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USER'S GUIDE AND MATHEMATICAL DESCRIPTION OF THE EPHEMERIS REPRESENTATION GROUND SUPPORT SYSTEM (ERGSS)

Prepared For
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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Prepared for

GODDARD SPACE FLIGHT CENTER

By

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Under

Contract NAS 5-24300
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ABSTRACT

This document provides a system description and user's guide for the Ephemeris Representation Ground Support System (ERGSS). The functions performed by ERGSS include data retrieval from a Goddard Trajectory Determination System (GTDS) ORBIT File, rotation of state vectors from mean-of-1950.0 coordinates to true-of-date coordinates, maximum entropy spectral (frequency) analysis of the data, least-squares fitting of the data to a Fourier series, evaluation of the Fourier series, computation of residuals, statistical analysis of curve fits, and output reporting.

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SECTION 1 - INTRODUCTION

1.1 EPHEMERIS REPRESENTATION CONCEPT

The concept of Multimission Modular Spacecraft (MMS) was developed in response to an increasing demand for standardization of spacecraft and detailed mission design. According to this concept, a spacecraft uses modular, standardized hardware components and onboard software that are adaptable to a variety of missions. Many of these missions require ground-based orbit determination and prediction with subsequent transmission of a 3-to-4-day span of predicted ephemeris data to the spacecraft. These ephemeris data, when used in conjunction with computational algorithms available in the onboard computer (OBC), must be sufficient to reconstruct the predicted spacecraft trajectory to within some specified degree of accuracy. The transmitted data plus the OBC ephemeris reconstruction algorithms are referred to as an "ephemeris representation." Onboard the spacecraft, the ephemeris representation can be used in real time to compute information required in the attitude and control algorithms, to compute the line-of-sight vector to Tracking and Data Relay Satellites (TDRSS), and to annotate the scientific data.

Results from a general investigation of ephemeris representations for MMS missions are presented in References 1 through 3. These studies identify the relationship of representation accuracy to OBC core storage and time requirements and uplink data transmission requirements. Use of the NASA Standard Spacecraft Computer-1 (NSSC-1) as the OBC for Landsat-D and the Solar Maximum Mission (SMM) is given particular attention. Ephemeris representations for the TDRS type of spacecraft are evaluated and documented in Reference 4.

Two constraints, in addition to the accuracy requirement, influence the design of an ephemeris representation. First, the size of the ground-to-spacecraft data transmission is limited. Therefore, a highly accurate ephemeris cannot be computed on the ground and transmitted to the spacecraft for every time of interest (every 30 seconds at a minimum). Second, the computational ability of NSSC-1 is limited. Hence, a highly accurate analytical (or quadrature) formulation is probably too time consuming for onboard computation of the spacecraft position and velocity at the desired times.

Both constraints were satisfied by adopting a compromise between a completely analytical and a totally numerical ephemeris representation that is nearly identical to the Block 5D algorithm discussed in Reference 5. In this approach, a simple analytical approximation to the ephemeris and a file of residuals are computed on the ground and transmitted to the spacecraft. The residuals are the differences between accurate ephemeris coordinates and the analytical approximation at the interpolation grid points. Each residual is constrained to fit in a single-precision OBC word. The analytical approximation acts as a data compression device that decreases the required data transmission. The OBC algorithm consists of evaluating the analytical approximation, adding the residuals to reconstruct the interpolation grid points, and interpolating for the times of interest.

Several possible analytic approximations to the ephemeris data are considered in the previous studies (References 1 and 3). From a physical viewpoint, an analytic representation of classical orbital elements is a natural possibility because an enormous theoretical background details the evolution in time of classical elements under various perturbing forces. However, the computation time required by NSSC-1 to convert from classical to Cartesian elements is

relatively large. For missions that require Cartesian elements at the times of interest (e.g., every 30 seconds), the first study (Reference 1) indicates that directly modeling the Cartesian coordinates, rather than using mean or osculating classical elements, is advantageous.

An analytic representation consisting of a set a Chebyshev polynomials was considered but found to be inappropriate because the data span of 3 to 4 days includes 45 revolutions of a spacecraft at low altitude. Because Cartesian components of position and velocity exhibit periodicities on the order of the spacecraft period, a Chebyshev polynomial representation requires too many coefficients to be sufficiently accurate.[1] Instead, a truncated Fourier series was adopted in the SMMER Program.

Various interpolators were also studied. A four-point Hermite interpolation used with a 16-minute interpolation interval yields an interpolation error below 300 meters when compared with the reference ephemeris for the SMM type of orbit. Therefore, SMMER (and, thus, ERGSS) was implemented using a truncated Fourier series with grid point residuals coupled with a Hermite interpolation scheme.

1.2 GROUND-SUPPORT FUNCTIONS

A 3-day file of Cartesian ephemeris data is generated by a numerical integration. These data are analyzed to determine the mean orbital frequency and the least-squares fit to the truncated Fourier series discussed in Section 3.4. An optional step is to compute the coordinate residuals or differences between the accurate ephemeris and the Fourier series representation. The Fourier coefficients, the mean

[1] Even dividing the data set into several subintervals would not alleviate the problem of too many coefficients.

orbital frequency, the Earth's sidereal frequency, reference times, grid spacing, and residuals can be transmitted to the spacecraft.

1.3 ONBOARD FUNCTIONS

The Fourier series are evaluated for $\bar{r}$ and $\dot{\bar{r}}$ at specified grid point times. An option at this step is to add the residuals at the grid points to reconstruct the accurate ephemeris data. Each time a new grid point value is computed (i.e., about every 16 minutes), new Hermitean interpolation coefficients are computed. At each request time, Hermitean interpolation is performed for the position and velocity coordinates. The Hermitean interpolation formulas are discussed in Section 3.2.

1.4 ORGANIZATION OF THE DOCUMENT

This document is a system description and user's guide to ERGSS. This program was developed by directly modifying the SMMER Program (see Reference 6) to be a general ephemeris representation package. The functional flow of the system is discussed in Section 2. Section 3 presents a mathematical description of all the algorithms used in the system. Section 4 is a user's guide to the system. Appendix A provides file formats and Appendix B presents a sample printer output.

SECTION 2 - FUNCTIONAL FLOW OF ERGSS

ERGSS consists of a main program and 36 subroutines. These subroutines are divided into several groups, each of which is to perform a specific function in the program. These functions include data retrieval from a GTDS ORBIT File, rotation of state vectors from a mean-of-1950.0 coordinate reference system to a true-of-date reference system, maximum entropy spectral analysis of the ephmeris data to determine orbital frequency, least-squares fitting of the data to a Fourier series, evaluation of the Fourier series, calculation of the residuals, statistical analysis of the curve fits, and output reporting. Figure 2-1 presents a hierarchical structure chart that demonstrates the interaction of the various subroutines.

The majority of the subroutines in ERGSS were taken intact or modified from the SMMER Program (Reference 6). Subroutines GETHDR, GETVCT, TODROT, INTP, HEMITR, DJUL1, OBSTIM, TCON, TDIF, TCWF, MA3331, DJUL, and DELTIM were taken directly or modified from GTDS. The source of subroutines ZCPOLY and VSORTP is the International Mathematical and Statistical Library (IMSL). FMOVE, INCORE, and ZTIME are utility subroutines available to the user at the Mission Operations Computing Facility of GSFC.

MAIN is the executive program. It serves as the driver of the system and calls different modules to perform the major functions mentioned above. The following subsections discuss each major function in the order of execution.

2.1 VARIABLE INITIALIZATION

Variables in NAMELIST SCTIM and CARDIN and variables for output functions are initialized to their default values.

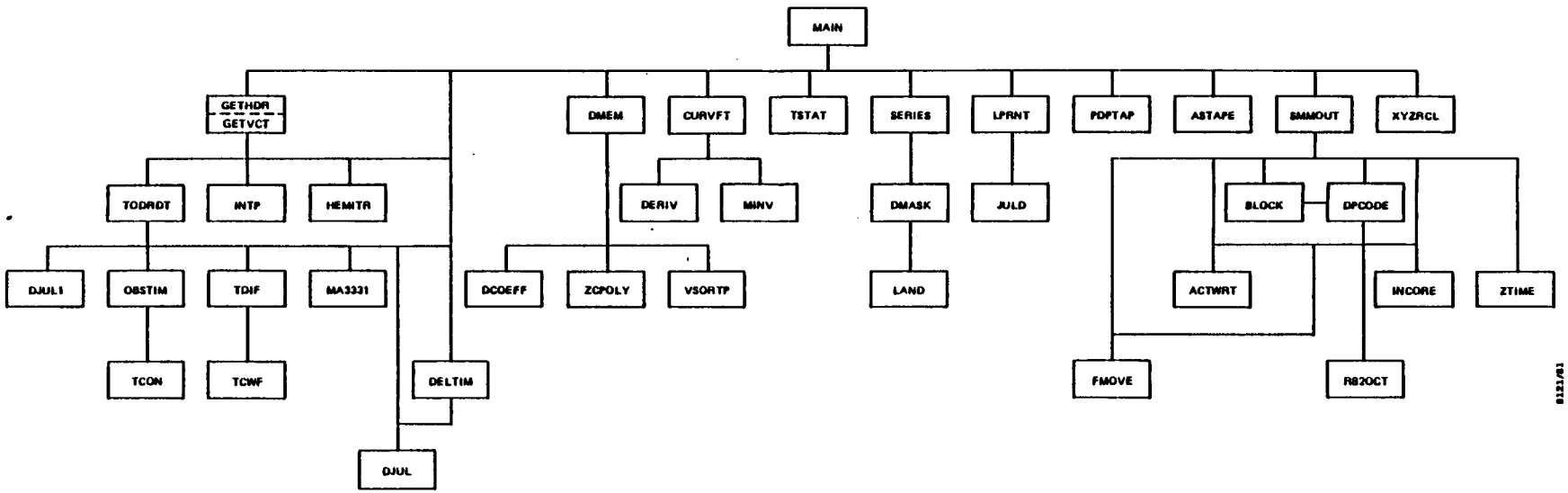

Figure 2-1. Hierarchical Structure Chart of ERGSS

2.2 READING OF INPUT DATA/WRITING OF OUTPUT FILES

Input data include three NAMELISTs and three additional input cards. Section 4 provides a detailed description of the NAMELIST and the card contents.

2.3 READING GTDS ORBIT FILE HEADER RECORDS

The header records are read by calling GETHDR (entry point GETHDR).

2.4 DETERMINATION OF START TIME AND END TIME OF EPHEMERIS REPRESENTATION RUN

The ephemeris representation start and end times are determined by comparing the start times and end times input by the user with those of the GTDS ORBIT File. Figure 2-2 illustrates how the start time and end times of the ephemeris representation span are determined for the five acceptable cases. The two cases that are unacceptable and will cause the termination of the run after printing error messages are illustrated in Figure 2-3.

2.5 TRANSFORMATION AND CALCULATION OF THE TIME SERIES

Two time systems, ground-based ephemeris time (universal time coordinated (UTC)) and spacecraft time, are involved in ERGSS. The start time and the end time of the ephemeris representation span and the user input reference time for the Fourier series are in ground-based ephemeris time. As the Fourier series is to be evaluated in spacecraft time, transformations between the two systems are necessary. (See Section 3.1 for discussions on these transformations.) The start time and the end time of the ephemeris representation span, which is the reference time for the Fourier series, are first transformed from ground-based ephemeris time (UTC) to spacecraft time. (Subroutines DELTIM and DJUL are involved in this part of the function.) The number of data points and an equispaced series of spacecraft time are

