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EARTH RESOURCES TECHNOLOGY SYSTEM

STANDALONE SOFTWARE PACKAGE

DESCRIPTION AND USER'S GUIDE

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Prepared for

GODDARD SPACE FLIGHT CENTER

By

COMPUTER SCIENCES CORPORATION

Under

Contract NAS 5-11999
Task Assignment 591

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Prepared by:

W. W. Chu 09-11-75
W. W. Chu Date

Approved by:

B. L. Hill 9/12/75
B. L. Hill Date
Section Manager

W. E. Wagner 9/12/75
W. E. Wagner Date
Technical Area Manager

ABSTRACT

This document provides a user's guide and program description for the ERTS-B Stand-Alone Software Package. This package was developed to compute the Keplerian elements at the descending node, the Brouwer mean elements at the node, the averaged Brouwer Mean Elements, and other orbital parameters for the orbits of the Earth Resources Technology Satellite (ERTS). The typical input for the program is an ephemeris file which resulted from a definitive orbit generated over a two day arc using the Cowell option in the Definitive Orbit Determination System (DODS) or the Goddard Trajectory Determination System (GTDS).

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Figure

SECTION 1 - OVERVIEW OF THE ERTS-B STAND-ALONE SOFTWARE PACKAGE

1.1 INTRODUCTION

The purpose of the Earth Resources Technology Satellite (ERTS-B) Stand-Alone Software Support Package is to identify the time of a specific event on a DODS (Definitive Orbit Determination System) formatted ephemeris (EPHEM) file, and to compute a set of parameters associated with that event. The specific event is defined to be the first descending node which is detected within the time span of the file after the epoch. Epoch is defined on the input EPHEM file header, or optionally, on cards input by the user. The computed parameters associated with the first descending node include the Brouwer mean elements, longitude of the descending node, mean local time, and the Brouwer mean elements averaged over a period specified by the user.

The subroutines used in this package include: 1) DEBTAP (Data Evaluation by Trajectory Analysis Program) subroutines (CALSEC/SECCAL, CONVRT, CROSSP, DOTPRD, ERRLNG, LAGRIN/INTRPX, SUBCAP, UNITV); 2) modified DEBTAP subroutines (COMPOS, COMPUT, OSCMN); and 3) new subroutines (DATOUT, PACK/UNPACK, READER, SHIFT, STORE, YIELD). The program was constructed from specifications provided by P. Shapiro and E. Herring of GSFC.

1.2 METHOD

The ERTS-B Stand-Alone Software Package processing is begun by reading the input constants and variables from card. The ephemeris file is then read and the first descending node after the specified or default epoch is located. An 8-point Lagrangian formula is used to obtain the time of nodal crossing by interpolation using the Cartesian z component as the independent variable. Next, the Keplerian elements and the related orbital parameters are computed at the nodal crossing time.

Starting with the point in the EPHEM file closest in time to the descending node, a user-specified number of position and velocity vectors, at specified intervals of time, are collected. These vectors are converted to Keplerian elements and then to Brouwer mean elements and the Brouwer mean semi-major axis, inclination, and eccentricity are averaged. A report is then generated of the Cartesian, Keplerian, Brouwer mean, and averaged Brouwer mean elements, along with the related orbital parameters at the time of nodal crossing. A functional flow of the program is shown in Figure 1-1.

1.3 LIMITATIONS

The ERTS-B Stand-Alone Software Support Package utilizes geocentric true of data coordinates.

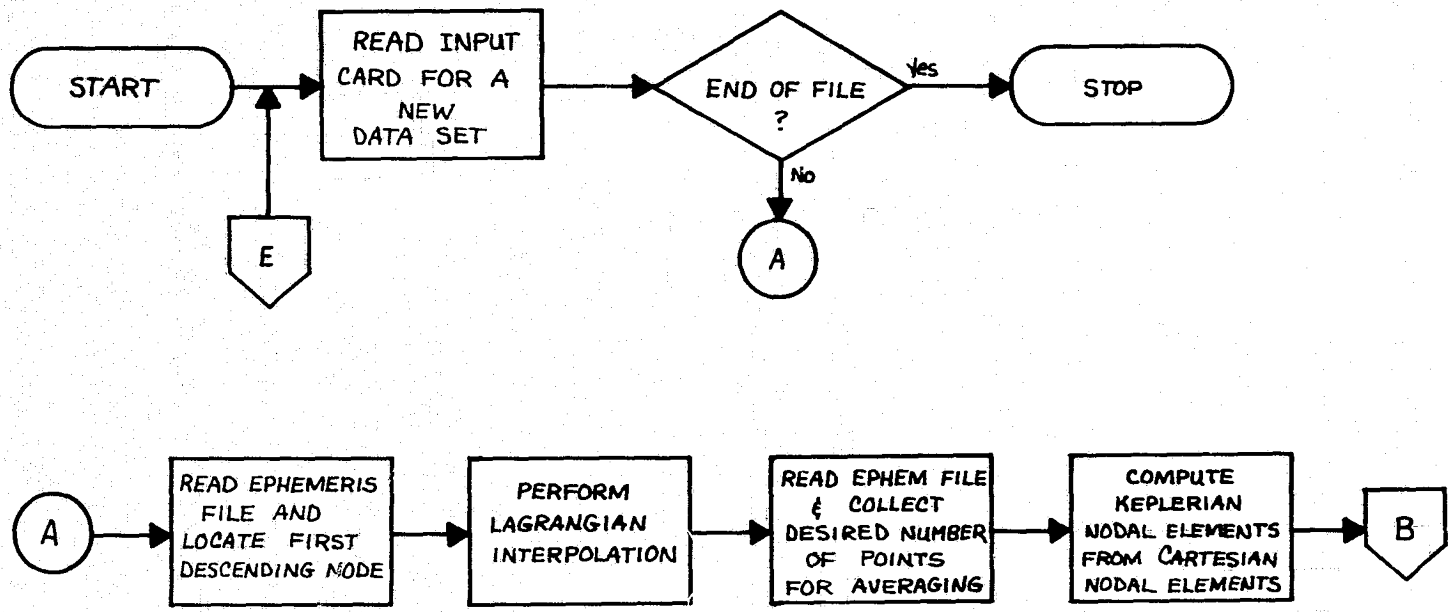

Figure 1-1. Program Functional Flow Diagram (1 of 2)

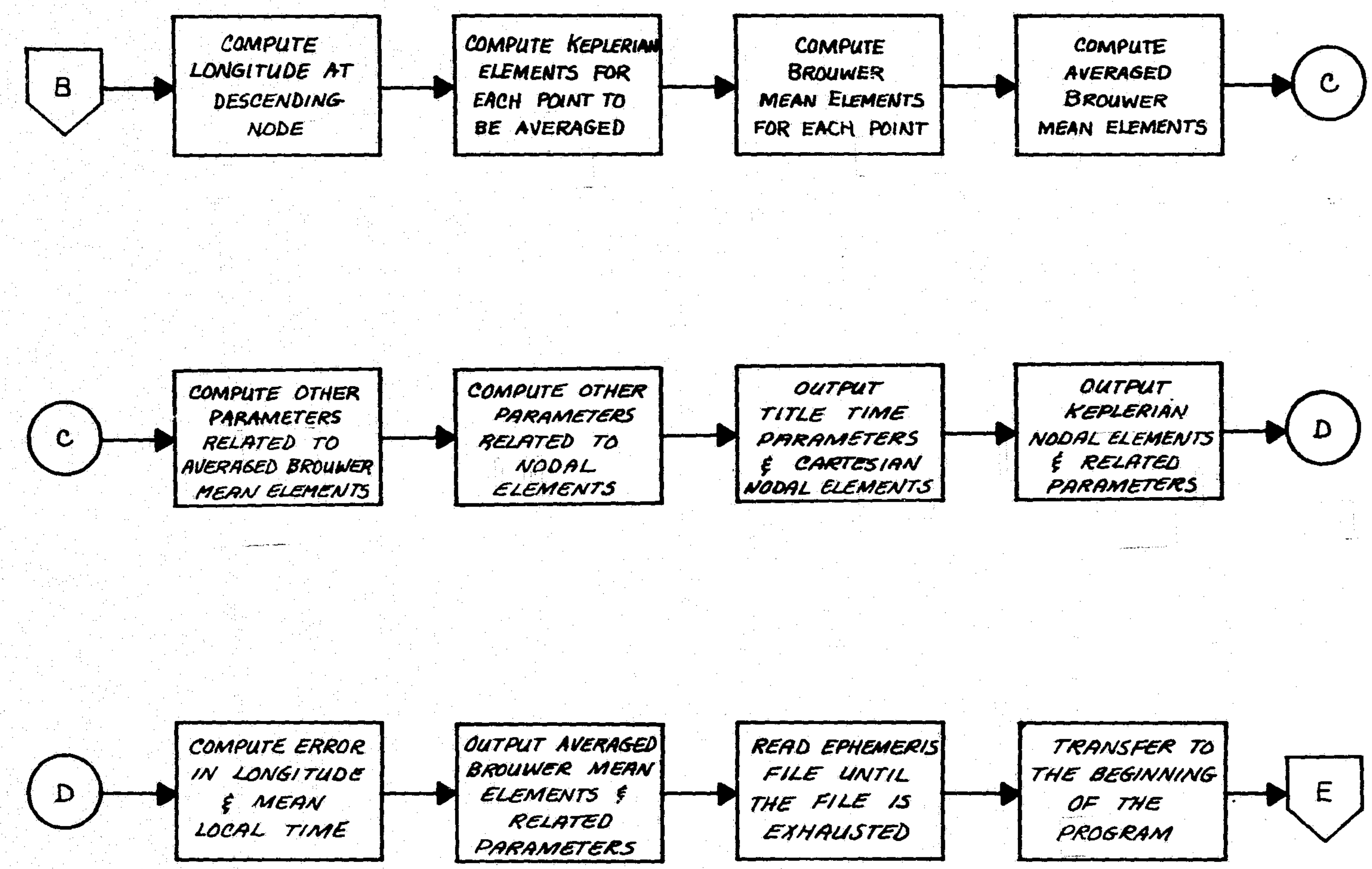

Figure 1-1. Program Functional Flow Diagram (2 of 2)

SECTION 2 - USER'S GUIDE

2.1 INTRODUCTION

The ERTS-B Stand-Alone Software Package requires card and ephemeris file input. The input cards are of three types: title card, mandatory constants, and optional constants. The title card is used to supply the header on the output report and may contain any information desired by the user. The mandatory constants cards supply the program with values that are not defaulted in the program and must be furnished by the user. Optional constants are those with default values defined in the program that may be overridden using the third type of card input. These constants are optional but three optional constant cards must appear in the input stream, even if blank.

