29763575	00	RX	-29776356	-01	KY	-17155122	-01	RZ	-99940932	00
BX	-48537410	00	BY	-82702738	00	BZ	-29776877	00	TX	-49916313	00	TY	-86649651	00	TZ	-00000000	00
SXI	-36598469	00	SYI	-49888828	00	SZI	-34366389	-01	DAI	-19694364	01	RAI	-20994596	03			
SXD	-86072571	00	SYD	-50768159	00	SZD	-37560297	-01	DAO	-21525520	01	RAO	-30933364	02			
ETE	-17296761	03	ETS	-34106506	03	ETC	-27702658	03									

BTT	-20786950	02	BRT	-64885049	01	B	-21776088	02	THA	-16266460	03	T VECTOR IN TRUE TARGET EQU. PLANE			
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615576114061	614444767212	612420651171	202701617723	604431537501	603535320551	EARTH
	630600617		455707		000000000000	INITIAL
613511766202	212777744203	211740002016	201776767451	60167727017	600561622465	MOON
				235631307323	202626217311	END

END TRAJECTORY (SFPRC) 016562 G



## REFERENCES

1. Holdridge, D. B., Space Trajectories Program for the IBM 7090 Computer, Technical Report No. 32-223, Revision No. 1, Jet Propulsion Laboratory, Pasadena, California, September 1, 1962.
2. Peabody, P. R., Scott, J. F., and Orozco, E. G., Users' Description of JPL Ephemeris Tapes, Technical Report No. 32-580, Jet Propulsion Laboratory, Pasadena, California, March 2, 1964.
3. Peabody, P. R., Scott, J. F., and Orozco, E. G., JPL Ephemeris Tapes E9510, E9511, and E9512, Technical Memorandum No. 33-167, Jet Propulsion Laboratory, Pasadena, California, March 2, 1964.
4. Newhall, N. S., Users' Guide for JPTRAJ, Engineering Document 199, Jet Propulsion Laboratory, Pasadena, California, January 4, 1964.
5. Clarke, Victor C., Jr., Constants and Related Data for Use in Trajectory Calculations as Adopted by the Ad Hoc NASA Standard Constants Committee, Technical Report No. 32-604, Jet Propulsion Laboratory, Pasadena, California, March 6, 1964.
6. Cary, C., Physical Constants and Other Parameters to be Used in MA-C Computation--Updated Version, Interoffice Memorandum 312.3-176, Jet Propulsion Laboratory, Pasadena, California, October 30, 1964.
7. Hansen, R. R., Programming Standards for SFOF User Programs, Engineering Planning Document No. 125, Revision No. 1, Jet Propulsion Laboratory, Pasadena, California, April 1, 1964.
8. Scott, J. F., et. al., User Guide for the JPL Trajectory Monitor System Under the IBM Fortran II, Version 2 Monitor, Section Report No. 372-11, Jet Propulsion Laboratory, Pasadena, California, August 9, 1963.
9. Explanatory Supplement to the Astronomical Ephemeris and the American Ephemeris and Nautical Almanac, London, Her Majesty's Stationery Office, 1961.
10. White, R. J., et. al., SPACE--Single Precision Cowell Trajectory Program, Technical Memorandum No. 33-198, Jet Propulsion Laboratory, Pasadena, California, January 15, 1965.
11. Roek, D. J., Rosenberg, A. D., TRIO--Trajectory Input-Output Program, Section Report No. 317-101, Jet Propulsion Laboratory, Pasadena, California, February 15, 1965.

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