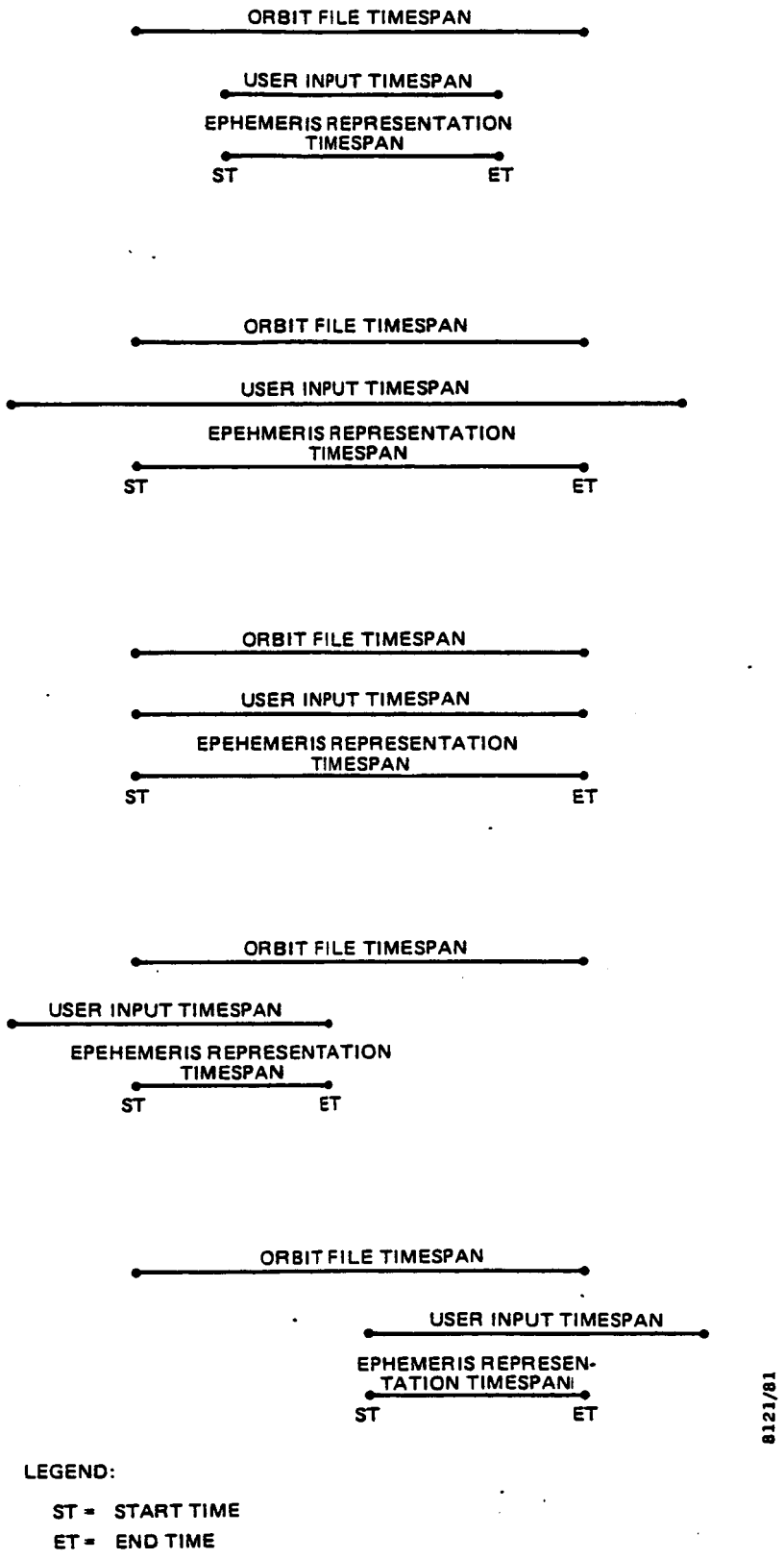

Figure 2-2. Five Acceptable User Input Start Times and End Times

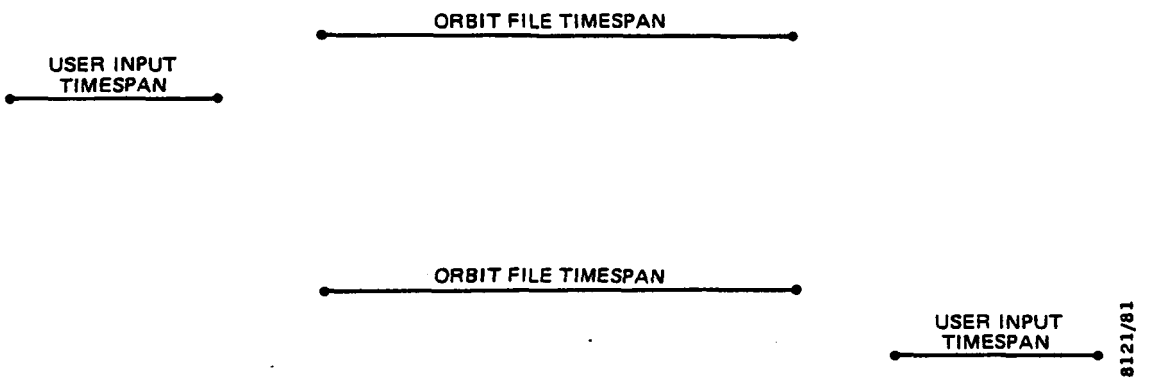

Figure 2-3. Two Unacceptable User Input Start Times and End Times

calculated according to the start time, the end time, the reference time, and the grid interval. Finally, the time series is transformed to ground-based A.1 (atomic) time for use in data retrieval from the GTDS ORBIT File.

2.6 DATA RETRIEVAL FROM GTDS ORBIT File

The time series calculated in Section 2.5 is used for the request times (REQTIM) needed to reconstruct position and velocity data from the GTDS ORBIT File by calling GETVCT, an entry point of subroutine GETHDR. If the data on the ORBIT File are in the mean-of-1950.0 Equator and equinox coordinate system, the position and the velocity will be transformed automatically to the true-of-date coordinate system. If the data in the ORBIT File are stored in the true-of-reference system, no rotation is done.

The rotation is accomplished by reading the GTDS true-of-date Solar/Lunar/Planetary (SLP) Ephemeris File and the Time Conversion Coefficients File to obtain the necessary information to compute the "C matrix." The C matrix is multiplied with the position and velocity vectors in the 1950.0 system to yield position and velocity vectors in the true-of-date system.

This module includes subroutines GETVCT, TODROT, INTP, HEMITR, DJUL1, OBSTIM, TCON, TDIF, TCWF, MA3331, DJUL, and DELTIM. Subroutine TODROT, together with DJUL1, OBSTIM, TCON, TDIF, TCWF, MA3331, DJUL, and DELTIM, forms the true-of-date rotation package.

2.7 MAXIMUM ENTROPY SPECTRAL ANALYSIS

Subroutines DMEM, DCOEFF, ZCPOLY, and VSORTP are included in this module. Subroutine DMEM, adapted from Reference 7, controls the spectral analysis. Subroutine DCOEFF is called to compute the filter (Burg) coefficients of the input series and subroutine ZCPOLY is called to compute the roots

of the power spectrum. These roots are converted to frequencies and sorted in subroutine VSORTP according to significance. Output includes the filter coefficients (for subsequent calculation of the power spectrum, if desired) and the frequencies in the time series.

2.8 LEAST-SQUARES FITTING OF THE EPHEMERIS DATA TO A FOURIER SERIES

This module includes subroutines CURVFT, DERIV, and MINV. Subroutine CURVFT controls the process. (The solution for the best-fit coefficients is discussed in Section 3.5.) The calculation performed in subroutine CURVFT includes

1. Computation of the derivative matrix, F (by calling subroutine DERIV)

2. Computation of $F^T F$ and its inverse (by calling subroutine MINV)

3. Computation of $F^T Y$, where Y is the position or velocity retrieved from the GTDS ORBIT File

4. Computation of the coefficient vector, A

2.9 EVALUATION OF THE FOURIER SERIES AND COMPUTATION OF THE RESIDUALS

The evaluation of the Fourier series is controlled by subroutine SERIES. Subroutines DMASK and LAND are also included in this module. The main function of this module is to calculate the ephemeris data (position and velocity) by evaluating the Fourier series using the calculated Fourier coefficients. The calculated ephemeris data are compared with the ephemeris data retrieved from the GTDS ORBIT File and the differences (residuals) are calculated.

2.10 STATISTICAL ANALYSIS OF THE CURVE FITS

The statistics that are computed include the residual mean, the standard deviation, and the distribution function. All calculations are done in the MAIN program except for the

distribution function, which is calculated by calling subroutine TSTAT.

2.11 OUTPUT FUNCTIONS

The output functions include output of printer reports and magnetic tapes. Output to the line printer is handled by subroutine LPRNT and another group of subroutines controlled by subroutine SMMOUT. This group of subroutines, which includes SMMOUT, BLOCK, DPCODE, ACTWRT, INCORE, ZTIME, FMOVE, and R82OCT, writes ephemeris uplink information unique to the SMM spacecraft on the print file. Subroutine LPRNT writes the remainder of all printed output. Tape output is optional. Subroutine PDPTAP writes the ephemeris representation tape file, which is compatible with the SMM onboard computer.

Subroutine ASTAPE writes the ephemeris representation tape file in the American Standard Code for Information Interchange (ASCII) format. Appendix A, Table A-2, describes the ASCII tape output format.

SECTION 3 - MATHEMATICAL DESCRIPTION

In this section, the mathematical algorithms used in ERGSS are described in the order of the functional flow presented in Section 2.

3.1 CONVERSION OF EPHEMERIS TIME TO SPACECRAFT TIME

The conversion of ephemeris time (UTC) to spacecraft time is provided by the equation:

$$t_i = t_0 + (1 + R)\ (T_i - T_0) + R_d(T_i - T_0)^2 \qquad (3\text{-}1)$$

where T_0 is the ephemeris time when the spacecraft clock is calibrated, T_i is any ephemeris time, R is the spacecraft clock drift rate, R_d is the rate of change of the spacecraft clock drift rate, and t_i, t_0 are the spacecraft times corresponding to T_i and T_0.

The reverse conversion of spacecraft time to ephemeris time can be obtained by considering Equation (3-1) as a quadratic equation for $(T_i - T_0)$ and solving for $(T_i - T_0)$:

$$T_i = T_0 + \frac{1 + R}{2\ R_d} \left\{ -1 + \left[1 + \frac{4\ R_d}{(1 + R)^2}\ (t_i - t_0) \right]^{1/2} \right\} \qquad (3\text{-}2)$$

If $(4\ R_d/(1 + R)^2)\ (t_i - t_0) << 1$ is assumed, $[1 + (4\ R_d/(1 + R)^2)\ (t_i - t_0)]^{1/2}$ can be expanded in the Taylor series, and Equation (3-2) becomes:

$$T_i = T_0 + \frac{t_i - t_0}{1 + R} \left[1 - \frac{R_d(t_i - t_0)}{(1 + R)^2} + \frac{2\ R_d^2(t_i - t_0)^2}{(1 + R)^4} - \ldots \right] \qquad (3\text{-}3)$$

3.2 ROTATION FROM THE MEAN-OF-1950.0 COORDINATE REFERENCE SYSTEM TO THE TRUE-OF-DATE REFERENCE SYSTEM

The user should consult Reference 8 for the definition of the two coordinate systems and a more detailed explanation of the transformation.

The "C rotation matrix," which is used to rotate from the mean 1950.0 system to the true-of-date system, is calculated by evaluating ephemeris polynomials from the GTDS SLP File, as follows:

$$C(t) = \sum_{i=1}^{N} A_i \left(\frac{t - t_0}{86,400}\right)^{i-1} \tag{3-4}$$

where $C(t)$ = C rotation matrix

A_i = ephemeris polynomial coefficients

t = time in seconds from beginning of year

t_0 = time in seconds from beginning of year to midpoint of this day (current day + 43,200 seconds)

N = degree of polynomial plus 1

Quantities A_i, t_0 are obtained from the SLP File.

Multiplying the position and velocity vectors in the 1950.0 coordinate system by matrix C gives the position and velocity vectors in the true-of-date coordinate system. The equation is as follows:

$$\bar{X}_{TOD} = C\ \bar{X}_{1950} \tag{3-5}$$

3.3 MAXIMUM ENTROPY SPECTRAL ANALYSIS METHOD

The maximum entropy spectral analysis method attempts to remove some of the difficulties of Fourier analysis by adding the maximum entropy constraint to the determination of a

power spectrum. Reference 9 provides a philosophical and mathematical comparison of the Fourier analysis method and the maximum entropy method (MEM). Reference 10 reviews the MEM literature.

Basically, the MEM technique attempts to remove the assumptions implicit in discrete Fourier analysis. The entropy function is a probabilistic measure of the lack of information in a time series. In principle, by maximizing the entropy function (subject to the constraint that the Fourier transform of a power spectrum equals the discrete samples of an autocorrelation function), the power spectrum of a time series is determined with maximum noncommittance to information that is not present in the data.

As a result of these improvements, MEM provides superior frequency resolution to Fourier analysis for short data sets (namely, MEM locates periodicities in data sets that are of the order of the length of the data set itself). Moreover, MEM can yield estimates of the frequencies inherent in a data set without quantizing them because the power spectrum can be computed at arbitrary frequencies within the Nyquist range.

A disadvantage of MEM is that as a nonlinear technique it does not provide an estimate of the amplitude of the sinusoidal variation in the ephemeris data (which would be obtained, for example, by a direct discrete Fourier transform of the data). For that reason, the MEM spectral analysis of the data is followed by a least-squares fit of the coefficients of a truncated Fourier series. The MEM algorithm is briefly discussed below.

First, the Burg coefficients of an M-coefficient filter are determined such that the digital filter convolved with the input time series has a constant spectrum. This entire process is described in detail in Ulrych and Bishop

(Reference 11). Subsequently, the frequencies present in the input power series are determined by finding the peak of the power spectrum. The power spectrum has the form

$$P(f) = \frac{K}{A(f)^2} = \frac{K}{z - z_1^2 \quad z - z_2^2 \quad \ldots \quad z - z_M^2} \qquad (3\text{-}6)$$

where $z = \exp(-2 \cdot \pi \cdot i \cdot \Delta t \cdot f)$, K is a constant, and A(f) is a complex polynomial in z of degree M. The maxima of P will occur at the roots of $|A(f)|^2$. Therefore, the frequencies "contained" in the input time series will occur at roots z_i. These roots are determined and the frequencies are ordered according to the magnitude of z_i. The larger the magnitude of z_i, the more likely it is that the corresponding f_i is a periodic frequency of the time series. Naturally, not all of the M frequencies are unique. Actually, the positive and negative frequencies are equal in number. (If M is odd, there are (M-1)/2 positive and negative frequencies and one near zero or the Nyquist frequency.) The negative frequencies are rejected and the positive frequencies are ordered as described.

Because the MEM algorithm is used in ERGSS to determine the dominant frequency in the Cartesian ephemeris data, MEM is used with M equal to 3. According to Reference 6, numerical experiments have shown that this choice of M is appropriate. For very noisy data, a larger value for M would probably be required to obtain an accurate estimate of the fundamental frequency.

3.4 FOURIER SERIES CARTESIAN COORDINATE REPRESENTATION

To represent the Cartesian ephemeris data at the equispaced grid points, a Fourier series is chosen of the form

$$\sum_{i=1}^{N=3} \sum_{j=0}^{M=5} \left[a_{ij}\, t^j \sin(i\omega t) + b_{ij}\, t^j \cos(i\omega t)\right]$$

$$+ \sum_{k=0}^{1} \left[\sin(\omega t) + \cos(\omega t)\right]^k \left[C_k \sin(2\omega_E t) + d_k \cos(2\omega_E t)\right] \tag{3-7}$$

The mean orbital frequency, ω, is assumed to be the same for each Cartesian coordinate. The Earth's sidereal rotation frequency, ω_E, is assumed to have a value of $2\pi/(23.934467 \times 3600)$ or 7.2921166×10^{-5} radians per second. Such a representation is consistent with modeling the variation of the Cartesian coordinates due to second- and third-degree zonal geopotential effects and atmospheric drag. In practice, the series is used in the nested form

$$\begin{aligned}
X(t) = {} & A_1 + t\left\{A_2 + t\left[A_3 + t\left(A_4 + t(A_5 + tA_6)\right)\right]\right\} \\
& + \left\{A_7 + t\left[A_8 + t\left(A_9 + t\left(A_{10} + t(A_{11} + tA_{12})\right)\right)\right]\right\} \sin(\omega t) \\
& + \left\{A_{13} + t\left[A_{14} + t\left(A_{15} + t\left(A_{16} + t(A_{17} + tA_{18})\right)\right)\right]\right\} \cos(\omega t) \\
& + \left\{A_{19} + t\left[A_{20} + t\left(A_{21} + t(A_{22} + tA_{23})\right)\right]\right\} \sin^2(\omega t)) \\
& + \left\{A_{24} + t\left[A_{25} + t\left(A_{26} + t(A_{27} + tA_{28})\right)\right]\right\} \sin(\omega t) \cos(\omega t) \\
& + \left\{A_{29} + t\left[A_{30} + t(A_{31} + tA_{32})\right]\right\} \sin^3(\omega t) \qquad (3\text{-}8) \\
& + \left\{A_{33} + t\left[A_{34} + t(A_{35} + tA_{36})\right]\right\} \sin^2(\omega t) \cos(\omega t) \\
& + \left\{A_{37} + A_{39} \sin(\omega t) + A_{41} \cos(\omega t)\right\} \sin(2\omega_E t) \\
& + \left\{A_{38} + A_{40} \sin(\omega t) + A_{42} \cos(\omega t)\right\} \cos(2\omega_E t)
\end{aligned}$$

where X is any position or velocity component and t is the time relative to the reference time for the span. This form is derived from the fact that trigonometric functions of multiple angles are simple polynomials in the functions of the fundamental angle. This computation requires 2 sines/cosines, [(2N + 1) Mn + 2Nn + 2N - 2] multiplications, and [(2N + 1) Mn + 2Nn] additions, where N and M are the highest harmonic and the highest power of t, respectively, and n is the number of position and velocity components.