A spacecraft ephemeris file, in EPHEM format, is the final required input. This file may be generated using either the Definitive Orbit Determination System (DODS) or the Goddard Trajectory Determination System (GTDS). Program output is a printer report of the averaged Brower mean elements and other orbital parameters.

2.1.1 Card Input

2.1.1.1 Title Card

Columns	Format	Description
1-80	10A8	Header or title for output report

2.1.1.2 Mandatory Constants Cards

Input of mandatory constants provides data that are not defaulted in the program. These cards must be applied by the user. These values are input in NAMELIST* format.

* Reference: IBM FORTRAN IV Language, #GC28-6515

The NAMELIST name is '&INCARD'. The following parameters are in the NAMELIST:

Parameter	Description	Units
REPTIM	Repeat cycle length, i.e. the total time required for a spacecraft (S/C) to repeat its ground trace. Ground trace is the projection on the earth's surface of the spacecraft's trajectory using the center of the earth as the center of the projection.	days
NREVDY	Number of S/C revolutions per day	rev/day
NUMREV	The number of S/C revolutions per repeat cycle.	rev/r.c.
NCNT	Number of points to be averaged	-
DELMIN	Time increment (interval) at which points are to be averaged.	min.
BASLON	A pre-assigned longitude of the descending node used in calculations to determine when a S/C maneuver is required. (Mission requirements state that the S/C orbit should remain within 18.5 kilometers of this base longitude at the specified descending node).	deg.
BASMLT (~) i = 1, 3	Base local mean time. A pre-assigned local mean time of the descending node used to indicate when a S/C maneuver is required.	
	i = 1 hour	hr.
	i = 2 minute	min.
	i = 3 second	sec.

2.1.1.3 Optional Constants Cards

Optional constants are those that have default values defined in the program. These constants are input on specific cards and all optional constant cards must appear in the prescribed order. A zero or blank field will cause the program to use the default value of that constant. There are three optional constant cards, all of which must appear in the input deck.

	Columns	Format	Description	Units
Card 1				
	1-10	G10	Epoch (YYMMDD)	Year, month, day
	11-20	G10	Epoch (HHMMSS)	Hour, min., sec.
	21-30	G10	Intermediate output indicator = 0 no ≠ 0 yes	
Card 2				
	1-25	G25.16	Earth gravity constant[1]	km^2/sec^3
	26-50	G25.16	Earth radius[1]	km
	51-75	G25.16	Earth dynamic radius[2]	km

	Columns	Format	Description	Units
Card 3	1-25	G25.16	Second harmonic constant[2]	
	26-50	G25.16	Fourth harmonic constant[2]	
	51-75	G25.16	Earth rotational velocity[3]	rad./sec.

Multiple cases may be processed by stacking the input decks (repeating the above sequence of cards for each case in a single execution of the program). Figure 2-1 shows a sample deck set-up.

2.1.2 Ephemeris File Input

The spacecraft ephemeris file input is generated in the EPHEM format by either the DODS or the GTDS programs. Figures 2-2 and 2-3 illustrate that format on the file.

---

[1] Used for computing Keplerian elements from Cartesian elements.

[2] Used for computing elements in secular terms which then lead to Latus Rectum and its derivatives.

[3] Used for computing the Greenwich hour angle and the Latus Rectum and its derivatives.

2.2 OUTPUT

Program output is a one page printer report of the Cartesian, Keplerian, and Brouwer mean orbital elements at the first descending node after epoch and the averaged Brouwer mean elements (semi-major axis, eccentricity, and inclination) and other mean elements. An example of this report is given in Figure 2-4.

2.3 JOB CONTROL LANGUAGE

The card input is read on FORTRAN Reference Number (FRN) 5, the input ephemeris file on FRN 24, and the output report on FRN 6. A scratch disk data set must also be provided on FRN 30. The program can be executed with the following JCL:

```
//              EXEC LOADER
// SYSLIN   DD   DSN = GRJJJ. ERTSB. LOAD(AVBME), DISP = SHR
//GO.FT24F001   DD   UNIT = 2400-9, DISP = (OLD, KEEP),
//      LABEL = (N,BLP), DCB = (RECFM = VS, BLKSIZE = 2808),
//      VOL = SER = XXXXXX
//GO.FT30F001   DD   UNIT = DISK, DISP = (,DELETE), SPACE = (CYL, (1,1)'
//GO.DATA5   DD  *
```

where N is file number on tape and XXXXXX is tape serial number.

```
//ZBWWCIST  JOB  (GR2111311H,T,G00080,002002),FFF,MSGLEVEL=(1,1)
// EXEC LOADER,REGION=150K,PARM=EP=MAIN'
//SYSLIN DD DSN=GTFFM.ERTS.LOAD(AVBME),DISP=SHR
//GO.FT24I001 DD DSN=ZBWWC001,DISP=(OLD,KEEP),
//     UNIT=(2400-9,,DEFER),VOL=SER=34081,
//     LABEL=(1,BLP),DCB=(RECFM=VS,BLKSIZE=2808)
//GO.FT24F002 DD DSN=ZBWWC002,DISP=(OLD,KEEP),
//     UNIT=(2400-9,,DEFER),VOL=SER=31949,
//     LABEL=(1,BLP),DCB=(RECFM=VS,BLKSIZE=2808)
//GO.FT24F003  DD DSN=ZBWWC003,DISP=(OLD,KEEP),
//     UNIT=(2400-9,,DEFER),VOL=SER=35002,
//     LABEL=(1,BLP),DCB=(RECFM=VS,BLKSIZE=2808)
//GO.FT30F001 DD UNIT=DISK,DISP=1, DELETE),SPACE=(CYL,(1,1))
//GO.DATA5 DD *
*****       ERTS-B PROGRAM FOR USING EPHEMERIS TAPE 34081       *****
 &INCARD
 NUMREV=251,  REPTIM=18.0, NCNT=20, DELMIN=5,0, BASLON=98.030596,
 BASMLT=9.0,     42.0,     15.805
 &END
     750621     200000          0
   3.986012D+5              6.378165D+3
   1.0823D-3               -1.8D-6
*****       ERTS-B  PROGRAM FOR USING EPHEMERIS TAPE 31949       *****
 &INCARD
 NUMREV=251,  REPTIM=18.0, NCNT=20, DELMIN=5.0, BASLON=98.030596,
 BASMLT=9.0,      42.0,     15.805
 &END
     750619     200000          0
   3.986012D+5              6.378165D+3
   1.0823D-3               -1.8D-6
*****        ERTS-B PROGRAM FOR USING EPHEMERIS TAPE 31949       *****
 &INCARD
 NUMREV=251,  REPTIM=18.0, NCNT=20, DELMIN=5.0, BASLON=98.030596,
 BASMLT=9.0,      42.0,     15.805
 &END
     750617      200000          0
   3.986012D+5                 6.378165D+3
   1.0823D-3                  -1.8D-6
/*
```

Figure 2-1 Sample Stacked Case Set Up

ENTRY DESCRIPTION (RECORD 1)		INTERNAL BYTES	INTERNAL FORMAT	INTERNAL UNITS	EPHEM OUTPUT FORMAT	EPHEM OUTPUT UNITS
(1)	TYPE OF TAPE ID (THE WORD "EPHEM" IN EBCDIC)	8	LF	–	EBCDIC	–
(2)	SATELLITE NUMBER (7 DIGITS)	4	LI	–	LF	–
(3)	UTC, A.1 INDICATOR: = 1, A.1 = 2, UTC	4	LI	–	LF	–
	(ITEMS 4, 5, AND 6 GIVE START TIME OF THE EPHEMERIS)					
(4)	DATE	8	LF	DUT	LF	YEAR, MONTH, DAY
(5)	DAY COUNT OF YEAR				LF	DAYS FROM JAN. 0
(6)	SECONDS OF DAY				LF	SEC
	(ITEMS 7, 8, AND 9 GIVE END TIME OF THE EPHEMERIS)					
(7)	DATE	8	LF	DUT	LF	YEAR, MONTH, DAY
(8)	DAY COUNT OF YEAR				LF	DAYS FROM JAN. 0
(9)	SECONDS OF DAY				LF	SEC
(10)	Δt, INTERVAL BETWEEN EPHEMERIS POINTS	8	LF	DUT	LF	SEC
(11)-(26)	RUN ID TAKEN FROM MIR COMMENT CARDS	8	LF	–	EBCDIC (UP TO 128 CHARACTERS)	–
(27)	REFERENCE DAY FOR DODS (570918)	8	LF	CALENDAR	LF	YEAR, MONTH, DAY
(28)	TYPE OF COORDINATE SYSTEM USED FOR OUTPUT: = 1, TRUE EQUATOR AND EQUINOX PLUS EQUATION OF EQUINOXES = 2, MEAN EQUATOR AND MEAN EQUINOX = 3, TRUE EQUATOR AND TRUE EQUINOX	4	LI	–	EBCDIC AND LI (1ST 4 BYTES EBCDIC, 2ND 4 BYTES INDICATOR VALUE): "TRUE" 1 "MEAN" 2 "INER" 3	–