Coefficients A_i are obtained by a least-squares fit of Equation (3-8) to the accurate ephemeris file generated by numerical integration. Frequency ω is assumed known, either from a priori knowledge of the orbital period or by spectral analysis (e.g., MEM, as described in Section 3.3) of the ephemeris file.

3.5 LEAST-SQUARES METHOD

Given a sequence of n measurements, Y_i, corresponding to a time series, t_i, its measurements can be represented with function f, which is a series consisting of m coefficients:

$$Y_i = f(A_1, A_2, \ldots, A_m, t_i) + \delta_i \qquad (3\text{-}9)$$

where δ_i are the residuals, A_j are the coefficients, $i = 1, 2, \ldots, n$, $j = 1, 2, \ldots, m$, and $n \geq m$. Equation (3-9) can also be expressed in matrix form as

$$Y_{nx1} = F_{nxm} A_{mx1} + \delta_{nx1} \qquad (3\text{-}10)$$

where F_{nxm} is an n-by-m matrix, Y_{nx1} and δ_{nx1} are n-by-1 column matrices, and A_{mx1} is an m-by-1 column matrix.

The sum of the square of residuals can be written as

$$S = \delta^T \delta = (FA - Y)^T (FA - Y) \tag{3-11}$$

The least-squares method requires that s be a minimum for the curve (the sequence of measurements Y) to be the best fit. In other words,

$$\frac{\partial S}{\partial A} = 0 \tag{3-12}$$

The solution of Equation (3-12) is

$$A = (F^T F)^{-1} F^T Y \tag{3-13}$$

3.6 FINAL STATISTICS

To provide the user with a statistical analysis of the least-squares estimate, a set of estimated overall errors and associated quantities is produced at the end of the run. An explanation of these quantities follows:

- Number of data points--Number of position or velocity components interpolated from the GTDS ORBIT File
- Sum of squares of residuals
- Standard deviation--Standard deviation, σ, given by

$$\sigma = \sqrt{\frac{S}{(n - m)}} \tag{3-14}$$

where S = sum of squared residuals
n = number of data points
m = number of coefficients

- Degrees of freedom--The difference between n and m, i.e., (n - m)
- Distribution function--Value of student's-T distribution, based on the number of degrees of freedom and the percentage of confidence desired (90, 95, or 99 percent)
- Percent confidence limits--Equal to the product of the distribution function and the standard deviation, σ. This value gives an estimate of the range of the residuals. Given an example of 95-percent confidence limits = 0.508, 95 percent of the residuals fall in the range of -0.508 to +0.508. The coefficients can be used to compute measurements to an accuracy of ± 0.508 in units equivalent to that of the data used in the least-squares solution.
- Number of residuals exceeding 0.75 kilometer or 0.75 meter/second--Result of the automatic counter to detect large deviations

SECTION 4 - USER'S GUIDE

4.1 INPUT REQUIREMENTS

4.1.1 PROGRAM CONTROL OPTIONS

The NAMELIST input needed to execute ERGSS consists of $SCTIM, $CARDIN, and $CLOCK. The variable names and their dimensions, types, default values, and brief descriptions for NAMELIST input are listed in Tables 4-1 through 4-3. Following the NAMELIST input, a flag input card is needed to indicate which Fourier coefficients among the maximum of 42 the user wishes to retain in the curve fit, and which position and velocity components among the six possibilities are to be represented by a Fourier series. Columns 1 through 42 define the 1st through 42nd coefficients, respectively, and columns 47 through 52 set the position and velocity components. Setting a flag to 1 means the component or coefficient is to be included, and 0 indicates that it is not to be included. Following the flag input card, two input cards are needed. These two cards contain the names of a partitioned data set and its members, which will be accessed in subroutine SMMOUT to retrieve data to generate the ephemeris uplink information.

The variable names and their description are listed in Table 4-4. Section 4.3 provides a more detailed example of the input deck setup.

4.1.2 GTDS ORBIT FILE

The ORBIT File can be either sequential or direct-access format. If it is sequential, parameter LEVEL in NAMELIST SCTIM must be set equal to 0. Any integer value greater than or equal to 1 indicates that the file is direct access and the input value must be the file level to be accessed. The file format is shown in Appendix A.

Table 4-1. NAMELIST $SCTIM Variable Descriptions

VARIABLE NAME	VARIABLE DIMENSION	VARIABLE TYPE	DEFAULT VALUE	DESCRIPTION
LEVEL	1	I*4	0	GTDS ORBIT FILE LEVEL: = 0, FILE IS SEQUENTIAL > 1, REQUEST ACCESS OF INDICATED LEVEL ON DIRECT-ACCESS, MULTILEVEL FILE
IFRN	1	I*4	22	FORTRAN REFERENCE NUMBER (FRN) OF GTDS ORBIT FILE
ISFSW	1	I*4	1	INDICATOR FOR USING SCALE FACTOR FOR POSITION AND VELOCITY VECTORS: = 1, YES = 0, NO
SFPOS	1	R*8	1000.D0	SCALE FACTOR FOR POSITION VECTOR (METERS)
SFVEL	1	R*8	1000.D0	SCALE FACTOR FOR VELOCITY VECTOR (METERS/SECOND)
IREQ	1	I*4	1	GTDS ORBIT FILE RETRIEVAL INDICATOR: = 1, FOR POSITION AND VELOCITY = 2, FOR POSITION ONLY = 3, FOR VELOCITY ONLY
IUNIT	1	I*4	0	INDICATOR FOR WRITING TAPES: = 0, NO TAPE OUTPUT = 1, ASCII TAPE > 2, PROGRAMMED DATA PROCESSOR (PDP) TAPE

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Table 4-2. NAMELIST $CARDIN Variable Descriptions

VARIABLE NAME	VARIABLE DIMENSION	VARIABLE TYPE	DEFAULT VALUE	DESCRIPTION
YMD1	1	R*8	ORBIT FILE START TIME	(YYMMDD.) REQUESTED START TIME OF EPHEMERIS REPRESENTATION
HMS1	1	R*8		(HHMMSS.SS)
YMD2	1	R*8	ORBIT FILE END TIME	(YYMMDD.) REQUESTED END TIME OF EPHEMERIS REPRESENTATION
HMS2	1	R*8		(HHMMSS.SS)
YMDR	1	R*8	15 HOURS AFTER ACTUAL START TIME OF EPH. REP.	(YYMMDD.) ZERO POINT OF TIME USED IN FOURIER SERIES
HMSR	1	R*8		(HHMMSS.SS)
G	1	R*8	600.DO	GRID INTERVAL (SPACECRAFT SECONDS)
NBIT	1	I*4	34	NUMBER OF SIGNIFICANT BITS TO BE USED IN EVALUATION OF FOURIER SERIES ($1 \leq NBIT \leq 56$)
IC	1	I*4	2	INDICATOR FOR PERCENT CONFIDENCE LIMIT IN STATISTICAL ANALYSIS SUMMARY: = 1, USE 90 PERCENT = 2, USE 95 PERCENT = 3, USE 99 PERCENT
COFFDA	1	I*4	8	FORTRAN REFERENCE NUMBER (FRN) OF UPLINK MESSAGE FILE
E	1	L*1	.FALSE.	FLAG TO INITIALIZE VARIABLE RLINE TO DEFAULT VALUE IN SUBROUTINE SMMOUT

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Table 4-3. NAMELIST $CLOCK Variable Descriptions

VARIABLE NAME	VARIABLE DIMENSION	VARIABLE TYPE	DEFAULT VALUE	DESCRIPTION
ETOYMD	1	R*8	NONE	(YYMMDD.) } EPHEMERIS TIME WHEN SPACECRAFT IS CALIBRATED
ETOHMS	1	R*8	NONE	(HHMMSS.SS) } EPHEMERIS TIME WHEN SPACECRAFT IS CALIBRATED
TO	1	R*8	NONE	SPACECRAFT CLOCK OFFSET (SPACECRAFT SECONDS)
DTPR	1	R*8	NONE	= 1/(1 + DRIFT RATE)
DTPP	1	R*8	NONE	RATE OF CHANGE OF DRIFT RATE

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Table 4-4. Input Cards for SMMOUT

COLUMNS	VARIABLE NAME	VARIABLE TYPE	DEFAULT VALUE	DESCRIPTION
1–8	DDNAME	R*8	NONE	NAME OF PARTITIONED DATA SET THAT CONTAINS UPLINK MESSAGES
11–18	MEMNAM(1)	R*8	NONE	NAME OF MEMBER IN DATA SET DDNAME
21–28	MEMNAM(2)	R*8	NONE	NAME OF MEMBER IN DATA SET DDNAME
31–38	MEMNAM(3)	R*8	NONE	NAME OF MEMBER IN DATA SET DDNAME
41–48	MEMNAM(4)	R*8	NONE	NAME OF MEMBER IN DATA SET DDNAME
51–58	MEMNAM(5)	R*8	NONE	NAME OF MEMBER IN DATA SET DDNAME
61–68	MEMNAM(6)	R*8	NONE	NAME OF MEMBER IN DATA SET DDNAME
71–78	MEMNAM(7)	R*8	NONE	NAME OF MEMBER IN DATA SET DDNAME
SECOND CARD				
1–8	LDSNAM	R*8	NONE	USER NAME
9–12	REVNO	R*4	NONE	REVISION NUMBER

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4.2 OUTPUT

4.2.1 PRINTER OUTPUT

Printer output can be separated into the following groups:

- Input card images listing (written by MAIN)
- Special time parameter and primary frequencies (written by MAIN)
- Fourier coefficients for satellite ephemeris and errors (written by LPRNT)
- Satellite ephemeris and residuals (written by LPRNT)
- Summary of statistical analysis (written by LPRNT)
- Uplink messages (written by SMMOUT)
- PDP tape contents (written bv PDPTAP)
- ASCII tape contents (written by ASTAPE)

A sample printer output is shown in Appendix B.

4.2.2 TAPE OUTPUT

The two optional tape output formats are as follows:

- PDP-11/70 tape--This tape, designed for SMM, will be created if parameter IUNIT, which is the FORTRAN reference number for the tape, is set equal to an integer number greater than or equal to 2. Tape specifications are provided by the following DD statement:

```
//FT24F001 DD DISP=(NEW,PASS),UNIT=9TRACK,
// DCB=(RECFM=FB,LRECL=80,BLKSIZE=80),
// VOL=SER=mmmmm
```

where mmmmm is the tape number. The tape format is provided in Table 4-5.

Table 4-5. PDP-11/70 Tape Format

RECORD	BYTES	NAME	DESCRIPTION
1	1	–	BLANK
	2–16	IDSAT	SATELLITE ID NUMBER
	17–33	NCHOP	NUMBER OF TERMS TO IGNORE
	34–79	–	BLANK
	80	–	CHARACTER X
2	1	–	BLANK
	2–26	TREF	REFERENCE TIME OF CURVE FIT (SPACECRAFT SECONDS)
	27–51	T(1)	FIRST DATA POINT TIME OF CURVE FIT (SPACECRAFT SECONDS)
	52–76	T(NP)	LAST DATA POINT TIME OF CURVE FIT (SPACECRAFT SECONDS)
	77–79	–	BLANK
	80	–	CHARACTER X
3	1	–	BLANK
	2–26	G	GRID INTERVAL (SPACECRAFT SECONDS)
	27–51	GINV	INVERSE GRID INTERVAL (1/SPACECRAFT SECONDS)
	52–76	W	ORBITAL FREQUENCY (RADIANS/SECOND)
	77–79	–	BLANK
	80	–	CHARACTER X
4–17	SAME FORMAT AS RECORDS 2 AND 3	A_1–A_{42}	FOURIER COEFFICIENTS FOR X
18–31	SAME FORMAT AS RECORDS 2 AND 3	A_1–A_{42}	FOURIER COEFFICIENTS FOR Y
32–45	SAME FORMAT AS RECORDS 2 AND 3	A_1–A_{42}	FOURIER COEFFICIENTS FOR Z
46–59	SAME FORMAT AS RECORDS 2 AND 3	A_1–A_{42}	FOURIER COEFFICIENTS FOR $\dot{X}$
60–73	SAME FORMAT AS RECORDS 2 AND 3	A_1–A_{42}	FOURIER COEFFICIENTS FOR $\dot{Y}$
74–87	SAME FORMAT AS RECORDS 2 AND 3	A_1–A_{42}	FOURIER COEFFICIENTS FOR $\dot{Z}$

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- ASCII tape--This tape, designed for the Landsat-D mission, will be created if parameter IUNIT in NAMELIST SCTIM is set equal to 1. Tape specifications are provided by the following DD statement:

```
//FT21F001 DD DISP=(NEW,PASS),UNIT=9TRACK,LABEL=(1,BLP),
//  DCB=(RECFM=FB,LRECL=924,BLKSIZE=924,BUFNO=1,OPTCD=Q),
//  VOL=SER=nnnnn
```

where nnnnn is the tape number. DCB subparameter OPTCD=Q must be coded. It specifies that translation from EBCDIC to ASCII output is required. Its omission will result in an output tape in EBCDIC format instead of the ASCII format as required.

The tape format is given in Appendix A.

4.3 JOB CONTROL LANGUAGE AND SAMPLE DECK SETUP

This subsection describes the job control language (JCL) cards that are required to execute ERGSS in the environment of the IBM S/360 at GSFC. A sample deck setup, which includes JCL cards and input data, is shown in Figure 4-1. The user should consult IBM JCL manuals and Reference 12 for the definition and usage of the JCL statements.

The 12 DD statements, which point to data sets or files that may be needed during execution, are described below.

DDNAME	Description
STEPLIB	Points to load module to be executed
FT05F001	By providing a DDNAME of DATA5, points to data set containing card deck input
FT06F001	Holds accumulating printer output during execution, which is printed after execution has terminated
FT08F001	Contains uplink messages
FT09F001	Contains $CLOCK NAMELIST input

```
//ZBYMLEPH JOB (GR2111311H,T,G00080,001002),FFF   THISDATE
//*FORMAT PR,DDNAME=,DEST=CSC
//  EXEC PGM=EPH,REGION=400K
//STEPLIB DD DSN=ORBIT.EPHEM.REP.LOAD,DISP=SHR
//FT05F001 DD DDNAME=DATA5
//FT06F001 DD SYSOUT=A,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=141)
//FT08F001 DD DUMMY          UPLINK MESSAGES
//FT09F001 DD DUMMY          NAMELIST/CLOCK/
//FT10F001 DD DUMMY          NAMELIST/CARDIN/ & FLAGS FOR SMM
//FT11F001 DD DUMMY          NAMELIST/CARDIN/ & FLAGS FOR TDRSE
//FT12F001 DD DUMMY          NAMELIST/CARDIN/ & FLAGS FOR TDRSW
//FT20F001 DD DSN=ORBIT.LANDSAT.DAOF.DATA,DISP=SHR
//FT21F001 DD DISP=(NEW,PASS),UNIT=DISK,SPACE=(TRK,7),
//     DCB=(RECFM=FB,LRECL=924,BLKSIZE=924,BUFNO=1),
//     VOL=SER=DISK09
//FT38F001 DD DSN=ORBIT.GTDS.TIMCOF.DATA,DISP=SHR
//FT78F001 DD DSN=ORBIT.GTDS.SLPTOD.DATA,DISP=SHR
//DATA5 DD *
 $SCTIM LEVEL=1,IFRN=20,IUNIT=1, $END
 $CARDIN YMD1=811002.0,HMS1=080000.0,YMD2=811004.0,HMS2=200000.0,
    YMDR=811002.0,HMSR=230000.0,G=600.0, $END
 $CLOCK ETOYMD=811002.,ETOHMS=080000.,TO=2000.,DTPR=1.,DTPP=0., $END
111111111111111111111111111111111111111111    111111
DDDDDDDD  MEMBER-A  MEMBER-B  MEMBER-C  MEMBER-D  MEMBER-E  MEMBER-F  MEMBER-G
SSSSSSSS     3
/*
//
```

Figure 4-1. Sample Deck Setup

DDNAME	Description
FT10F001	Contains $CARDIN NAMELIST input and flag input card for SMM
FT11F001	Contains $CARDIN NAMELIST input and flag input card for TDRS-E
FT12F001	Contains $CARDIN NAMELIST input and flag input card for TDRS-W
FT20F001	Points to GTDS ORBIT File
FT21F001	Points to output ASCII format tape file
FT38F001	Points to GTDS Time Conversion Coefficients File containing time conversion and polar motion data used for true-of-date rotation
FT78F001	Points to GTDS SLP File (in true-of-date coordinates) containing planetary ephemeris data

APPENDIX A - FILE FORMAT

Table A-1 presents the GTDS ORBIT File format and Table A-2 provides the ephemeris representation tape format.

Table A-1. GTDS ORBIT File Format (1 of 8)

DATA SET LAYOUT

DATE 12/31/79

DATA SET NAME: ORBIT File (without partial derivatives) PAGE NO. 1 of 8

PURPOSE: This file is used to store satellite data, the force model and orbit generator parameters, the element set used in generating the satellite ephemeris, and the satellite ephemeris in the form of acceleration vectors.

WRITTEN BY: ORBFIL, ORBINT
(NAME OF SUBROUTINE)

READ BY: GETHDR, ORBFIL, ORBINT
(NAME OF SUBROUTINE)

NOTES: DSPEXC and ORBINT close file

GENERAL

PHYSICAL UNIT 2314 FORTRAN LOG UNIT 20

LOG RECORD SIZE 1092 BLOCK SIZE 1092

RECORD FORMAT F

TOTAL SIZE: 524160 BYTES

BLOCKS: 480

TYPE: Direct Access

DEVICE CHARACTERISTICS

TAPE ☐

PARITY: EVEN (DEC) ☐ ODD (BIN) ☐

CHANNEL: 7 ☐ 9 ☐ OTHER ___

DENSITY: ___

DISK ☒

OTHER ☐ ___

Table A-1. GTDS ORBIT File Format (2 of 8)

DATA SET LAYOUT

DATE 12/31/79

DATA SET NAME: ORBIT File (without partial derivatives) PAGE NO. 2 of 8

PHYSICAL UNIT 2314 FORTRAN LOG UNIT 20
LOG RECORD SIZE 1092 BLOCK SIZE 1092
RECORD FORMAT F

RECORD	RECORD SIZE	BYTES	NAME, DESCRIPTION, ETC.	
1	1092 bytes	1-400	IDIR(I,J):	I=1,2; J=1,50 File directory
			INDIR(1,1):	Number of levels in file
			INDIR(2,1):	Next available record
			INDIR(1,level+1):	Number of first record for level
			INDIR(2,level+1):	Number of last record for level
		401-1092	Not used	
2	1092 bytes	1-8	SATNAM:	Satellite name in EBCDIC
		9-16	AREA:	Area of satellite (cm^2)
		17-24	SCMASS:	Mass of satellite (kg)
		25-32	CSUBR:	Satellite reflectivity constant
		33-40	CSUBDZ:	Drag coefficient
		41-48	YMDOUT:	YYMMDD. of start date
		49-56	HMSOUT:	HHMMSS.SSSS of start date
		57-64	YMDFN:	YYMMDD. of end date
		65-72	HMSFN:	HHMMSS.SSSS of end date
		73-80	YMDIC:	YYMMDD. of epoch date
		81-88	HMSIC:	HHMMSS.SSSS of epoch date
		89-96	YMDREF:	YYMMDD. of reference line for time coordinate system
		97-104	EGHA:	Greenwich hour angle at epoch (rad)
		105-112	EJED:	Julian ephemeris date of epoch

Table A-1. GTDS ORBIT File Format (3 of 8)

DATA SET LAYOUT

DATE 12/31/79

DATA SET NAME: ORBIT File (without partial derivatives) PAGE NO. 3 of 8

PHYSICAL UNIT 2314 FORTRAN LOG UNIT 20
LOG RECORD SIZE 1092 BLOCK SIZE 1092
RECORD FORMAT F

RECORD	RECORD SIZE	BYTES	NAME, DESCRIPTION, ETC.
2	1092 bytes	113-160	AEINT(K): K=1,6 Keplerian elements in coordinate system of integration
		161-208	SPINT(K): K=1,6 Spherical elements in coordinate system of integration
		209-256	PVINT(K): K=1,6 Position and velocity of satellite in coordinate system of integration
		257-368	OBLINT(L): L=1,14 Auxiliary orbital elements in coordinate system of integration: L = 1, Eccentric anolmal 2, Period 3, Time derivative of period 4, Mean motion 5, True anomaly 6, Perifocal height 7, Apofocal height 8, Time derivative of argument of perigee 9, Time derivative of ascending node 10, Velocity at apogee 11, Velocity at perigee 12, Latitude 13, Longitude 14, Height
		369-376	OBSYMD: YYMMDD. of start of fitted data span for element set
		377-384	OBSHMS: HHMMSS.SSSS of start fitted span for element set
		385-392	OBEYMD: YYMMDD. of end of fitted data span for element

Table A-1. GTDS ORBIT File Format (4 of 8)

DATA SET LAYOUT

DATE 12/31/79

DATA SET NAME: ORBIT File (without partial derivatives) PAGE NO. 4 of 8

PHYSICAL UNIT 2314 FORTRAN LOG UNIT 20
LOG RECORD SIZE 1092 BLOCK SIZE 1092
RECORD FORMAT F

RECORD	RECORD SIZE	BYTES	NAME, DESCRIPTION, ETC.	
2	1092 bytes	393-400	OBEHMS:	HHMMSS.SSSS of end of fitted data span for element set
		401-408	WRMS:	Weighted RMS of fit for element set
		409-576	COVMAT(I):	I=1,21 Upper triangle of state covariance matrix
		577-584	AZERO:	Difference between A.1 time and UTC
		585-592	TZERO1:	Time from beginning of year in seconds
		593-600	DEPOCH:	Julian date of epoch (A.1 system)
		601-608	SPARE	Space location
		609-612	IDSAT:	Satellite number
		613-616	NBRRUN:	Run number
		617-620	NBRELS:	Element set number
		621-624	I5Ø:	Inertial coordinate system reference indicator
		625-1024	INDSEC(I,J):	I=1,20; J=1,5 Force model indicators
		1025-1048	MODWF(K):	K=1,6 Model identifiers
		1049-1052	NBROBS:	Number of observations in fitted data span for elements set
		1053-1056	NSTATE:	Number of state partials
		1057-1080	KSTATE(K):	K=1,6 Label numbers of state unknowns
		1081-1084	IPART	Partial indicator = 1 partials on data record = 2 no partials on data record

Table A-1. GTDS ORBIT File Format (5 of 8)

DATA SET LAYOUT

DATE 12/31/79

DATA SET NAME: ORBIT File (without partial derivatives) PAGE NO. 5 of 8

PHYSICAL UNIT 2314 FORTRAN LOG UNIT 20
LOG RECORD SIZE 1092 BLOCK SIZE 1092
RECORD FORMAT F

RECORD	RECORD SIZE	BYTES	NAME, DESCRIPTION, ETC.	
2	1092 bytes	1085-1088	ICENT:	Central body indicator
		1089-1092	IND(1)	Orbit generator indicator = 1 time regularized Cowell orbit generator = 2 Cowell orbit generator
3	1092 bytes	1-8	DTIM	Dummy time word for internal retrieval use (±99999999.0)
		9-16	ZERO	Zero word for internal retrieval use
		17-104	GM(I):	I=1,11 Gravitational constant times the mass of body[1] (km^3/sec^2)
		105-144	SECMOD(36,1):	I=1,5 Time regularized exponent of satellite radius for Section I
		145-384	COEF1(I,J):	I=1,10; J=1,3 Time conversion coefficients I indicates date interval
		385-408	SAE(I):	I=1,3 Drag coefficient times area of spacecraft surfaces I=1, sphere or end of cylinder 2, sides of cylinder 3, paddles
		409-608	SPARE	Spare locations
		609-612	IND(40)	State partials indicator 1 = yes, 2 = no
		613-616	IND(41)	Drag partials indicator 1 = yes, 2 = no

Table A-1. GTDS ORBIT File Format (6 of 8)

DATA SET LAYOUT

DATE 12/31/79

DATA SET NAME: ORBIT File (without partial derivatives) PAGE NO. 6 of 8

PHYSICAL UNIT 2314 FORTRAN LOG UNIT 20
LOG RECORD SIZE 1092 BLOCK SIZE 1092
RECORD FORMAT F

RECORD	RECORD SIZE	BYTES	NAME, DESCRIPTION, ETC.	
3	1092 bytes	617-620	IND(42)	Solar radiation partials indicator 1 = yes, 2 = no
		621-624	IND(43)	Potential partials indicator 1 = yes, 2 = no
		625-628	IND(44)	Thrust partials indicator 1 = yes, 2 = no
		629-632	NTAB	
		633-672	JARG1(I):	I=1,10 Julian dates which define date intervals for time conversion
		673-676	KONFIG	S/C configuration switch 0 = spherical 1 = cylindrical 2 = cylindrical with paddles
		677-680	NEQ	Number of variational equations to be integrated
		681-684	NCNM	Number of $C_{N,M}$ to be estimated
		685-688	NSNM	Number of $S_{N,M}$ to be estimated
		689-768	NDEG(I):	I=1,20 N indicies (for $C_{N,M}$ and $S_{N,M}$)
		769-848	MORD(I):	I=1,20 M indicies (for $C_{N,M}$ and $S_{N,M}$)
		849-868	INDY(I):	I=1,5 I=1, array location for drag partials in the integrator

Table A-1. GTDS ORBIT File Format (7 of 8)

DATA SET LAYOUT

DATE 12/31/79

DATA SET NAME: ORBIT File (without partial derivatives) PAGE NO. 7 of 8

PHYSICAL UNIT 2314 FORTRAN LOG UNIT 20
LOG RECORD SIZE 1092 BLOCK SIZE 1092
RECORD FORMAT F

RECORD	RECORD SIZE	BYTES	NAME, DESCRIPTION, ETC.
3	1092 bytes		I=2, array location for drag radiation partials in the integrator 3, array location for drag potential partials in the integrator 4, array location for thrust partials in the integrator 5, spare
		869-872	IND(39) Transformation partials required 1 = Partial of state with respect to initial state elements 2 = Partial of state with respect to Keplerian state elements 3 = Partial of state with respect to spherical state elements 4 = Partial of state with respect to DODS state elements
		873-1092	SPARES
All others	1092 bytes	1-8	TN Time (from epoch in seconds) of last acceleration in XDD
		9-16	H Integrator stepsize in seconds
		17-280	XDD(I,J): I=K-10,K; J=1,3 Satellite acceleration vectors K = acceleration array indicator
		281-368	TREG(I): I=K-10,K Time corresponding to acceleration array

Table A-1. GTDS ORBIT File Format (8 of 8)

DATA SET LAYOUT

DATE 12/31/79

DATA SET NAME: ORBIT File (without partial derivatives) PAGE NO. 8 of 8

PHYSICAL UNIT 2314 FORTRAN LOG UNIT 20
LOG RECORD SIZE 1092 BLOCK SIZE 1092
RECORD FORMAT F

RECORD	RECORD SIZE	BYTES	NAME, DESCRIPTION, ETC.
All others	1092 bytes	369-392	SX1(I): I=1,3 First sum vector of satellite acceleration
		393-416	SX2(I): I=1,3 Second sum vector of satellite acceleration
		417-420	NSECTN Current section number
		421-1092	Not used

Table A-2. Ephemeris Representation Tape Format (1 of 4)

DATA SET LAYOUT

DATE 2/16/81

DATA SET NAME: Ephemeris Representation Tape (File 1) PAGE NO. 1 of 4

PURPOSE: This file contains the Fourier coefficients and residuals of the ephemeris representation. It is written in ASCII format.