Figure 2-2 EPHEM File Title Records (1 of 5)

ENTRY DESCRIPTION (RECORD 1)		INTERNAL			EPHEM OUTPUT	
		BYTES	FORMAT	UNITS	FORMAT	UNITS
(29)	ORBIT THEORY USED: = 1, COWELL = 2, BROUWER	4	LI	–	EBCDIC ("COWELL " OR "BROUWER ")	–
(30)	SOLAR RADIATION CONSTANT	4	SF	Gm/DUL-DUT^2	LF	Gm/Cm-SEC^2
(31)	SOLAR FLUX NUMBER	4	SF	–	LF	–
(32)	C_D, COEFFICIENT OF DRAG	4	SF	–	LF	–
(33)	C_R, SHAPE PARAMETER	8	LF	–	LF	–
(34)	ATMOSPHERE MODEL ID	8	LF	–	EBCDIC ("HAR-PRIE")	–
(35)	CROSS SECTIONAL AREA OF SATELLITE	8	LF	DUL^2	LF	Cm^2
(36)	MASS OF SATELLITE	8	LF	Gm	LF	Gm
(37)	ZONAL AND TESSERAL HARMONICS INDICATOR: = 0, USED = 1, NOT USED (USE SAME INDICATOR SETTINGS FOR ITEMS 38, 39, 40, 41 AND 42)	4	LI	–	LF	–
(38)	BROUWER COMPLEMENTARY PERTURBATION INDICATOR	4	LI	–	LF	–
(39)	LUNAR GRAVITATION PERTURBATION INDICATOR	4	LI	–	LF	–
(40)	SOLAR RADIATION PERTURBATION INDICATOR	4	LI	–	LF	–
(41)	SOLAR GRAVITATION PERTURBATION INDICATOR	4	LI	–	LF	–
(42)	DRAG PERTURBATION INDICATOR	4	LI	–	LF	–
(43)	ELEMENTS EPOCH, t_0	8	LF	DUT	LF	DUT

Figure 2-2 EPHEM File Title Records (2 of 5)

ENTRY DESCRIPTION (RECORD 1)		INTERNAL BYTES	INTERNAL FORMAT	INTERNAL UNITS	EPHEM OUTPUT FORMAT	EPHEM OUTPUT UNITS
(44)	YEAR (ELEMENTS EPOCH)	8	LF	DUT	LF	YEAR
(45)	MONTH				LF	MONTH
(46)	DAY				LF	DAY
(47)	HOUR				LF	HOUR
(48)	MINUTE				LF	MINUTE
(49)	SECONDS X 1000				LF	SEC
	(ITEMS 50 THROUGH 55 ARE BROUWER MEAN IF ITEM 29 = "BROUWER," CLASSICAL KEPLERIAN IF ITEM 29 = "COWELL")					
(50)	SEMI-MAJOR AXIS AT t_o	8	LF	DUL	LF	Km
(51)	ECCENTRICITY AT t_o	8	LF	—	LF	—
(52)	INCLINATION AT t_o	8	LF	RAD	LF	RAD
(53)	ARGUMENT OF PERIGEE AT t_o	8	LF	RAD	LF	RAD
(54)	RIGHT ASCENSION OF THE ASCENDING NODE AT t_o	8	LF	RAD	LF	RAD
(55)	MEAN ANOMALY AT t_o	8	LF	RAD	LF	RAD
	(ITEMS 56 THROUGH 71 ARE OSCULATING VALUES EVALUATED AT t_o)					
(56)	TRUE ANOMALY	8	LF	RAD	LF	RAD
(57)	ARGUMENT OF LATITUDE = (53) + (56)	8	LF	RAD	LF	RAD
(58)	FLIGHT PATH ANGLE	8	LF	RAD	LF	RAD
(59)	ECCENTRIC ANOMALY	8	LF	RAD	LF	RAD
(60)	PERIOD	8	LF	DUT	LF	DUT
(61)	PERIGEE HEIGHT	8	LF	DUL	LF	Km

Figure 2-2 EPHEM File Title Records (3 of 5)

ENTRY DESCRIPTION (RECORD 1)		INTERNAL			EPHEM OUTPUT	
		BYTES	FORMAT	UNITS	FORMAT	UNITS
(62)	APOGEE HEIGHT	8	LF	DUL	LF	Km
(63)	MEAN MOTION	8	LF	RAD/DUT	LF	RAD/DUT
(64)	ARGUMENT OF PERIGEE SECULAR RATE OF CHANGE	8	LF	RAD/DUT	LF	RAD/DUT
(65)	SECULAR RATE OF CHANGE OF RIGHT ASCENSION OF ASCENDING NODE	8	LF	RAD/DUT	LF	RAD/DUT
(66) (67) (68)	X, Y, Z } EPOCH POSITION VECTOR	8	LF	DUL	LF	DUL
(69) (70) (71)	$\dot{X}$, $\dot{Y}$, $\dot{Z}$ } EPOCH VELOCITY VECTOR	8	LF	DUL/DUT	LF	DUL/DUT
(72)-(91)	TIMES OF BROUWER DRAG COEFFICIENTS: $t_{p,0}, t_{p,1}, \ldots, t_{p,19}$	8	LF	DUT	LF	DUT
(92)-(111)	BROUWER FIRST ORDER DRAG COEFFICIENTS: $N_{2,0}, \ldots, N_{2,19}$, OR COWELL DRAG COEFFICIENTS	8	LF	RAD/DUT^2 OR UNITS OF ρ_i	LF	RAD/DUT^2 OR INTERNAL UNITS OF ρ_i
(112)-(131)	BROUWER SECOND ORDER DRAG COEFFICIENTS: $N_{3,0}, N_{3,1}, \ldots, N_{3,19}$	8	LF	RAD/DUT^3	LF	RAD/DUT^3
(132)	NUMBER OF NON-ZERO TIMES IN ITEMS (72)-(91)	4	LI	—	LF	—
(133)-(192)	UNKNOWNS ASSOCIATED WITH EPOCH ELEMENTS IF THEIR ORIGIN WAS PREVIOUS DC OR PCE	8	LF	—	SIXTY 8-BYTE EBCDIC WORDS, ONE FOR EACH UNKNOWN USED)	—
(193)	START TIME OF EPHEMERIS	8	LF	DUT	LF	DUT
(194)	END TIME OF EPHEMERIS	8	LF	DUT	LF	DUT

Figure 2-2 EPHEM File Title Records (4 of 5)

ENTRY DESCRIPTION (RECORD 1)		INTERNAL BYTES	INTERNAL FORMAT	INTERNAL UNITS	EPHEM OUTPUT FORMAT	EPHEM OUTPUT UNITS
(195)	Δt, INTERVAL BETWEEN EPHEMERIS POINTS	8	LF	DUT	LF	DUT
(196)	LPN INDICATOR = 1, INCLUDE PRECESSION AND NUTATION = 2, INCLUDE PRECESSION ONLY = 3, NEGLECT PRECESSION AND NUTATION	4	LI	–	LF	–
(197)	GREENWICH HOUR ANGLE AT EPOCH	8	LF	RAD	LF	RAD
(198)-(293)	NOT USED (ZEROS)	8	LF	–	LF	–
(294)-(296)	COSINE IDENTIFICATION	8	LF	–	LF	–
	COSINE HARMONIC COEFFICIENT	4	SF	–		–
	SINE IDENTIFICATION	8	LF	–		–
	SINE HARMONIC COEFFICIENT	4	SF	–		–
	. . .	. . .	. . .	. . .	. . .	. . .
(348)-(350)	COSINE IDENTIFICATION	8	LF	–	LF	–
	COSINE HARMONIC COEFFICIENT	4	SF	–		–
	SINE IDENTIFICATION	8	LF	–		–
	SINE HARMONIC COEFFICIENT	4	SF	–		–

ENTRY DESCRIPTION (RECORD 2)
THIS RECORD IS A CONTINUATION OF RECORD NUMBER 1. THERE IS A MAXIMUM OF 135 PAIRS OF SINES AND COSINES OF HARMONIC COEFFICIENTS, OF WHICH THE FIRST 19 APPEAR IN RECORD NUMBER 1. THE REST, THAT IS, 20-135, ARE IN RECORD 2. THE FORMAT IS AS SHOWN IN RECORD NUMBER 1.