WRITTEN BY: ASTAPE
(NAME OF SUBROUTINE)

READ BY: _____
(NAME OF SUBROUTINE)

NOTES: _____

GENERAL

PHYSICAL UNIT 2400 FORTRAN LOG UNIT 21

LOG RECORD SIZE 924 BLOCK SIZE 924

RECORD FORMAT FB

TOTAL SIZE: 30492 BYTES

BLOCKS: 33

TYPE: Sequential

DEVICE CHARACTERISTICS

TAPE ☒

PARITY: EVEN (DEC) ☐ ODD (BIN) ☒

CHANNEL: 7 ☐ 9 ☒ OTHER ___

DENSITY: 1600 bpi

DISK ☐

OTHER ☐ _____

Table A-2. Ephemeris Representation Tape Format (2 of 4)

DATA SET LAYOUT

DATE 2/16/81

DATA SET NAME: Ephemeris Representation Tape (File 1) PAGE NO. 2 of 4

PHYSICAL UNIT 2400 FORTRAN LOG UNIT 21
LOG RECORD SIZE 924 BLOCK SIZE 924
RECORD FORMAT FB

RECORD	RECORD SIZE	BYTES	NAME, DESCRIPTION, ETC.	
1	924 bytes	1-8	SATNA1:	Satellite name
		9-16	SATNA2:	
		17-24	IYMD:	YYMMDD. of epoch time
		25-32	IHMS:	HHMMSS. of epoch time
		33-54	X:	Position at epoch (km)
		55-76	Y:	Position at epoch (km)
		77-98	Z:	Position at epoch (km)
		99-120	XD:	Velocity at epoch (km/sec)
		121-142	YD:	Velocity at epoch (km/sec)
		143-164	ZD:	Velocity at epoch (km/sec)
		165-172	IYMD1:	YYMMDD of start time
		173-180	IHMS1:	HHMMSS of start time
		181-188	IYMD2:	YYMMDD of end time
		189-196	IHMS2:	HHMMSS of end time
		197-204	IYMDR:	YYMMDD of reference time
		205-212	IHMSR:	HHMMSS of reference time
		213-234	SF:	Scale factor (m/sec)
		235-256	DTP:	Spacecraft clock drift rate (s/c sec)/E.T. sec)
		257-278	W:	Orbital frequency (rad/sec)
		279-300	WE:	Earth's sidereal rotation frequency (rad/sec)

Table A-2. Ephemeris Representation Tape Format (3 of 4)

DATA SET LAYOUT

DATE 2/16/81

DATA SET NAME: Ephemeris Representation Tape (File 1) PAGE NO. 3 of 4

PHYSICAL UNIT 2400 FORTRAN LOG UNIT 21
LOG RECORD SIZE 924 BLOCK SIZE 924
RECORD FORMAT FB

RECORD	RECORD SIZE	BYTES	NAME, DESCRIPTION, ETC.
1	924 bytes	301-304	IG: Grid interval (s/c sec)
		305-308	NTMAX: Number of grid points
		309-312	NTO: 1
		313-924	Blank
2	924 bytes	1-22	Fourier coefficients for X component: C(1,1)
		23-44	Fourier coefficients for X component: C(2,1)
		45-66	Fourier coefficients for X component: C(3,1)
		⋮	----------
		903-924	Fourier coefficients for X component: C(42,1)
3	924 bytes	1-22	Fourier coefficients for Y component: C(1,2)
		23-44	Fourier coefficients for Y component: C(2,2)
		45-66	Fourier coefficients for Y component: C(3,2)
		⋮	----------
		903-924	Fourier coefficients for Y component: C(42,2)
4	924 bytes	1-22	Fourier coefficients for Z component: C(1,3)
		23-44	Fourier coefficients for Z component: C(2,3)
		45-66	Fourier coefficients for Z component: C(3,3)
		⋮	----------
		903-924	Fourier coefficients for Z component: C9(42,3)
5	924 bytes	1-22	Fourier coefficients for XD component: C(1,4)
		23-44	Fourier coefficients for XD component: C(2,4)

Table A-2. Ephemeris Representation Tape Format (4 of 4)

DATA SET LAYOUT

DATE 2/16/81

DATA SET NAME: Ephemeris Representation Tape (File 1) PAGE NO. 4 of 4

PHYSICAL UNIT 2400 FORTRAN LOG UNIT 21
LOG RECORD SIZE 924 BLOCK SIZE 924
RECORD FORMAT FB

RECORD	RECORD SIZE	BYTES	NAME, DESCRIPTION, ETC.
5	924 bytes	45-66	Fourier coefficients for XD component: C(3,4)
		⋮	----------
		903-924	Fourier coefficients for XD component: C(42,4)
6	924 bytes	1-22	Fourier coefficients for YD component: C(1,5)
		23-44	Fourier coefficients for YD component: C(2,5)
		45-66	Fourier coefficients for YD component: C(3,5)
		⋮	----------
		903-924	Fourier coefficients for YD component: C(42,5)
7	924 bytes	1-22	Fourier coefficients for ZD component: C(1,6)
		23-44	Fourier coefficients for ZD component: C(2,6)
		45-66	Fourier coefficients for ZD component: C(3,6)
		⋮	----------
		903-924	Fourier coefficients for ZD component: C(42,6)
8-32	924 bytes	1-924	14 sets of position residuals (3 in a set for X, Y, Z) for 14 grid points
33	924 bytes	1-660	10 sets of position residuals (3 in a set for X, Y, Z) for 10 grid points

APPENDIX B - SAMPLE ERGSS PRINTER OUTPUT

Figures B-1 through B-7 present sample ERGSS printer output.

```
&SCTIM
LEVEL=          1,IFRN=          20,ISFSW=          1,SFPOS=  1.00000000000000000    ,SFVEL=  1000.00000000000000    ,IREQ=
        1,IUNIT=          2
&END
&CARDIN
YMD1=  811002.000000000000    ,HMS1=  80000.0000000000000    ,YMD2=  811004.000000000000    ,HMS2=  200000.000000000000    ,YMDR=
  811002.000000000000    ,HMSR=  230000.000000000000    ,G=  600.000000000000000    ,NBIT=          34,IC=          2,COFFDA=
        8,E=F
&END
&CLOCK
ETOYMD=  811002.000000000000    ,ETOHMS=  80000.0000000000000    ,TO=  2000.00000000000000    ,DTPR=  1.00000000000000000    ,DTPP=
  .0
&END
111111111111111111111111111111111111111111111111    111111
DDDDDDDD  MEMBER-A  MEMBER-B  MEMBER-C  MEMBER-D  MEMBER-E  MEMBER-F  MEMBER-G
SSSSSSSS     3
END OF FILE ON UNIT 5
```

Figure B-1. Input Card Images Listing

	*********START TIME*********		*********END TIME*********	
	YYMMDD	HHMMSS.SS	YYMMDD	HHMMSS.SS
ORBIT FILE :	811002.0000	70000.0000	811005.0000	80000.0000
USER INPUT :	811002.0000	80000.0000	811004.0000	200000.0000
ACTUAL EPH. REP.:	811002.0000	80000.0000	811004.0000	200000.0000

EPOCH	=	14879.8333333			
DATA START	=	0.0	S/C START	=	2000.0000000
DATA END	=	216000.0000000	S/C STOP	=	218000.0000000
REFEREN POINT	=	56000.0000000	# OF POINTS	=	360

FREQUENCIES	0.0010546497
FREQUENCIES	0.0010561268
FREQUENCIES	0.0010632811
FREQUENCIES	0.0000000000
FREQUENCIES	0.0010633616
FREQUENCIES	0.0010615781
FREQUENCIES	0.0010547677
FREQUENCIES	0.0

W	0.0010589608207905
WE	0.0000729211660000

Figure B-2. Special Time Parameter and Primary Frequencies

COEFFICIENTS FOR SATELLITE EPHEMERIS FOR LANDSAT

PROBABLE ERROR IS AT 95 PERCENT CONFIDENCE LIMITS

THE FOURIER FUNCTION IS OF THE FORM:

```
  S= DSIN(W*T)
  C= DCOS(W*T)
 SE= DSIN(2*WE*T)
 CE= DCOS(2*WE*T)

XYZ=      A1+T*( A2+T*( A3+T*( A4+T*( A5+T* A6))))
     +S*( A7+T*( A8+T*( A9+T*(A10+T*(A11+T*A12)))))
     +C*(A13+T*(A14+T*(A15+T*(A16+T*(A17+T*A18)))))
     +     S*(S*(A19+T*(A20+T*(A21+T*(A22+T*A23))))
     +          C*(A24+T*(A25+T*(A26+T*(A27+T*A28))))
     +               S*(S*(A29+T*(A30+T*(A31+T*A32)))
     +                    C*(A33+T*(A34+T*(A35+T*A36))))))
     +SE*(A37+A39*S+A41*C)
     +CE*(A38+A40*S+A42*C)
```

COEF.	X ERROR	Y ERROR	Z ERROR	DX ERROR	DY ERROR	DZ ERROR
1	-0.1041160194D+02 0.3724717976D-01	0.6038412285D+01 0.2366533569D-01	-0.8908101265D+01 0.4196984502D-01	0.8435334931D+01 0.3626198160D-01	-0.4339278903D+01 0.2124540183D-01	0.3764383902D+01 0.4065812778D-01
2	-0.1521364401D-06 0.1300871840D-05	-0.4071427439D-05 0.8265207994D-06	0.1035373781D-04 0.1465812711D-05	-0.5006679812D-05 0.1266463422D-05	0.3811947425D-05 0.7420036940D-06	0.3319066817D-05 0.1420000490D-05
3	0.3169361358D-10 0.2398195368D-10	-0.2167031521D-10 0.1523715320D-10	0.2163195137D-10 0.2702268697D-10	0.1300768710D-10 0.2334762440D-10	-0.1025198070D-10 0.1367905559D-10	0.1707730986D-10 0.2617812525D-10
4	0.1815846212D-14 0.5085800491D-15	-0.7495774318D-15 0.3231309771D-15	0.3063463053D-15 0.5730642154D-15	-0.2135766157D-15 0.4951279668D-15	0.2268823723D-15 0.2900887416D-15	-0.4175813259D-15 0.5551537796D-15
5	-0.2833353718D-19 0.5642101916D-20	0.1304259545D-19 0.3584760959D-20	-0.8427919262D-20 0.6357478460D-20	0.2004814184D-20 0.5492866767D-20	-0.2187053787D-20 0.3218195932D-20	0.2361551996D-20 0.6158783084D-20
6	0.1063694843D-24 0.2009507829D-25	-0.5114995901D-25 0.1276759144D-25	0.3958097446D-25 0.2264298471D-25	-0.8622390883D-26 0.1956355794D-25	0.7412677615D-26 0.1146202252D-25	-0.2446686036D-26 0.2193530534D-25
7	0.2356933757D+04 0.8730275007D-01	-0.2055766110D+04 0.5546859925D-01	0.6356513435D+04 0.9837208923D-01	-0.6404427190D+04 0.8499356830D-01	0.2343371498D+04 0.4979657569D-01	0.3138092455D+04 0.9529758739D-01
8	0.3170605739D-03 0.2188386584D-05	0.5081997187D-03 0.1390411394D-05	0.4690451715D-04 0.2465857721D-05	-0.5102285210D-03 0.2130503157D-05	-0.1250500939D-02 0.1248232823D-05	-0.1072004455D-03 0.2388790291D-05
9	-0.1112262894D-10 0.4686179446D-10	-0.1842351659D-11 0.2977406892D-10	-0.2298451191D-10 0.5280352134D-10	0.1524241097D-09 0.4562228710D-10	-0.3947790048D-10 0.2672947751D-10	0.6850253913D-10 0.5115321051D-10
10	0.1671965219D-14 0.6168612910D-15	-0.1334164939D-14 0.3919284526D-15	-0.1153751240D-14 0.6950747131D-15	0.1353828884D-14 0.6005451401D-15	0.3360534932D-15 0.3518512297D-15	0.2476606290D-14 0.6733509854D-15
11	-0.2831428180D-19 0.7814077535D-20	0.2074561111D-19 0.4964745497D-20	0.1835023058D-19 0.8804844428D-20	-0.2168702568D-19 0.7607393033D-20	-0.6502798757D-20 0.4457068112D-20	-0.4159362064D-19 0.8529659560D-20
12	0.1102707628D-24 0.2839309021D-25	-0.7782896493D-25 0.1803980907D-25	-0.6939441727D-25 0.3199312279D-25	0.8245945010D-25 0.2764208516D-25	0.2663923790D-25 0.1619512174D-25	0.1599532908D-24 0.3099321606D-25
13	0.6045451244D+04 0.4108878492D-01	-0.2212614648D+04 0.2610613460D-01	-0.2954566109D+04 0.4629853714D-01	0.2496380622D+04 0.4000197525D-01	-0.2175794001D+04 0.2343661324D-01	0.6731399983D+04 0.4485153181D-01
14	0.4818464056D-03 0.1475166509D-05	0.1180280973D-02 0.9372605084D-06	0.1005671822D-03 0.1662206647D-05	0.3352273852D-03 0.1436147949D-05	0.5381770224D-03 0.8414195505D-06	0.4963801293D-04 0.1610256369D-05
15	-0.1504374299D-09 0.2679163191D-10	0.4218928069D-10 0.1702230792D-10	-0.6078666129D-10 0.3018861150D-10	-0.1291982623D-10 0.2608298587D-10	-0.3490169790D-11 0.1528166667D-10	-0.3277319510D-10 0.2924510260D-10
16	-0.1657516707D-14 0.5577297652D-15	-0.2034604150D-15 0.3543586979D-15	-0.2263112479D-14 0.6284457498D-15	0.1965651068D-14 0.5429776594D-15	-0.1390327746D-14 0.3181232257D-15	-0.1083101253D-14 0.6088044305D-15
17	0.2681141400D-19 0.7639667118D-20	0.3881699697D-20 0.4853932247D-20	0.3873888389D-19 0.8608320068D-20	-0.3206312081D-19 0.7437595820D-20	0.2209696055D-19 0.4357586234D-20	0.1900102719D-19 0.8339277333D-20
18	-0.1022925709D-24 0.2804163566D-25	-0.1587568756D-25 0.1781650921D-25	-0.1510054887D-24 0.3159710642D-25	0.1225949711D-24 0.2729992667D-25	-0.8368235200D-25 0.1599465574D-25	-0.7458274947D-25 0.3060957670D-25
19	-0.3793282237D+01 0.6076706605D-01	0.2796415129D+00 0.3860891016D-01	0.8842016362D+01 0.6847187790D-01	-0.1686673405D+02 0.5915976042D-01	0.8669994594D+01 0.3466089901D-01	-0.7514808537D+01 0.6633187135D-01