Figure 2-2 EPHEM File Title Records (5 of 5)

DOUBLE WORD NUMBER	ENTRY DESCRIPTION (RECORD 3)	INTERNAL BYTES	INTERNAL FORMAT	INTERNAL UNITS	INPUT/OUTPUT FORMAT	INPUT/OUTPUT UNITS
1	DATE OF FIRST EPHEMERIS POINT (TIME t OF FIRST EPHEMERIS POINT)	8	LF	DUT	LF	YEAR, MONTH, DAY
2	DAY COUNT OF YEAR (TIME t OF FIRST EPHEMERIS POINT)				LF	DAYS FROM JAN 0
3	SECONDS OF DAY (TIME t OF FIRST EPHEMERIS POINT)				LF	SEC
4	INTERVAL BETWEEN DATA POINTS (Δt)	8	LF	DUT	LF	SEC
5	X (POSITION VECTOR COMPONENTS AT TIME t)	8	LF	DUL	LF	DUL
6	Y (POSITION VECTOR COMPONENTS AT TIME t)	8	LF	DUL	LF	DUL
7	Z (POSITION VECTOR COMPONENTS AT TIME t)	8	LF	DUL	LF	DUL
8	$\dot{X}$ (VELOCITY VECTOR COMPONENTS AT TIME t)	8	LF	DUL/DUT	LF	DUL/DUT
9	$\dot{Y}$ (VELOCITY VECTOR COMPONENTS AT TIME t)	8	LF	DUL/DUT	LF	DUL/DUT
10	$\dot{Z}$ (VELOCITY VECTOR COMPONENTS AT TIME t)	8	LF	DUL/DUT	LF	DUL/DUT
11-304	49 SETS OF POSITION AND VELOCITY VECTORS AT TIMES $t+\Delta t, t+2\Delta t, \ldots, t+49\Delta t$	48 PER SET	LF	DUL, DUL/DUT	LF	DUL, DUL/DUT
305	TIME t OF FIRST EPHEMERIS POINT IN DUT	8	LF	DUT	LF	DUT
306	$\lvert \Delta t \rvert$, TIME DIFFERENCE BETWEEN POINTS IN DUT	8	LF	DUT	LF	DUT
307-350	ZEROS (NOT USED)	8 EACH	—	—	—	—

Figure 2-3 EPHEM File Data Record

```
ERTS-B STAND-ALONE SOFTWARE PACKAGE FOR USING EPHEMERIS TAPE 35002 --- RECORD  1

                    SATELLITE ID. = 7205801

                       TAPE BEGIN = JUN. 16, 1975     0 HR.   0 MIN.  0.000000 SEC.
                       TAPE   END = JUN. 18, 1975     6 HR.   0 MIN.  0.000000 SEC.
                       TAPE EPOCH = JUN. 17, 1975    20 HR.   0 MIN.  0.000000 SEC.
                INPUT SEARCH TIME = JUN. 17, 1975    20 HR.   0 MIN.  0.000000 SEC.

  FIRST DESCENDING NODE AFTER SEARCH TIME = JUN. 17, 1975   20 HR. 58 MIN. 31.292060 SEC.

                    GEOCENTRIC TRUE OF DATE COORDINATES

                                 *  *  *  *

                    TYPE OF ORBIT = ELLIPTICAL ORBIT

        X=  0.51017376425623510 04         Y=  0.52044428105356040 04          Z=  0.0
     XDOT=  0.82422294381204670 00      YDOT= -0.80567859812270230 00       ZDOT= -0.73084733340572290 01

 HT= 0.90979194D 03    LAT= 0.0              LON= 0.18544333D 03    V= 0.73988002D 01    GAM= 0.12603160D-01     AZ= 0.13896205D 03
SMA= 0.72944641D 04    ECC= 0.92212251D-03  AINC= 0.98962059D 02  LAN= 0.22557096D 03    APF= 0.16618678D 03    SML= 0.72944579D 04
RCA= 0.72877378D 04    APR= 0.73011905D 04   PER= 0.17222387D 01   TA= 0.13813215D 02     EA= 0.13800607D 02     MA= 0.13788003D 02
HCA= 0.90959776D 03    APH= 0.92305054D 03  HCAN= 0.49114350D 03 APHN= 0.47840742D 03
                 PREDICTED TIME OF PERICENTER PASSAGE BEFORE DESCENDING NODE = 17:JUN:75 20 54 0.33827D 02
                 PREDICTED TIME OF PERICENTER PASSAGE AFTER  DESCENDING NODE = 17:JUN:75 22 37 0.42636D 02

 *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *

                                         MEAN  ELEMENTS

   SMA =  0.72855814D 04  KM        NODE     RATE =  0.97231305D 00 DEG/DAY        DLR    = -0.25816631D 02 DEG/REV
   ECC =  0.61764115D-03            PERIGEE RATE = -0.27419607D 01 DEG/DAY        DLRDA  = -0.53407762D-02 DEG/REV/KM
   INC =  0.98967753D 02 DEG        ANOMALY RATE =  0.50229477D 04 DEG/DAY        DLRDI  =  0.84035691D-02 DEG/REV/DEG
   LAN =  0.22557095D 03 DEG        MEAN  MOTION =  0.10152494D-02 RAD/SEC        DOMGDA = -0.33442955D-04 DEG/REV/KM
   APF =  0.15819825D 03 DEG        OVERLAP      =  0.15080530D 02 PERCENT        DOMGDI =  0.77152041D-02 DEG/REV/DEG
    MA =  0.21776585D 02 DEG        RPTCYL ERROR =  0.15315475D 01 N MILES        MEAN LOCAL TIME =  9 20 0.18892D 02
  APGH =  0.91194126D 03 KM         PRGH         =  0.90294151D 03 KM             NODAL PERIOD    =  0.10326270D 03 MIN
ERRLON = -0.43381023D 01 N MILES    ERRMLT       = -0.53110775D 03 SEC       ANOMALISTIC PERIOD   =  0.10314682D 03 MIN
```

Figure 2-4 Sample Program Output (1 of 3)

```
ERTS-B STAND-ALONE SOFTWARE PACKAGE FOR USING EPHEMERIS TAPE 31949 --- RECORD  1

                    SATELLITE ID. = 7205801

                          TAPE BEGIN = JUN. 18, 1975    0 HR.  0 MIN.  0.000000 SEC.
                          TAPE   END = JUN. 20, 1975    6 HR.  0 MIN.  0.000000 SEC.
                          TAPE EPOCH = JUN. 19, 1975   20 HR.  0 MIN.  0.000000 SEC.
                   INPUT SEARCH TIME = JUN. 19, 1975   20 HR.  0 MIN.  0.000000 SEC.
FIRST DESCENDING NODE AFTER SEARCH TIME = JUN. 19, 1975   21 HR.  9 MIN. 52.832519 SEC.

                    GEOCENTRIC TRUE OF DATE COORDINATES

                               *  *  *  *

                    TYPE OF ORBIT = ELLIPTICAL ORBIT

      X=  0.49210227363304730 04        Y=  0.53747707712270250 04          Z=  0.0
   XDOT=  0.85151978196839760 00     YDOT= -0.77692400870001390 00       ZDOT= -0.73091180185070850 01

 HT= 0.90915206D 03   LAT= 0.0              LON= 0.18258204D 03    V= 0.73994529D 01   GAM= 0.15470733D-01    AZ= 0.18896206D 03
SMA= 0.72944714D 04   ECC= 0.10205812D-02  AINC= 0.98962057D 02  LAN= 0.22752346D 03   APF= 0.16464312D 03   SML= 0.72944638D 04
RCA= 0.72870266D 04   APR= 0.73019160D 04   PER= 0.17222612D 01   TA= 0.15356877D 02    EA= 0.15341399D 02    MA= 0.15325928D 02
HCA= 0.90888679D 03   APH= 0.92377599D 03  HCAN= 0.49075960D 03 APHN= 0.49879913D 03
                 PREDICTED TIME OF PERICENTER PASSAGE BEFORE DESCENDING NODE = 19:JUN:75 21  5 0.28880D 02
                 PREDICTED TIME OF PERICENTER PASSAGE AFTER  DESCENDING NODE = 19:JUN:75 22 48 0.37694D 02

*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *

                                MEAN ELEMENTS

   SMA =  0.72855847D 04  KM       NODE     RATE =  0.97230232D 00 DEG/DAY        DLR     = -0.25816650D 02 DEG/REV
   ECC =  0.64932761D-03           PERIGEE  RATE = -0.27419728D 01 DEG/DAY        DLRDA   = -0.53407772D-02 DEG/REV/KM
   INC =  0.98967667D 02 DEG       ANOMALY  RATE =  0.50229443D 04 DEG/DAY        DLRDI   =  0.84035580D-02 DEG/REV/DEG
   LAN =  0.22752345D 03 DEG       MEAN   MOTION =  0.10152488D-02 RAD/SEC        DOMGDA  = -0.33442571D-04 DEG/REV/KM
   APF =  0.17137771D 03 DEG       OVERLAP       =  0.15065324D 02 PERCENT        DOMGDI  =  0.77151942D-02 DEG/REV/DEG
    MA =  0.85913929D 01 DEG       RPTCYL ERROR  =  0.12559112D 01 N MILES        MEAN LOCAL TIME    =  9 20 0.12523D 02
  APGH =  0.91217541D 03 KM        PRGH          =  0.90271394D 03 KM             NODAL PERIOD       =  0.10326277D 03 MIN
ERRLON = -0.42039641D 01 N MILES   ERRMLT        = -0.13232820D 04 SEC      ANOMALISTIC PERIOD       =  0.10314689D 03 MIN
```

Figure 2-4 Sample Program Output (2 of 3)

```
ERTS-B STAND-ALONE SOFTWARE PACKAGE FOR USING EPHEMERIS TAPE 34081 --- RECORD  1

                    SATELLITE ID. = 7205801

                     TAPE BEGIN = JUN. 20, 1975     0 HR.  0 MIN.  0.000000 SEC.
                     TAPE   END = JUN. 22, 1975     6 HR.  0 MIN.  0.000000 SEC.
                     TAPE EPOCH = JUN. 21, 1975    20 HR.  0 MIN.  0.000000 SEC.
              INPUT SEARCH TIME = JUN. 21, 1975    20 HR.  0 MIN.  0.000000 SEC.
FIRST DESCENDING NODE AFTER SEARCH TIME = JUN. 21, 1975    21 HR. 21 MIN. 14.445623 SEC.

                    GEOCENTRIC TRUE OF DATE COORDINATES

                              *  *  *  *

                    TYPE OF ORBIT = ELLIPTICAL ORBIT

     X=  0.47346341741605520 04          Y=  0.55389144103214440 04          Z=  0.0
  XDOT=  0.87734314741553690 00       YDOT= -0.74715063000857320 00       ZDOT= -0.73096955162364870 01

 HT= 0.90658310D 03   LAT= 0.0             LON= 0.17971581D 03     V= 0.74000332D 01    GAM= 0.18980411D-01    AZ= 0.18896184D 03
SMA= 0.72944776D 04   ECC= 0.11134792D-02  AINC= 0.98961838D 02  LAN= 0.22947636D 03    APF= 0.16267294D 03   SML= 0.72944685D 04
RCA= 0.72863553D 04   APR= 0.73025998D 04   PER= 0.17222634D 01   TA= 0.17327060D 02     EA= 0.17308070D 02    MA= 0.17289089D 02
HCA= 0.90821532D 03   APH= 0.92445982D 03  HCAN= 0.49039704D 03 APHN= 0.49916837D 03
                  PREDICTED TIME OF PERICENTER PASSAGE BEFORE DESCENDING NODE = 21:JUN:75 21 16 0.16682D 02
                  PREDICTED TIME OF PERICENTER PASSAGE AFTER  DESCENDING NODE = 21:JUN:75 22 59 0.25496D 02

*  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *

                              MEAN  ELEMENTS

   SMA =  0.72855654D 04  KM        NODE     RATE =  0.97226876D 00 DEG/DAY      DLR    = -0.25816656D 02 DEG/REV
   ECC =  0.69341403D-03            PERIGEE  RATE = -0.27419981D 01 DEG/DAY      DLRDA  = -0.53407768D-02 DEG/REV/KM
   INC =  0.98967357D 02 DEG        ANOMALY  RATE =  0.50229435D 04 DEG/DAY      DLRDI  =  0.84035408D-02 DEG/REV/DEG
   LAN =  0.22947635D 03 DEG        MEAN   MOTION =  0.10152486D-02 RAD/SEC      DOMGDA = -0.33441413D-04 DEG/REV/KM
   AP  =  0.17052685D 03 DEG        OVERLAP       =  0.15059924D 02 PERCENT      DOMGDI =  0.77151987D-02 DEG/REV/DEG
    MA =  0.94352432D 01 DEG        RPTCYL ERROR  =  0.11592159D 01 N MILES      MEAN LOCAL TIME =  9 20 0.62408D 01
  APGH =  0.91249732D 03 KM         PRGH          =  0.90239346D 03 KM           NODAL PERIOD    =  0.10326279D 03 MIN
ERRLON = -0.40662372D 01 N MILES    ERRMLT        = -0.13295642D 04 SEC    ANOMALISTIC PERIOD    =  0.10314691D 03 MIN
```

Figure 2-4 Sample Program Output (3 of 3)

SECTION 3 - PROGRAM DESCRIPTION

The ERTS-B Stand-Alone Software Package consists of an executive routine, fifteen subroutines, one function subprogram, and one BLOCK DATA subprogram. The Executive, the BLOCK DATA, and subroutines DATOUT, YIELD, PACK, READER, SHIFT, and STORE were designed and programmed by the Computer Sciences Corporation (CSC); subroutines COMPUT, COMPOS, and OSCMN were extracted from the DEBTAP subroutines of the same names; and subroutines CALSEC, CONVRT, CROSSP, ERRLNG, LAGRIN, SUBCAP, UNITV, and function DOTPRD were taken from DEBTAP with no modifications. Only the CSC subroutines and the modified DEBTAP subroutines are documented herein. The unmodified DEBTAP subroutine descriptions may be obtained from the Goddard Space Flight Center, mail code 571.2.

3.1 SUBROUTINE DESCRIPTIONS

The subroutines that were designed and programmed or modified by CSC are described in the following pages.

Subroutine: Executive Routine

PURPOSE

To compute the averaged Brouwer mean elements at the first descending node.

METHOD

The main routine is divided into four parts. Each part has a specific function.

Part I:
- a) Reads in data from both card deck and ephemeris tape.
- b) Searches for descending node from epoch or tape start whichever occurs last.
- c) Uses Lagrangian interpolation to obtain nodal elements by assuming that the Z coordinate is the independent variable and setting Z equal, to zero.
- d) Obtains the closest point to the nodal point according to time. This then becomes the first point used for averaging. A number of subsequent points are then collected over a given interval.

Part II:
- a) Calls subroutine COMPUT to obtain Keplerian elements from Cartesian elements at the descending node.
- b) Calls subroutine OSCMN to obtain averaged Brouwer mean elements from those points collected previously.

Part III: Collects and outputs appropriate parameters on a single page

Part IV: Processes error conditions. Should any error occur an appropriate message is printed and the run terminated. Should no error occur the remainder of the ephemeris file is read and discarded and the control is then transferred to the beginning of the program to start another ephemeris file.

USAGE

1. Calling sequence:

   Not applicable

2. COMMON blocks used:

   $BLANKCOM, CBSTAT, CNVFCT, DUMP, ECONS, ELEM, INDATA, RAS

3. COMMON block parameters used:

FORTRAN Name	COMMON Name	I/O	Dimension	Description
KTR	CBSTAT	I/O	400	Subroutine/entry point counter
DEGPRD	CNVFCT	I	1	Degrees per radian
TWOPI	CONFCT	I	1	Pi times two
L	DUMP	O	1	Intermediate output control 30 = no intermediate output 6 = intermediate output
IRAD	ECONS	I	1	Radius of Earth in km
EMU	ECONS	I	1	Gravity constant of Earth in km^3/sec^2
X	ELEM	I/O	100	Position vector of a point in km
Y	ELEM	I/O	100	
Z	ELEM	I/O	100	
XDOT	ELEM	I/O	100	Velocity vector of a point in km/sec.
YDOT	ELEM	I/O	100	
ZDOT	ELEM	I/O	100	
TITLE	INDATA	O	10	Title record
DELMIN	INDATA	O	1	Tentative interval size between point in minutes
NCNT	INDATA	O	1	Number of points to be used for averaging
IEPYMD	INDATA	O	1	Optional epoch in YYMMDD and HHMMSS
IEPHMS	INDATA	O	1	
IWRITE	INDATA	O	1	Intermediate output indicator that defines L in common block DUMP IWRITE = 0, L = 30 no intermediate output IWRITE ≠ 0, L = 6 intermediate output

4. Subroutines and functions used:

   CALSEC/SECCAL, COMPOS, CROSSP, DATOUT, DOTPRD, ERRLNG, LAGRIN/INTRPX, OSCMN, PACK/UNPACK, READER, SHIFT, STORE, SUBCAP, UNITV

5. This routine is called by:

   Not applicable

6. Core locations required:

   11984 bytes

COMMENTS AND RESTRICTIONS

The output statements are partially taken from subroutine CLASEM of the DEBTAP program.

REFERENCES

Documentation and program listing of subroutine CLASEM of the DEBTAP program.