Figure B-3. Fourier Coefficients for Satellite Ephemeris (1 of 2)

20	-0.26333221250D-05	0.12178365690D-05	-0.61826578120D-05	0.10365813670D-04	-0.80411710330D-05	-0.63700772170D-05
	0.17364277270D-05	0.11032552080D-05	0.19565938440D-05	0.16904987360D-05	0.99044021720D-06	0.18954428460D-05
21	-0.19497759710D-10	0.57508635330D-11	0.19439376710D-10	-0.27402991320D-10	0.21629610670D-10	-0.33164688090D-10
	0.35775359770D-10	0.22730201420D-10	0.40311409210D-10	0.34829091650D-10	0.20405891100D-10	0.39051524390D-10
22	0.40549295060D-15	-0.14139207410D-15	-0.93438318220D-16	0.12514809480D-15	-0.16471559200D-15	0.67502964880D-15
	0.66665357160D-15	0.42356443260D-15	0.75118028440D-15	0.64902040110D-15	0.38025222580D-15	0.72770304420D-15
23	-0.18221307310D-20	0.69516594660D-21	-0.24726508560D-21	0.52297721420D-21	0.30552861230D-21	-0.30060851970D-20
	0.29974919200D-20	0.19044838560D-20	0.33775515930D-20	0.29182074330D-20	0.17097380450D-20	0.32719902630D-20
24	0.79659467120D+01	-0.40935295550D+01	0.35444552490D+01	-0.80444574550D+01	0.59377531730D+00	0.18732243560D+02
	0.60480221820D-01	0.38426661060D-01	0.68148663950D-01	0.58880503300D-01	0.34497286060D-01	0.66018759080D-01
25	-0.52895814440D-05	0.40087620690D-05	0.29833109650D-05	-0.53697793860D-05	0.24408029960D-05	-0.13096109890D-04
	0.17412202460D-05	0.11063001790D-05	0.19619940180D-05	0.16951644910D-05	0.99317381980D-06	0.19006742450D-05
26	0.10025663520D-10	-0.10365528700D-10	0.16752275400D-10	-0.34309169690D-10	0.15860892920D-10	0.36882895960D-10
	0.34893158470D-10	0.22169686780D-10	0.39317351350D-10	0.33970224820D-10	0.19902692700D-10	0.38088534620D-10
27	0.12455940940D-15	0.36268025570D-17	-0.32136907570D-15	0.68953829340D-15	-0.30838919460D-15	-0.13168324100D-15
	0.65794266650D-15	0.41802987950D-15	0.74136490130D-15	0.64053990180D-15	0.37528361660D-15	0.71819442920D-15
28	-0.13120856870D-20	0.33946046880D-21	0.13842115650D-20	-0.30665628870D-20	0.13914420690D-20	-0.78110216690D-21
	0.29804457660D-20	0.18936534260D-20	0.33583441140D-20	0.29016121550D-20	0.17000150980D-20	0.32533830910D-20
29	-0.39796459290D+01	0.19522074070D+01	-0.11812336100D+01	0.42806177150D+01	0.30471270670D+00	-0.13911059190D+02
	0.10904801540D+00	0.69284652070D-01	0.12287449240D+00	0.10616366530D+00	0.62199847620D-01	0.11903419730D+00
30	-0.25052543840D-06	-0.91046111100D-06	-0.12232056930D-06	0.76413964270D-06	0.72311230060D-06	0.90584346240D-06
	0.22066266870D-05	0.14020004100D-05	0.24864105330D-05	0.21482608040D-05	0.12586367870D-05	0.24087007490D-05
31	0.18698695210D-11	0.13104153530D-11	-0.59399799830D-12	-0.16373709320D-11	-0.82304809170D-12	-0.14636566660D-10
	0.54923205970D-10	0.34895960310D-10	0.61887059840D-10	0.53470472050D-10	0.31327622330D-10	0.59952853900D-10
32	-0.19346850190D-16	-0.24162803720D-17	-0.23337957980D-17	-0.14784046270D-17	-0.53500539090D-17	0.63385734030D-16
	0.32240538170D-15	0.20484320250D-15	0.36328398530D-15	0.31387767060D-15	0.18389665820D-15	0.35192997940D-15
33	-0.13566511350D+01	-0.90876947920D-01	0.43777612730D+01	-0.12633586230D+02	0.61990168010D+01	-0.37572144890D+01
	0.10916136030D+00	0.69356666820D-01	0.12300220860D+00	0.10627401230D+00	0.62264498390D-01	0.11915792190D+00
34	-0.13819698440D-06	-0.26018845070D-06	-0.25289940980D-06	-0.54983550970D-06	-0.25781952000D-05	-0.58600900830D-06
	0.22105474410D-05	0.14044914970D-05	0.24908284090D-05	0.21520778520D-05	0.12608731440D-05	0.24129805500D-05
35	0.78713200130D-11	-0.43919541410D-11	0.51428729310D-11	-0.67282609590D-11	0.22465822050D-11	0.51473697970D-11
	0.55164815350D-10	0.35049469040D-10	0.62159303500D-10	0.53705690800D-10	0.31465433800D-10	0.60216588910D-10
36	-0.65076559740D-16	0.40748632630D-16	-0.26599305130D-16	0.20156291250D-16	-0.15400831840D-16	-0.48178777570D-16
	0.32465135000D-15	0.20627019900D-15	0.36581472570D-15	0.31606423240D-15	0.18517773510D-15	0.35438162450D-15
37	0.61517656610D-01	-0.27322897950D-01	-0.34086348500D-03	0.36149249740D-03	-0.16772940120D-02	0.24481678570D-02
	0.15554660320D-01	0.98827954320D-02	0.17526875510D-01	0.15143235270D-01	0.88722155850D-02	0.16979094010D-01
38	0.15958776360D-01	0.45874047850D-02	-0.16684849770D-01	0.60082870120D-02	-0.14037887560D-02	-0.90306544030D-03
	0.16241922790D-01	0.10319453920D-01	0.18301277760D-01	0.15812319460D-01	0.92642229140D-02	0.17729293240D-01
39	-0.52791792580D+00	0.24307120900D+00	0.29183046140D+00	-0.18641158940D+00	0.24851702520D+00	-0.61100846200D+00
	0.22014400570D-01	0.13987050370D-01	0.24805662770D-01	0.21432113610D-01	0.12556783870D-01	0.24030391490D-01
40	-0.30925552500D+00	-0.10642855900D+00	0.27254243540D-01	-0.14992549630D+00	0.40080614090D-01	-0.21469276100D+00
	0.22958741450D-01	0.14587045970D-01	0.25869739050D-01	0.22351476420D-01	0.13095426040D-01	0.25061211340D-01
41	0.22210768940D+00	-0.22273805150D+00	0.57412806770D+00	-0.56791165690D+00	0.25817892810D+00	0.27347789950D+00
	0.21981485860D-01	0.13966137710D-01	0.24768574710D-01	0.21400069500D-01	0.12538009660D-01	0.23994462570D-01
42	0.60405615190D-01	-0.11766047480D-02	0.24298826860D+00	-0.29305914740D+00	-0.14562207130D+00	0.11220254740D+00
	0.22915779380D-01	0.14559749630D-01	0.25821329710D-01	0.22309650710D-01	0.13070920920D-01	0.25014314970D-01

Figure B-3. Fourier Coefficients for Satellite Ephemeris (2 of 2)

SATELLITE EPHEMERIS AND RESIDUALS FOR LANDSAT

DATA #	S/C CLOCK(SEC)	X(KM)	Y(KM)	Z(KM)	DX(M/SEC)	DY(M/SEC)	DZ(M/SEC)
ET(YMD)	ET(HMS.S)	O - C	O - C	O - C	O - C	O - C	O - C
		RERR(KM)	CERR(KM)	LERR(KM)	DRERR(M/SEC)	DCERR(M/SEC)	DLERR(M/SEC)
1	2000.000	3441.15353	-587.79572	-6159.32662	5780.35037	-3204.80137	3544.27503
811002	75960.000	0.02365	0.03726	-0.08400	-0.03522	-0.01790	-0.18091
		0.08148	-0.03119	-0.03739	0.14176	0.05659	-0.10499
2	2600.000	6009.09679	-2269.10779	-2968.61638	2486.29190	-2208.70246	6732.90979
811002	80960.000	0.05899	-0.00829	-0.15936	0.14400	-0.07983	-0.05544
		0.11961	0.00611	-0.12091	0.17115	0.02066	0.02145
3	3200.000	6224.27377	-3061.80134	1386.10057	-1794.80989	-343.10122	7287.72262
811002	81960.000	0.14021	-0.05889	-0.14011	0.06541	-0.06167	0.09122
		0.12141	0.01552	-0.16671	0.10213	0.01555	0.07567
4	3800.000	3998.61131	-2653.87527	5196.09833	-5369.89325	1655.55925	4980.50151
811002	82960.000	0.16167	-0.08228	-0.08141	-0.00093	-0.00664	0.09409
		0.06246	0.01936	-0.18776	0.07108	-0.00716	0.06161
5	4400.000	208.26811	-1207.79379	6969.59929	-6835.61705	3000.50459	733.42122
811002	83960.000	0.16059	-0.07851	-0.02608	-0.04436	0.04319	0.07804
		-0.00756	0.00849	-0.18029	0.06818	-0.03189	0.06533
6	5000.000	-3664.00697	709.23949	6020.69451	-5636.30290	3173.76550	-3788.35450
811002	84960.000	0.13946	-0.04136	-0.00405	-0.03640	0.07794	-0.00327
		-0.07972	-0.01942	-0.12032	0.02386	-0.05478	0.06202
7	5600.000	-6110.59802	2350.33575	2723.15600	-2243.15972	2111.68763	-6831.68090
811002	85960.000	0.15058	-0.00536	-0.00552	0.04328	0.04929	0.02420
		-0.13366	-0.05617	-0.04155	-0.01167	-0.06562	-0.02113
8	6200.000	-6178.51332	3076.52084	-1637.00188	2024.00708	227.34716	-7209.97092
811002	90960.000	0.16732	0.00943	0.03611	-0.06300	0.03117	0.07665
		-0.14998	-0.08234	0.01073	0.05070	-0.01322	-0.08984
9	6800.000	-3842.63770	2605.83392	-5359.12839	5498.38771	-1742.67663	-4778.47002
811002	91960.000	0.10436	0.01812	0.04054	-0.10091	-0.01603	-0.06057
		-0.08054	-0.06497	0.04653	0.09457	0.06454	-0.03170
10	7400.000	-14.14709	1123.04468	-6995.02053	6833.39199	-3033.44008	-490.49380
811002	92960.000	0.03515	-0.01124	0.02130	-0.04846	-0.04552	-0.01713
		-0.02288	-0.00735	0.03522	0.00980	0.06333	-0.02464
11	8000.000	3819.28764	-795.67235	-5907.26482	5512.61602	-3146.53161	3996.74641
811002	93960.000	-0.01444	-0.03488	0.03120	-0.00927	0.00991	-0.00976
		-0.02990	0.03285	0.02064	0.00203	-0.00373	-0.01617
12	8600.000	6162.80673	-2403.59698	-2511.70001	2031.06693	-2030.44776	6939.53428
811002	94960.000	0.00152	-0.03540	0.04607	0.03394	0.01153	0.07146
		-0.00300	0.02465	0.05255	0.00028	-0.03456	0.07210
13	9200.000	6092.46839	-3069.92060	1869.06384	-2258.45955	-114.63479	7164.73865
811002	95960.000	-0.01601	-0.01445	0.08843	-0.08935	0.04314	0.03321
		0.01585	0.00688	0.08936	-0.08690	-0.00701	0.05787
14	9800.000	3633.21350	-2532.59409	5515.48305	-5658.37541	1843.67494	4577.29541
811002	100960.000	-0.06695	0.00706	0.06769	-0.02956	0.01023	-0.07761
		0.01586	0.01134	0.09346	-0.07936	0.01405	-0.02253
15	10400.000	-247.19737	-1004.98458	7001.16641	-6837.65170	3075.15164	209.83563
811002	101960.000	-0.06260	0.00406	0.03384	0.03074	-0.01017	-0.02436
		0.03509	0.01711	0.05968	-0.02373	0.00008	-0.03287
16	11000.000	-4032.01968	914.39228	5752.93762	-5352.63177	3106.71967	-4229.06624
811002	102960.000	-0.05217	0.00757	0.02026	0.02814	0.00051	-0.02989
		0.04712	0.01162	0.02896	-0.04022	-0.00768	-0.00302
17	11600.000	-6247.92009	2477.94343	2260.55129	-1783.77247	1928.94457	-7018.41731
811002	103960.000	-0.02727	-0.00300	0.01200	0.05601	-0.03655	0.02239
		0.02680	0.01214	-0.00552	-0.05498	0.00679	-0.04370
18	12200.000	-6031.61922	3076.85053	-2113.99329	2479.84368	0.25748	-7069.62343
811002	104960.000	-0.01652	-0.01859	0.04155	-0.04513	0.00357	0.04050
		-0.00640	0.01755	-0.04467	0.02786	0.00944	-0.05316
19	12800.000	-3468.96564	2478.91282	-5664.61910	5773.10824	-1925.48197	-4366.64409
811002	105960.000	-0.03987	-0.00540	0.03094	-0.00743	0.01985	-0.05236

Figure B-4. Satellite Ephemeris and Residuals (1 of 2)

		-0.00710	0.01674	-0.04739	0.05241	-0.00733	0.01969
20	13400.000	440.99697	918.28446	-7010.25194	6821.16522	-3101.44651	32.85860
811002	110960.000	-0.03866	-0.00320	0.03026	0.01748	0.01862	0.03404
		-0.03276	0.01435	-0.03374	-0.03018	-0.02882	0.00836
21	14000.000	4178.97734	-998.78767	-5625.63972	5216.90880	-3073.02140	4429.56470
811002	111960.000	-0.04825	0.01071	0.05779	0.00614	0.05081	0.01806
		-0.07592	0.00177	-0.00382	-0.01789	-0.05090	-0.00588
22	14600.000	6285.97785	-2525.67646	-2042.15442	1564.98668	-1842.85026	7111.25540
811002	112960.000	-0.03484	0.03501	0.07460	0.01039	0.03097	0.05988
		-0.06498	-0.02803	0.05478	-0.01911	-0.04075	0.05126
23	15200.000	5930.15296	-3062.86144	2342.56144	-2711.15831	113.38821	7005.63943
811002	113960.000	-0.07298	0.06297	0.09695	-0.11189	0.03724	-0.02027
		-0.05634	-0.04084	0.11770	-0.11664	0.01508	0.02203
24	15800.000	3249.45653	-2399.37189	5807.12702	-5918.80000	2021.85903	4151.35648
811002	114960.000	-0.13126	0.07180	0.04402	-0.02660	-0.02633	-0.11693
		-0.04851	-0.01740	0.14718	-0.09928	0.05141	-0.05079
25	16400.000	-701.81142	-798.08472	6997.68874	-6805.86248	3134.45062	-314.65846
811002	115960.000	-0.14041	0.04954	-0.00654	-0.00972	-0.04071	-0.06065
		0.00187	0.01364	0.14840	-0.05441	0.04938	-0.00565
26	17000.000	-4380.38978	1114.24808	5456.36529	-5042.19904	3024.75792	-4648.76430
811002	120960.000	-0.15313	0.03034	-0.06028	0.01892	-0.05389	-0.11517
		0.05302	0.04384	0.15263	-0.10886	0.05741	0.03696
27	17600.000	-6354.39129	2592.92251	1786.52978	-1315.09346	1737.52967	-7170.11149
811002	121960.000	-0.12305	-0.01336	-0.11027	0.08656	-0.08173	-0.02989
		0.07759	0.07811	0.12400	-0.11498	0.04263	-0.00555
28	18200.000	-5854.69789	3062.17894	-2580.54613	2923.74063	-225.80807	-6893.96710
811002	122960.000	-0.07548	-0.03797	-0.10524	0.07245	0.00396	0.03147
		0.08420	0.08016	0.06853	-0.06954	-0.03767	-0.00080
29	18800.000	-3077.80110	2340.49002	-5941.96074	6019.42244	-2098.05940	-3933.06930
811002	123960.000	-0.01697	-0.01344	-0.07875	0.10319	0.06016	0.07730
		0.06894	0.03036	0.03148	-0.08973	-0.10746	0.02549
30	19400.000	894.31806	709.98475	-6990.61600	6775.08856	-3154.01761	556.13091
811002	124960.000	0.02526	0.02300	0.00066	0.01164	0.07999	0.15457
		0.00484	-0.03114	0.01321	-0.14307	-0.09909	-0.01167
31	20000.000	4518.14824	-1196.06586	-5315.99366	4894.82778	-2984.73060	4840.31858
811002	125960.000	-0.00324	0.06864	0.07126	-0.06701	0.07459	0.05521
		-0.06718	-0.07081	0.01655	-0.09684	-0.04787	-0.03777
32	20600.000	6377.84100	-2634.74910	-1562.56571	1090.65006	-1646.99093	7247.14089
811002	130960.000	-0.03934	0.10109	0.08483	-0.06699	0.02757	0.02134
		-0.09184	-0.08730	0.05396	-0.07537	-0.00061	0.00482
33	21200.000	5738.15510	-3040.75260	2804.01651	-3150.37373	339.71626	6811.38874
811002	131960.000	-0.10596	0.12588	0.07599	-0.12459	0.03776	-0.07505
		-0.10995	-0.08122	0.11902	-0.14705	0.02752	-0.01409
34	21800.000	2849.39612	-2255.01138	6069.51269	-6149.74315	2189.19051	3705.10817
811002	132960.000	-0.15824	0.13482	0.00662	-0.02954	-0.01849	-0.11821
		-0.10104	-0.05803	0.17224	-0.10743	0.04570	-0.03954
35	22400.000	-1153.11935	-588.26600	6959.29866	-6740.36136	3178.12721	-837.13678
811002	133960.000	-0.18359	0.11551	-0.05435	-0.05555	-0.04259	-0.11614
		-0.03313	-0.02157	0.22004	-0.10160	0.07774	0.04485
36	23000.000	-4707.20300	1307.71145	5132.78357	-4706.67267	2928.42428	-5044.98177
811002	134960.000	-0.20039	0.07827	-0.15059	0.04128	-0.09816	-0.17426
		0.03848	0.03264	0.25778	-0.17177	0.09676	0.05302
37	23600.000	-6429.44503	2694.71715	1303.95320	-839.78570	1538.62032	-7285.85500
811002	135960.000	-0.14987	0.01227	-0.22009	0.12679	-0.10563	-0.04870
		0.10006	0.08154	0.23330	-0.16403	0.05065	0.01145
38	24200.000	-5648.81357	3032.71341	-3033.84436	3353.11348	-449.57340	-6684.06569
811002	140960.000	-0.06633	-0.02852	-0.21911	0.15700	-0.03998	0.05565
		0.13435	0.08419	0.16752	-0.16593	-0.03585	0.02302
39	24800.000	-2671.44921	2191.43633	-6189.48552	6235.94258	-2259.55270	-3480.35603
811002	141960.000	0.03189	-0.03507	-0.15050	0.13025	0.01297	0.17789
		0.10856	0.04028	0.10706	-0.20040	-0.09027	0.02187
40	25400.000	1343.19080	499.31654	-6936.18823	6695.49303	-3191.03334	1076.32668

Figure B-4. Satellite Ephemeris and Residuals (2 of 2)

SUMMARY OF ERROR STATISTICS

	X	Y	Z	DX	DY	DZ
NUMBER OF DATA POINTS	360	360	360	360	360	360
RESIDUAL MEAN	0.7527681D-07	-0.9750534D-08	-0.5949762D-07	0.2846314D-07	0.4819115D-08	0.1613011D-06
STANDARD DEVIATION	0.1043549D+00	0.6630283D-01	0.1175863D+00	0.1015947D+00	0.5952294D-01	0.1139113D+00
DEGREES OF FREEDOM	318	318	318	318	318	318
DISTRIBUTION FUNCTION	0.1967735D+01	0.1967735D+01	0.1967735D+01	0.1967735D+01	0.1967735D+01	0.1967735D+01
95 PERC. CONF. LIMITS	0.2053428D+00	0.1304664D+00	0.2313787D+00	0.1999114D+00	0.1171254D+00	0.2241473D+00
NO. OF RESIDUALS THAT EXCEED 1.500 KM OR M/SEC	0	0	0	0	0	0
3 SIGMA OF RCL ERRORS	0.1770228D+00	0.1734734D+00	0.4478203D+00	0.4064429D+00	0.1664013D+00	0.2205492D+00

Figure B-5. Summary of Statistical Analysis

```
*****************************************************************************************************************
** THIS BEGINS AN UPLINK MESSAGE BLOCK **
** MEMBER #  1 PUT INTO PDS MEMBER "MEMBER-A" OF DDNAME "DDDDDDDD" **
*****************************************************************************************************************


LPTR= 1  LINE=  XSMM TABLES,  DATE=81Y070D,ID=MEMBER-A,USER=DDDDDDDD
PREMATURE END OF FILE ON UNIT 8 IN SMMOUT
```

Figure B-6. Uplink Messages

ASCII TAPE CONTENTS

```
LANDSAT D           811002    80000
0.3441153489760258D+04-.5877957019598743D+03-.6159326640685645D+04
0.5780350397103589D+01-.3204801376677727D+010.3544274987584217D+01
  811002    80000  811004   200000   811002  230000
0.1000000000000000D+010.0                    0.1058960820790463D-020.7292116600000000D-04
 600 360    1

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Figure B-7. ASCII Tape Contents (1 of 5)

```
0.160586608097521 1D+00-.785094127408001 4D-01-.260769056903882 3D-010.139459705967510 7D+00
-.413582470945925 7D-01-.405240714917454 2D-020.150580306686606 5D+00-.536477746032915 1D-02
-.551845494260305 7D-020.167320880202169 1D+000.942963361700321 9D-020.361143586109733 4D-01
0.104360620898148 7D+000.181238473609023 8D-010.405396907290196 4D-010.351539969622872 2D-01
-.112450378648589 0D-010.212951847652220 7D-01-.144404822614774 3D-01-.348750813510037 0D-01
0.311970902757821 0D-010.151672871470509 6D-02-.354038405391179 4D-010.460651868166337 4D-01
-.160109752896460 1D-01-.144459581013052 2D-010.884317883428025 2D-01-.669493547113688 7D-01
0.706312507412576 5D-020.676901097776863 0D-01
-.626012809060156 9D-010.406482855220247 1D-020.338438197477444 2D-01-.521705683949562 6D-01
0.757229711905438 3D-020.202576631536430 8D-01-.272695645307976 5D-01-.300342674808007 4D-02
0.119970780473863 7D-01-.165208534863268 1D-01-.185919579580513 5D-010.415466557271884 1D-01
-.398746498306081 8D-01-.539965554031596 2D-020.309442225379825 7D-01-.386634128085461 3D-01
-.319870598831606 2D-020.302553429764884 6D-01-.482518360995527 5D-010.107106350933037 9D-01
0.577897914981804 2D-01-.348376758192898 7D-010.350108364928587 4D-010.746013402114726 9D-01
-.729840736212281 6D-010.629690953255135 4D-010.969526944350604 9D-01-.131263045350522 1D+00
0.718006199957843 0D-010.440197013649594 7D-01-.140408928343163 1D+000.495383783163561 0D-01
-.653812393829866 8D-02-.153131071574534 9D+000.303370847883570 6D-01-.602756925463836 5D-01
-.123052744842425 5D+00-.133627178750309 0D-01-.110272878118848 9D+00-.754841360317341 0D-01
-.379676676670328 6D-01-.105238013800203 6D+00
-.169734872220033 1D-01-.134387913529963 0D-01-.787518090401135 9D-010.252600605055590 7D-01
0.229998717275066 2D-010.661413949273992 3D-03-.324185623230732 7D-020.686371408391437 4D-01
0.712602297753619 5D-01-.393395227056316 8D-010.101092198208562 0D+000.848250828770460 4D-01
-.105964473887979 7D+000.125876596460898 3D+000.759850361696408 1D-01-.158242097845175 1D+00
0.134821451275058 7D+000.661971831323171 5D-02-.183588345519183 3D+000.115514115608277 7D+00
-.543545819409700 9D-01-.200394360706923 2D+000.782661953396655 0D-01-.150591677168449 7D+00
-.149866741159712 5D+000.122735165383005 6D-01-.220090849885252 7D+00-.663345234343069 0D-01
-.285210589677262 8D-01-.219113620854159 3D+000.318880025382668 5D-01-.350686154236541 4D-01
-.150504655577606 2D+000.738426710509543 2D-01-.182296399065649 0D-01-.188488390795100 7D-01
0.186186897653897 2D-010.196620415381971 7D-010.811106521678084 4D-01-.572128824360334 0D-01
0.555519021498867 0D-010.958963216647816 8D-01
-.108836977396094 9D+000.949608147080880 4D-010.584248612166220 5D-01-.909959296678835 0D-01
0.114154572649169 9D+000.898360149761959 D-02-.738318086965250 6D-010.987050293203424 2D-01
0.772688064262183 6D-02-.823845415261530 4D-010.618981971591097 1D-01-.586163097068492 8D-03
-.100304087914082 6D+000.264099849556487 2D-010.560852517614654 0D-02-.120235901710657 3D+00
0.971248043140349 2D-02-.991101064931854 1D-02-.934662009052544 8D-01-.164320636550883 1D-01
-.316575872948305 9D-01-.541367599144564 3D-01-.465794160528503 2D-01-.111175178253688 5D-01
-.580326382323619 3D-01-.599494427427771 4D-010.218156562614240 1D-01-.760451496580572 0D-01
-.536186011818244 9D-010.177552137021166 3D-01-.363757802091598 5D-01-.356194649401118 1D-01
-.160021684228581 8D-010.760275833807782 0D-01-.407041047939742 4D-010.789713875110464 9D-02
0.145533181437974 0D+00-.578647018328162 2D-010.129764129994328 0D+000.114652576084154 1D+00
-.486897239112522 6D-010.276429211795402 8D+00
-.215754779046619 7D-010.521155989571298 1D-020.363665597572719 4D+00-.174862670309266 8D+00
0.619511459737509 5D-010.295351457261915 6D+00-.212630077634287 3D+000.559471247225928 9D-01
0.132573133880214 3D+00-.152193747491765 0D+00-.658797978850955 7D-020.916741677337995 5D-02
-.866824700369761 6D-01-.783399671279880 7D-01-.361532252127290 1D-01-.415608398857880 0D-01
-.121929205217611 5D+00-.501474202923333 2D-010.334274095266664 5D-01-.144814664698628 8D+00
-.557286257055125 1D-010.135217310031464 4D+00-.165604618743145 7D+00-.282396106103988 1D-02
0.193091000570973 4D+00-.160129135579527 6D+000.126181065582386 5D+000.162971200139509 2D+00
-.101141032448936 1D+000.263750518175697 8D+000.496869840417275 6D-01-.621836441268970 2D-02
0.323530953071088 6D+00-.565864100826729 6D-010.682775828573767 3D-010.247964701758974 1D+00
-.658845093898321 3D-010.697205625667720 6D-010.117450661909970 2D+00-.210251930353138 1D-01
0.131247861371512 9D-010.202296384541114 1D-01
0.140329221831052 6D-01-.542320352395790 9D-01-.193968577563623 5D-010.348267148974628 1D-01
-.971107189761255 5D-01-.298326417161547 4D-010.509746638999786 2D-01-.112631138232519 0D+00
-.242875273470417 6D-010.598723459567480 6D-01-.102260854734652 2D+00-.213664426955801 9D-01
0.645525290237856 1D-01-.687254333816440 5D-01-.179891332409170 0D-010.764712621694343 0D-01
-.268227838029133 6D-01-.350041150444401 0D-010.986903941047785 3D-010.296940182226990 1D-02
-.529695805903429 6D-010.135762422750303 8D+000.908899404532803 6D-02-.542405614341987 5D-01
0.153020305398797 5D+00-.415062070874228 1D-02-.230700493912081 6D-010.126005027134738 2D+00
-.141171975130873 8D-01-.151211201473415 7D-010.911860391097434 3D-01-.135705937834700 3D-01
-.432738755114314 7D-010.101712491508806 1D+00-.205385623547158 5D-01-.704363157265675 0D-01
0.108439633812849 9D+00-.190559001750898 5D-01-.548779308755911 2D-010.830830098885257 9D-01
0.861874170635701 4D-02-.479149811535535 3D-01
0.420894258028852 2D-010.393045431995915 4D-01-.798339214015868 5D-010.399119753728882 6D-01
0.403262875198606 7D-01-.156583621908964 7D+000.929657066308209 3D-010.130218936674850 7D-01
-.205108425746459 5D+000.157474146844833 7D+00-.294302427992079 2D-01-.163724472238755 0D+00
0.143331777267064 8D+00-.468091966365591 4D-01-.839671779049240 3D-010.798748386762326 8D-01
-.184792120321617 4D-01-.719111850950142 9D-010.530696726182213 8D-010.191788092841116 0D-01
-.138203538209154 4D+000.118550807270366 9D+000.291532893305657 1D-02-.183821714237410 6D+00
0.190092634737709 4D+00-.273833239057808 0D-01-.140830257119887 4D+000.206993179061345 27D+00
-.264572150052231 3D-01-.434990042504068 7D-010.148267136342042 0D+000.245523233331823 6D-03
0.295733502543953 4D-010.766410492151408 1D-010.252204791948997 8D-010.244063200783557 5D-01
0.531771967689569 0D-010.269844565889343 4D-01-.224261478553557 9D-010.554669753520329 3D-01
-.560815353344423 8D-02-.288728670157070 2D-01
0.326674744346817 6D-01-.283920359531748 5D-01-.251563224137498 8D-010.926336800262106 4D-04
-.109945402703033 3D-01-.485890116869995 8D-010.431023984947387 4D-020.186537657509688 9D-02
-.116771414630989 1D+000.654074580725136 9D-01-.417003037525773 8D-01-.151201295862588 1D+00
0.143862437575080 5D+00-.962077325306154 3D-01-.119306819035045 9D+000.187395804496944 2D+00
-.110957352430659 7D+00-.432202223964850 4D-020.154278667054200 0D+00-.668596903173011 0D-01
0.106072993267844 1D+000.903622050327612 7D-01-.648831360535950 8D-030.134873040525462 8D+00
0.509198246421197 4D-010.266313868870611 3D-010.957543777654450 4D-010.344583601137173 9D-01
0.490164390504332 9D-020.507709252863901 9D-010.463263375764102 0D-01-.232680733703318 8D-01
0.293518809548913 9D-010.365333582794846 7D-01-.177551090163206 0D-010.353327667826306 4D-01
```

Figure B-7. ASCII Tape Contents (2 of 5)