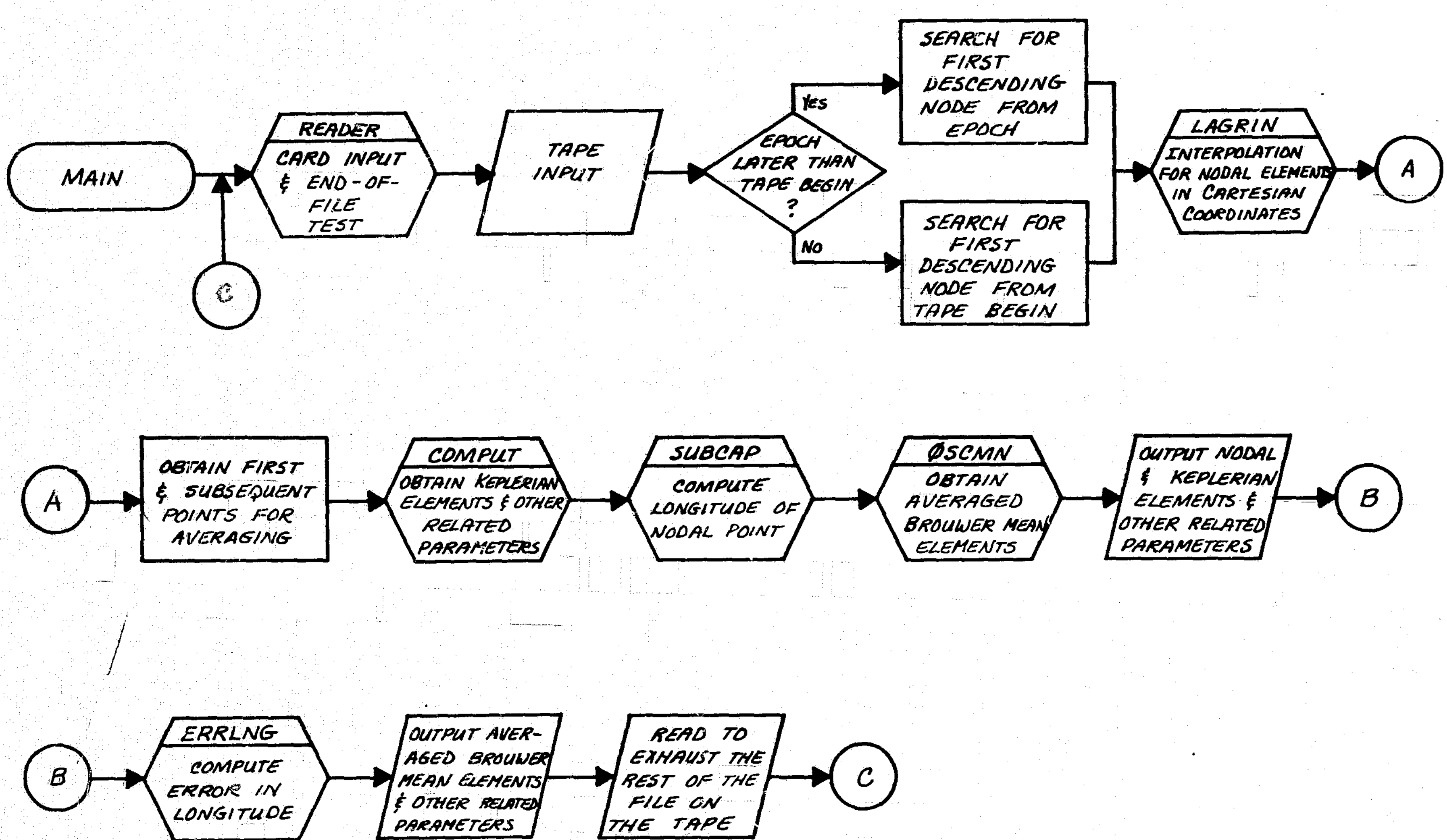

Figure 3-1. Executive Flow Diagram

Subroutine: Compute Keplerian Elements and Other Related Parameters (COMPOS)

PURPOSE

To compute Keplerian elements and other related parameters from Cartesian elements.

METHOD

The Keplerian elements and other related parameters are computed as follows:

1. Semimajor axis (SMA)

$$r_o = \sqrt{\vec{r}_o \cdot \vec{r}_o} \qquad \text{position}$$

$$v_o = \sqrt{\dot{\vec{r}}_o \cdot \dot{\vec{r}}_o} \qquad \text{velocity}$$

$$D_o = \frac{\vec{r}_o \cdot \dot{\vec{r}}_o}{\sqrt{U}} \qquad \text{parabolic anomaly}$$

$$\frac{v_o^2}{U} = \frac{\dot{\vec{r}}_o \cdot \dot{\vec{r}}_o}{U}$$

$$a = \frac{r_o}{2 - r_o\left(\frac{v_o^2}{U}\right)} = \text{SMA}$$

where U is the gravitational coefficient of the Earth.

2. Eccentricity (ESQRT)

$$e^2 = \left(1 - \frac{r_o}{a}\right)^2 + \frac{D_o^2}{a} = \text{ECC} = \text{ESQRT}^2$$

$$e = \text{ESQRT}$$

3. Semiparameter (SEMIP)

$$p = r_o \left(2 - \frac{r_o}{a}\right) - D_o^2 = a(1 - e^2) = \text{SEMIP}$$

4. Point of closest approach (RCA)

$$q = r_o - \frac{1}{2} D_o^2 = \frac{p}{1 + e} = \text{RCA}$$

$$\text{HCA} = q - \text{RADIUS}$$

$$\text{HCAN} = \frac{\text{HCA}}{1.852}$$

5. Apocenter radius (APR)

$$q_2 = a(1 + e) = \text{APR}$$

$$\text{APH} = q_2 - \text{RADIUS}$$

$$\text{APHN} = \frac{\text{APH}}{1.852}$$

6. True anomaly (TA)

$$\dot{r}_o = \frac{\vec{r}_o \cdot \dot{\vec{r}}_o}{r_o}$$

$$\sin f_o = \frac{\dot{r}_o}{e} \sqrt{\frac{p}{U}}$$

$$\cos f_o = \frac{1}{e}\left(\frac{p}{r_o} - 1\right) = \frac{p - r_o}{e\, r_o}$$

$$f_o = \tan^{-1} \frac{\sin f_o}{\cos f_o} = \text{TA}$$

7. Orthogonal vectors ($\vec{P}$ and $\vec{Q}$)

The $\vec{P}$ and $\vec{Q}$ vectors are formed from the orthogonal unit vectors $\vec{U}$ and $\vec{V}$ and the true anomaly by:

$$\vec{P} = \vec{U} \cos f_o - \vec{V} \sin f_o$$

$$\vec{Q} = \vec{U} \sin f_o + \vec{V} \cos f_o$$

where

$$\vec{U} = \frac{\vec{r}_o}{r_o} = \left(\frac{r_x}{r_o}\right)\vec{I} + \left(\frac{r_y}{r_o}\right)\vec{J} + \left(\frac{r_z}{r_o}\right)\vec{K} = U_x\vec{I} + U_y\vec{J} + U_z\vec{K}$$

and

$$\vec{V} = \frac{r\dot{\vec{r}} - \dot{r}\vec{r}}{\sqrt{pU}} = \left(\frac{r\dot{x} - \dot{r}x}{\sqrt{pU}}\right)\vec{I} + \left(\frac{r\dot{y} - \dot{r}y}{\sqrt{pU}}\right)\vec{J} + \left(\frac{r\dot{z} - \dot{r}z}{\sqrt{pU}}\right)\vec{K}$$

8. Inclination (AINC)

$$i = \tan^{-1} \frac{\sqrt{U_z^2 + V_z^2}}{\sqrt{(U_x + V_y)^2 + (U_y - V_x)^2} - 1} = \text{AINC}$$

9. Longitude of the ascending node (ELAN)

The true longitude is defined by:

$$\ell_o = \Omega + \omega + f_o = \Omega + u_o$$

where

Ω = longitude of the ascending node

ω = argument of perigee

u_o = argument of latitude

f_o = true anomaly (computed in step 6 as TA)

True longitude is computed in terms of the orthogonal vectors $\vec{U}$ and $\vec{V}$ as:

$$\ell_o = \tan^{-1}\left(\frac{U_y - V_x}{U_x + V_y}\right)$$

The argument of latitude is:

$$u_o = \omega + f_o = \tan^{-1}\left(\frac{U_z}{V_z}\right)$$

thus yielding

$$\Omega = \ell_o - u_o = \text{ELAN}$$

10. Argument of perigee (APF)

$$\omega = u_o - f_o = \text{APF}$$

11. Flight path angle (GAM)

$$Y = \tan^{-1}\left(\frac{\sin Y}{\cos Y}\right) = \tan^{-1}\left(\frac{e \sin f_o}{1 + e \cos f_o}\right) = \text{GAM}$$

12. Azimuth (AZ)

$$A = \tan^{-1}\left[\frac{r_o\,(x\dot{y} - \dot{x}y)}{y\,(\dot{z}y - z\dot{y}) - x\,(\dot{x}z - x\dot{z})}\right] = \tan^{-1}\left[\frac{r_o\,(r\,W_z)}{y\,(r\,W_x) - x\,(r\,W_y)}\right]$$

where W_x, W_y, and W_z are the components of $\vec{W}$, the cross product of $\vec{r}_o$ and $\dot{\vec{r}}_o$.

The quadrant of the azimuth is checked by the library function DATAN2 as follows:

II $\left(\frac{+}{-}\right)$	I $\left(\frac{+}{+}\right)$
III $\left(\frac{-}{-}\right)$	IV $\left(\frac{-}{+}\right)$

13. Period (PER)

$$P = \frac{\sqrt{(2\pi/U)^2\,a^3}}{3600} = \text{PER}$$

USAGE

1. Calling sequence:

   CALL COMPOS (RVEC, VVEC, ELM)

FORTRAN Name	I/O	Dimension	Description
RVEC	I	3	Position vector
VVEC	I	3	Velocity vector
ELM	O	6	Keplerian elements

2. COMMON blocks used:

   CBSTAT, CNVFCT, DUMP, ICONS

3. COMMON block parameters used:

FORTRAN Name	COMMON Name	I/O	Dimension	Description
KTR	CBSTAT	I/O	400	Subroutine/entry point counter
DEGPRD	CNVFCT	I	1	Degrees per radian
TWOPI	CNVFCT	I	1	Pi times two
L	DUMP	I	1	Intermediate output control 30 = no intermediate output 6 = intermediate output
ERAD	ECON	I	1	Radius of Earth in km
IMU	ECON	I	1	Gravity constant of Earth in km^3/sec^2

4. Subroutine and functions used:

   CROSSP, DOTPRD, UNITV

5. This routine is called by:

   OSCMN

6. Core locations required:

   3098 bytes

COMMENTS AND RESTRICTIONS

The computation statements are taken from subroutine CLASEM of the DEBTAP program.

REFERENCES

Documentation and program listing of subroutine CLASEM of the DEBTAP program.

Subroutine: Compute Keplerian elements (COMPUT)

PURPOSE

To compute Keplerian elements from Cartesian elements.

METHOD

The Keplerian elements are computed as follows:

1. Semimajor axis (ELM(1))

$$a = \frac{R}{2 - (RV^2/U)}$$

2. Eccentricity (ELM(2))

$$e = \left(f_1^2 + f_2^2\right)^{1/2}$$

3. Inclination (ELM(3))

$$i = \tan^{-1} \frac{\left(D_x^2 + D_y^2\right)^{1/2}}{D_z}$$

4. Longitude of the ascending node (ELM(4))

$$\Omega = \tan^{-1} \left(\frac{D_x}{-D_y}\right)$$

5. Argument of perigee (ELM(5))

$$\omega = \tan^{-1}\left(\frac{R_z D}{R_y D_x - R_x D_y}\right) - \tan^{-1}\left(\frac{(1 - e^2)^{1/2} f_1}{f_2 - e^2}\right)$$

6. Mean anomaly

$$\text{MEAN ANOMALY} = \tan^{-1}\left(\frac{f_1}{f_2}\right) - f_1$$

where

$$R = \left(R_x^2 + R_y^2 + R_z^2\right)^{1/2}$$

$$V = \left(V_x^2 + V_y^2 + V_z^2\right)^{1/2}$$

$$D_x = R_y V_z - R_z V_y$$

$$D_y = R_z V_x - R_x V_z$$

$$D_z = R_x V_y - R_y V_x$$

$$D = \left(D_x^2 + D_y^2 + D_z^2\right)^{1/2}$$

$$f_1 = \frac{R_x V_x + R_y V_y + R_z V_z}{\sqrt{U a}}$$

$$f_2 = 1 - \frac{R}{a}$$

where (R_x, R_y, R_z) and (V_x, V_y, V_z) are position and velocity vectors in Cartesian coordinates. The quantity U is the gravity constant of the Earth.