```
0.2140529262032942D-01-.1550594766524682D-010.2359603888436368D-010.9601912852303940D-03
-.3523121866709289D-010.1212013628673958D-01
0.3842349817489321D-02-.6284433695321923D-01-.1266734068667574D-010.1533738549960617D-01
-.6971255856353764D-01-.2761724078482075D-020.2703562072201748D-01-.3621705603285363D-01
-.4746024931591819D-020.6155218675030483D-01-.8550796770975921D-02-.2151135687580563D-01
0.7759890252327750D-01-.1228430163234862D-01-.2179765344294537D-010.7735525407866817D-01
-.1899074282118818D-01-.2765184980398772D-010.9494309616377450D-01-.8827189042449390D-02
-.2609166129332152D-020.7783067744821892D-010.3142912764508310D-010.2837824858033855D-01
0.6130098574612930D-010.5663776080473326D-010.5072417249226646D-010.3876870211570349D-02
0.6915650237783666D-010.6968996695860596D-01-.7041539546418107D-010.6522532168548878D-01
0.2427704302408529D-01-.1253714145280469D-000.5045079692996524D-01-.6873775846815988D-01
-.9562237487170933D-010.2608917226820040D-01-.1974524900297183D-000.2026447825937794D-01
-.2564405308589812D-01-.2428724760654859D+00
0.7547177014566842D-01-.4815279433189649D-01-.1768858098975556D+000.7280157216115413D-01
-.1406294456353407D-01-.1150546909066179D+000.5807163052600117D-010.3118144165248850D-01
-.6144461332678475D-010.4517970496544876D-010.1215450010776067D+00-.5262306228269154D-01
0.6838821226392611D-010.1462698476668152D+00-.1761541146839818D-010.1054768780340964D-01
0.1552160729763727D+000.4664290576477015D-01-.1171320295938472D+000.1552281966070836D+00
0.1470647442238260D-01-.2135918452324290D+000.1256313336031667D+00-.1252562339468568D+00
-.1697640052261704D+000.5421530372268535D-01-.2939759259143102D+00-.2026947207283520D-01
-.2897704170726456D-01-.3127262831929443D+000.4513947953273600D-01-.4124900588482205D-01
-.1943203980422470D+000.3007395838454840D-010.3559247747773497D-02-.9895061898805579D-01
-.2602355737849393D-020.6077410161418584D-01-.4470118337212625D-01-.5531246551981894D-04
0.1067490772448423D+00-.3488963668769429D-01
0.2469515552547819D-010.1142429091855706D+000.4057658461721303D-01-.7167196475984383D-01
0.1356767907986978D+000.1232694527030276D+00-.2144744535284531D+000.1580317848361688D+00
0.6609679649227473D-01-.2728880122185728D+000.1334896822296550D+00-.8573704931950488D-01
-.1923644126572981D+000.6193877445213047D-01-.2081790934780656D+00-.5152480119340908D-01
-.9695131311502792D-02-.1768703026747289D+00-.1721229873965058D-01-.2396593794719593D-01
-.5581875753381382D-01-.4750012762093547D-01-.1386025462244334D-010.2512880918402516D-02
-.6596498546610974D-01-.9953664493981051D-020.3070491250127816D-01-.4268384918668744D-01
-.4983397968373993D-020.5600298563967954D-01-.3616415528176731D-010.5909088786154371D-02
0.1602433969805510D+00-.1499753340722236D+000.6003293387661097D-010.2146929993414233D+00
-.2396128270289637D+000.9870696500411213D-010.1269675220828503D+00-.2243061162927233D+00
0.8375916519131010D-010.2558582431356626D-01
-.1441768264821803D+000.3722943497382403D-01-.7988402235753256D-02-.7589361276950513D-01
-.1310325536042001D-010.5411812102642344D-01-.1125796453097792D+00-.1841863827104362D-01
0.1189926850411211D+00-.1500444445259745D+00-.1242815022811783D-010.9237020769160154D-01
-.1407495826091463D+00-.2451081357360962D-010.6333256824382261D-01-.8547882923085126D-01
-.3806542531219748D-010.5835861023615507D-01-.5418098330937937D-01-.3290016613539137D-01
0.1364717632056340D+00-.1217238437102424D+000.1021377486659958D-010.1600929033193097D+00
-.1434609513039504D+000.2617686076030168D-010.9782674923917511D-01-.1176316012832785D+00
0.1534709045979454D-010.7397518424204463D-01-.8975948772513220D-01-.8678436426293956D-02
0.7865690007292869D-01-.8608059614834929D-01-.3529477961382099D-010.1191685870869605D+00
-.1303023465652586D+00-.8687715947075958D-020.1268349500805925D+00-.1364120334291101D+00
0.3141643370281599D-010.8261560076152819D-01
-.1211117583694659D+000.4188184209294832D-010.4737093782750890D-01-.7500047624580475D-01
0.2338911429285417D-010.1470722005461766D-01-.3974612337863540D-010.4468550750800659D-02
0.4812029458662437D-01-.7314535667683231D-010.1762864214720139D-010.4918129252382641D-01
-.7511890942498667D-010.1726546219913416D-010.2013944262034784D-01-.8806839601095362D-01
0.1485850477115491D-010.6474560786045913D-02-.8365013145248668D-01-.6138368123970395D-02
-.2890757853094783D-01-.6069955943348759D-01-.2855217036670865D-01-.3327944081502210D-01
-.2973413387280743D-01-.7396386600362348D-02-.2459666677350469D-010.2790805195218127D-02
0.2772630049787494D-010.8758572985243518D-02-.1285613380491668D-010.4129468933928138D-01
0.4312509439296264D-01-.3322798377121217D-010.2428243045225560D-010.3193968107626688D-01
-.4321774362870201D-010.1262326683121273D-010.3022995997423550D-01-.4887200591230112D-01
0.3674360933746357D-010.4260406411958684D-02
-.2442604234616397D-010.4960783102052346D-010.1341283549663785D-02-.4234417263705836D-01
0.5217483619679797D-01-.1808220315069775D-02-.4778988238285820D-010.2894458061564364D-01
-.2765154311538254D-01-.3997399532181589D-010.4244675548875421D-02-.4253206108813856D-01
-.8744688081719687D-02-.1120955584019612D-01-.4793082932246762D-010.1497607346671970D-01
-.2653493552492137D-01-.1403846927587438D-01-.8234665926750040D-02-.4836461913384937D-01
0.2682722452300368D-01-.4270411731522472D-01-.7061957641656136D-010.2363391345386390D-01
-.3781710267321614D-01-.6004992697501166D-01-.5595768679995672D-020.4792371278148266D-01
-.2747179530490484D-01-.2288205208424188D-010.1462675760914181D+00-.1608393013253817D-01
0.5938245483230276D-010.1442844483086674D+00-.6963220098270995D-020.1796104235972962D+00
0.5844023606914561D-010.1116390886539875D-010.2675212232840636D+00-.6983283435147314D-01
0.3467474250390978D-010.2546498035593459D+00
-.1432336217000625D+000.2624095121461778D-010.1419422039161873D+00-.1389372153993236D+00
-.2456629773161012D-010.3373234025639249D-01-.1044790772120905D+00-.9747401628237640D-01
-.2168811573301355D-01-.6797908374483006D-01-.1509135533531207D+00-.5260460944862189D-01
0.8324687036292744D-02-.1568670468632263D+00-.8648356618147091D-010.1656543108496749D+00
-.1552003419584480D+00-.6017674369377346D-010.2977452663077429D+00-.1583119513255156D+00
0.1011688928538206D+000.2853107095479572D+00-.1195855840185232D+000.3185925570460313D+00
0.1322375747831757D+00-.3411388443419128D-010.4617808281938665D+00-.6545204478970845D-01
0.5013300103394158D-010.4223757196880342D+00-.1654308638184148D+000.7215450986655014D-01
0.2386873884479428D+00-.1484461063051299D+000.1918792143646897D-010.6401547016230325D-01
-.8216157049355388D-01-.7486969940333665D-01-.2966098945125850D-01-.2375819052758743D-01
-.1442268874998831D+00-.6751560710296189D-01
0.4792321456079662D-01-.1670417660978387D+00-.8968249292939845D-010.1497796257366986D+00
-.1762255805537620D+00-.6253621579526225D-010.2209441983691818D+00-.1668501715988668D+00
0.4254511624640145D-010.1950947538625769D+00-.1058949101242774D+000.1590202464221875D+00
0.1101727497052707D+00-.2397629817488678D-010.2034850978188842D+000.4209597432236478D-01
```

Figure B-7. ASCII Tape Contents (3 of 5)

```
0.3313981967346535D-010.1506542631109369D+000.3903457136544830D-010.4030142316617003D-01
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0.5155270293562353D-01-.3797035217900202D-01-.6893704571666603D-020.5249907130018983D-01
-.6187896085623379D-01-.4245158573462504D-010.7272114009811048D-01-.6437646609452941D-01
-.6502381137971724D-010.9011244630193005D-01-.5400884659297844D-01-.6453813810458087D-01
0.8131185831274479D-01-.2919212563642759D-01-.5395500315171375D-010.4157325185587979D-01
0.8304671144344411D-02-.8854925760806509D-01
0.4712712544824171D-010.1995746309785318D-01-.1560757089073945D+000.1212484575826238D+00
-.3708505833515119D-03-.1865078610016440D+000.1795326760245644D+00-.2597855241822344D-01
-.1237568892702257D+000.1475945715123948D+00-.2272480472163352D-01-.5166048800310818D-01
0.8493959966654074D-010.5263632728087941D-02-.4896482376807398D-010.7350521171792934D-01
0.2774995736086794D-01-.1143657380191030D+000.1142979365904466D+000.2184852946976434D-01
-.1398094656231024D+000.1438488352007994D+000.1476832020068741D-01-.1044473714182459D+00
0.1064879199868756D+000.2560225812538519D-01-.5398039750980388D-010.2062804751221847D-01
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Figure B-7. ASCII Tape Contents (4 of 5)

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Figure B-7. ASCII Tape Contents (5 of 5)

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