USAGE

1. Calling sequence:

CALL COMPUT (RVEC, VVEC, ELM)

FORTRAN Name	I/O	Dimension	Description
RVEC	I	3	Position vector
VVEC	I	3	Velocity vector
ELM	O	6	Keplerian elements

2. COMMON blocks used:

CBSTAT, CNVFCT, ECONS

3. COMMON block parameters used.

FORTRAN Name	COMMON Name	I/O	Dimension	Description
KTR	CBSTAT	I/O	400	Subroutine/entry point counter
DEGPRD	CNVFCT	I	1	Degrees per radian
TWOPI	CNVFCT	I	1	Pi times two
EMU	ECONS	I	1	Gravity constant of Earth in km^3/sec^2

4. Subroutines and functions used:

None

5. This routine is called by:

Main routine

6. Core locations required:

1600 bytes

COMMENTS AND RESTRICTIONS

The computation statements are taken from subroutine OSCMN of the DEBTAP program.

REFERENCES

Documentation and program listing of subroutine OSCMN of the DEBTAP program.

Subroutine: Convert year, month, day, hour, and minute from floating point variables to integer variables (DATOUT)

PURPOSE

To convert year, month, day, hour, and minute to integer. Seconds remain in floating point for output purpose.

METHOD

Truncate floating point variables after calling subroutine SECCAL.

USAGE

1. Calling sequence:

   CALL DATOUT (REFDMY, SECIN, IDAY, IMONTH, IYEAR, IHRMIN, SECOUT)

FORTRAN Name	I/O	Dimension	Description
REFDMY	I	1	Date in DDMMYY.0
SECIN	I	1	Seconds from the date
IDAY	O	1	Day
IMONTH	O	1	Month
IYEAR	O	1	Year
IHRMIN	O	2	1 = hour, 2 = minute
SECOUT	O	1	Second

2. COMMON blocks used:

   CBSTAT

3. COMMON block parameters used:

FORTRAN Name	COMMON Name	I/O	Dimension	Description
KTR	CBSTAT	I/O	400	Subroutine/entry point counter

4. Subroutines and functions used:

   Entry point CALSEC in SECCAL

5. This routine is called by:

   Main routine

6. Core locations required:

   682 bytes

COMMENTS AND RESTRICTIONS

None

REFERENCES

Documentation of subroutine/SECCAL of the DEBTAP program.

Subroutine: Compute osculating elements and mean elements (OSCMN)

PURPOSE

To compute osculating elements at ascending or descending node, mean elements and other related parameters.

METHOD

The Brouwer mean elements required for the averaging are computed from Keplerian elements at each collected point by calling subroutine CONVRT. Subroutine COMPOS computes the Keplerian elements for each point used for averaging. The averaging applies to the first three of the six Brouwer mean elements, namely, semi-major axis, eccentricity, and inclination. The averaging operation is given by

$$\overline{a} = \sum_{i=1}^{n} a_i / n$$

where n is the number of points used for averaging and a and a refers to either semi-major axis, eccentricity, or inclination.

USAGE

1. Calling sequence:

   CALL OSCMN (ELE, TIME, RLON, NCNT, SECTOR)

FORTRAN Name	I/O	Dimension	Description
ELE	I	6	Keplerian elements at descending node
TIME	I	1	Time of descending node
RLON	I	1	Longitude at descending node
NCNT	I	1	Number of points used for averaging
SECTOR	I	1	Time interval in seconds between two points

2. COMMON blocks used:

   CBMNVR, CBSTAT, CNVFCT, DUMP, ECONS, ELEM, MORCON, RAS

3. COMMON block parameters used:

FORTRAN Name	COMMON Name	I/O	Dimension	Description
REPTIM	CBMNVR	I	1	Repeat cycle length in days
NREVDY	CBMNVR	I	1	Revolutions per day
NUMREV	CBMNVR	I	1	Number of revolutions per repeat cycle
KTR	CBSTAT	I/O	400	Subroutine/entry point counter
DEGPRD	CNVFCT	I	1	Degrees per radian
TWOPI	CNVFCT	I	1	Pi times two
L	DUMP	O	1	Intermediate output control 30 = no intermediate output 6 = intermediate output
ERAD	ECONS	I	1	Radius of Earth in km
EMU	ECONS	I	1	Gravity constant of Earth in km^3/sec^2
X	ELEM	I	100	Position vector of a point in km
Y	ELEM	I	100	
Z	ELEM	I	100	
XDOT	ELEM	I	100	Velocity vector of a point in km/sec
YDOT	ELEM	I	100	
ZDOT	ELEM	I	100	
WE	MORCON	I	1	Rotational velocity of the Earth in rad/sec
SPD	MORCON	I	1	Seconds per day
RMN	RAS	I/O	6	Mean elements
DOT	RAS	O	3	Secular terms
PART	RAS	O	3	Partial derivatives of secular terms
OVERLP	RAS	O	1	Overlap error
RPTCYL	RAS	O	1	Repeat cycle error
TIMMLT	RAS	O	1	Mean local time

4. Subroutines and functions used:

   COMPOS, CONVRT

5. This routine is called by:

   Main routine

6. Core locations required:

   1758 bytes

COMMENTS AND RESTRICTIONS

None

REFERENCES

Documentation and program listing of subroutine OSCMN of the DEBTAP program.

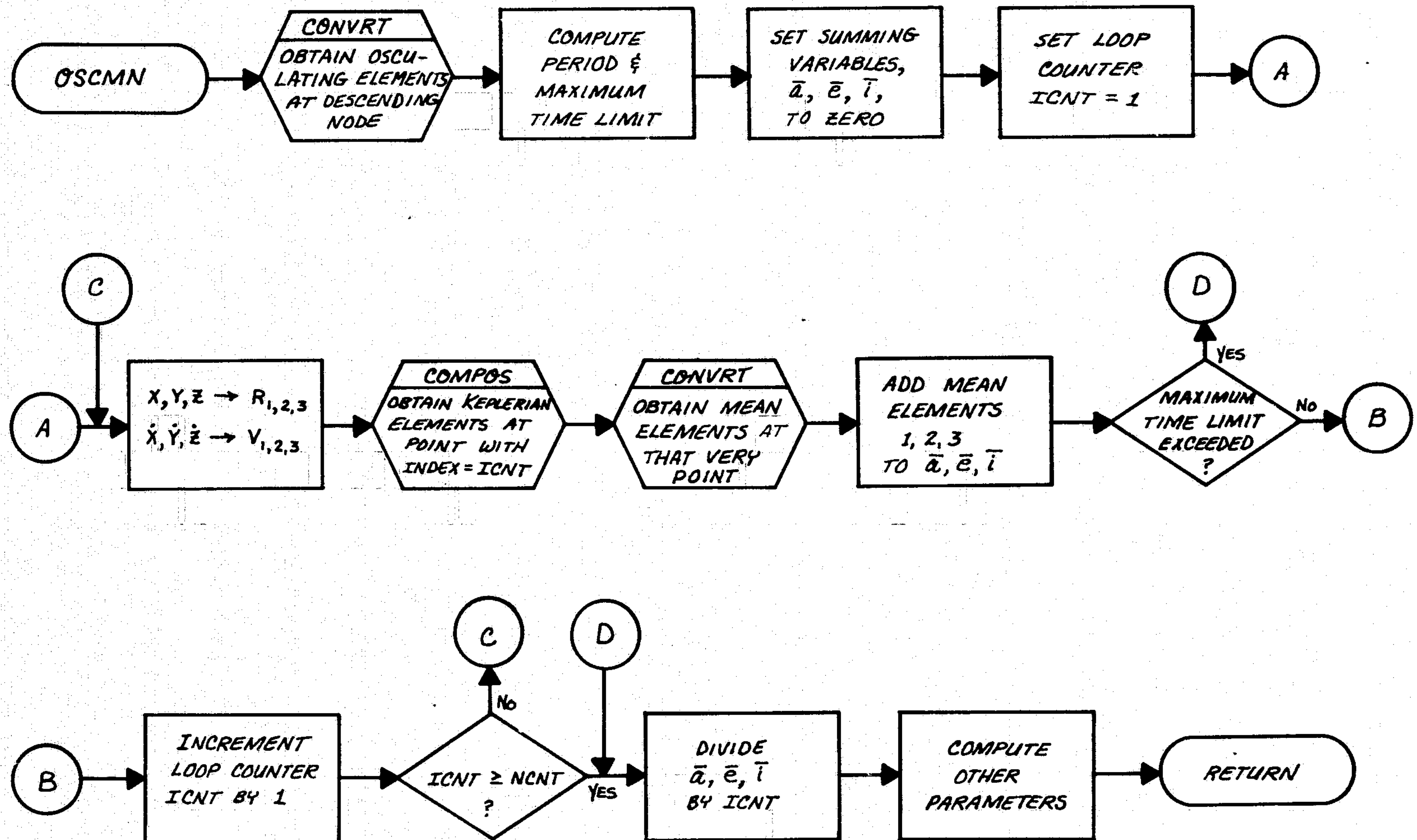

Figure 3-2. Subroutine OSCMN Flow Diagram

Subroutine: Pack or unpack a numerical code (PACK)

PURPOSE

1. PACK

   To pack an array of a given base into a single code of base 10.

2. UNPACK (entry point)

   To unpack a single code of base 10 into an array of a given base.

METHOD

Packing and unpacking is done according to:

$$C = A_1 + A_2 b + A_3 b^2 + \ldots\ldots + A_n b^{n-1}$$

where

C = single code

A = array

b = given base

n = numbers in an array

USAGE

1. Calling sequence for PACK/UNPACK:

```
CALL PACK (IARRAY, NARRAY, IBASE, ICODE)
CALL UNPACK (ICODE, IBASE, NARRAY, IARRAY)
```

FORTRAN Name	I/O PACK	UNPACK	Dimension	Description
IARRAY	I	O	Variable	Array
NARRAY	I	I	1	Numbers in an array
IBASE	I	I	1	Given base
ICODE	O	I	1	Code

2. COMMON blocks used:

   CBSTAT

3. COMMON block parameters used:

FORTRAN Name	COMMON Name	I/O	Dimension	Description
KTR	CBSTAT	I/O	400	Subroutine/entry point counter

4. Subroutines and functions used:

   None

5. This routine is called by:

   Main routine, YIELD

6. Core locations required:

   650 bytes

COMMENTS AND RESTRICTIONS

This routine is used to pack and unpack YYMMDD or HHMMSS into components and vice versa. Therefore, the given base is 100 and the number in an array is 3.

REFERENCES

None

Subroutine: Read data from cards (READER)

PURPOSE

To read data from cards and perform end-of-file test.

METHOD

1. Title is read in format 10A8.
2. Mandatory constants are read in namelist INCARD.
3. Optional constants are read in formats 8G10 and 3G25.16.

USAGE

1. Calling sequence:

   CALL READER

2. COMMON blocks used:

   CBMNVR, CBSTAT, DUMP, ECONS, INDATA, MORCON

3. COMMON block parameters used:

FORTRAN Name	COMMON Name	I/O	Dimension	Description
REPTIM	CBMNVR	I	1	Repeat cycle length in days
NREVDY	CBMNVR	I	1	Revolutions per day
NUMREV	CBMNVR	I	1	Number of revolutions per repeat cycle
KTR	CBSTAT	I/O	400	Subroutine/entry point counter
L	DUMP	O	1	Intermediate output control 30 = no intermediate output 6 = intermediate output
ERAD	ECONS	O	1	Radius of Earth in km
EMU	ECONS	O	1	Gravity constant of Earth in km^3/sec^2
TITLE	INDATA	O	10	Title record

FORTRAN Name	COMMON Name	I/O	Dimension	Description
DELMIN	INDATA	O	1	Tentative interval size between points in minutes
NCNT	INDATA	O	1	Number of points to be used for averaging
IEPYMD	INDATA	O	1	Optional epoch in YYMMDD and
IEPHMS	INDATA	O	1	HHMMSS
IWRITE	INDATA	O	1	Intermediate output indicator that defines L in common block DUMP IWRITE = 0, L = 30 No intermediate output IWRITE ≠ 0, L = 6 Intermediate output

4. Subroutines and functions used:

   None

5. This routine is called by:

   Main routine

6. Core locations required:

   938 bytes

COMMENTS AND RESTRICTIONS

None

REFERENCES

None

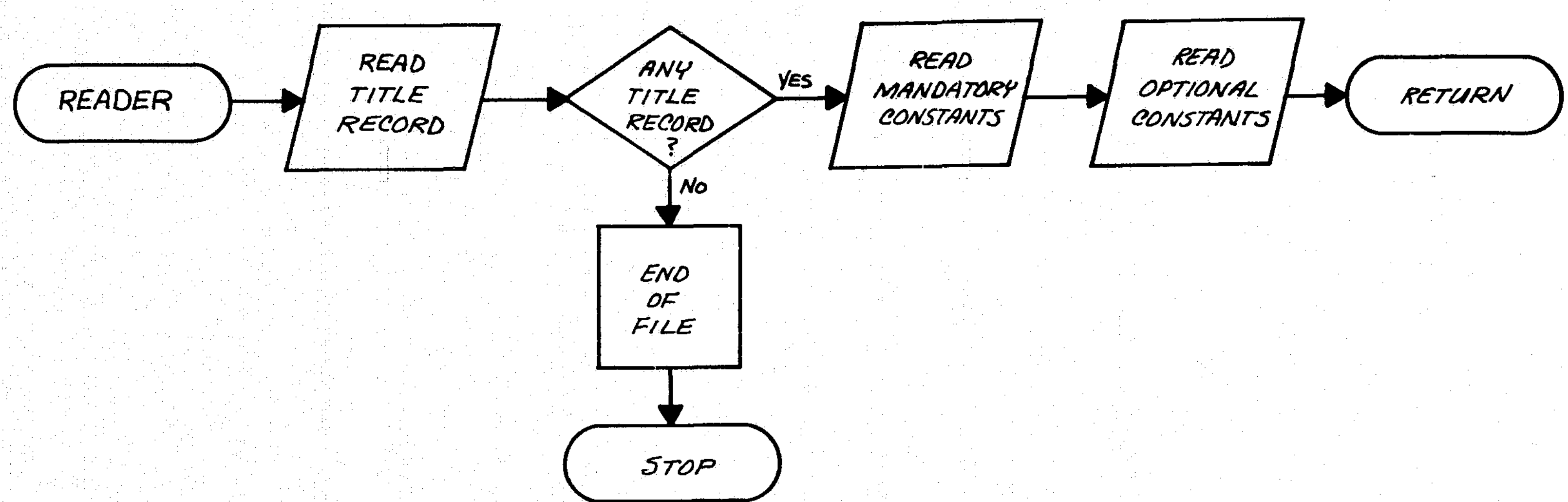

Figure 3-3. Subroutine READER Flow Diagram

Subroutine: Shift an array (SHIFT)

PURPOSE

To shift an array left by 300 positions and fill the rightmost 300 positions with another array.

METHOD

Use a DO-LOOP from 1 to 300 to address each element in the array.

USAGE

1. Calling sequence:

   CALL SHIFT

2. COMMON blocks used:

   CBSTAT, $BLANKCOM

3. COMMON block parameters used:

FORTRAN Name	COMMON Name	I/O	Dimension	Description
KTR	CBSTAT	I/O	400	Subroutine/entry point counter
TEMP	$BLANKCOM	I/O	900	Temporary array
TAPE	$BLANKCOM	I/O	350	Ephemeris tape elements

4. This routine is called by:

   Main routine

5. Subroutines and functions used:

   None

6. Core locations required:

   316 bytes

COMMENTS AND RESTRICTIONS

None

REFERENCES

None

Subroutine: Store vector elements (STORE)

PURPOSE

To store position and velocity vectors from temporary arrays and convert their units from DUL and DUL/DUT to km and km/sec.

METHOD

Temporary array elements are stored into x, y, z, $\dot{x}$, $\dot{y}$, and $\dot{z}$ by increasing index of the array by 1.

The conversion factors are:

1 DUL = 10000 km

1 DUT = 864 sec

1 DUL/DUT = 1/0.0864 km/sec

USAGE

1. Calling sequence:

CALL STORE (IPTBG, IPTND, TPT, TIME, IND, NSTEP6)

FORTRAN Name	I/O	Dimension	Description
IPTBG	I	1	First point to be stored
IPTND	I	1	Last point to be stored
TPT	I/O	1	Corresponding time
TIME	I	1	Time interval between points
IND	I/O	1	Index to point a temporary array element
NSTEP6	I	1	Increment between points taken, times six

2. COMMON blocks used:

CBSTAT, ELEM, $BLANKCOM

3. COMMON block parameters used:

FORTRAN Name	COMMON Name	I/O	Dimension	Description
KTR	CBSTAT	I/O	400	Subroutine/entry point counter
X	ELEM	O	100	Position vector of a point in km
Y	ELEM	O	100	
Z	ELEM	O	100	
XDOT	ELEM	O	100	Velocity vector of a point in km/sec
YDOT	ELEM	O	100	
ZDOT	ELEM	O	100	
TEMP	$BLANKCOM	I	300	Temporary array

4. This routine is called by:

   Main routine

5. Subroutines and functions used:

   None

6. Core locations required:

   596 bytes

COMMENTS AND RESTRICTIONS

None

REFERENCES

None

Subroutine: Unpack time codes (YIELD)

PURPOSE

To convert YYMMDD and fraction of a day in seconds into year, month, day, hour, minutes, and seconds.

METHOD

1. Unpack YYMMDD into year, month, and day.
2. Convert seconds into hour, minutes, and seconds.

USAGE

1. Calling sequence:

   CALL YIELD (IND, SECTOR, IEPHY, MEPHM, IEPHD, IEPHH, IEPHM, DEPHS)

FORTRAN Name	I/O	Dimension	Description
IND	I	1	Date in YYMMDD
SECTOR	I	1	Fraction of a day in seconds
IEPHY	O	1	Year in 1900's
MEPHY	O	1	Month in numbers
IEPHD	O	1	Day in numbers
IEPHH	O	1	Hour
IEPHM	O	1	Minute
DEPHS	O	1	Second

2. COMMON blocks used:

   None

3. COMMON block parameters used:

   None

4. Subroutines and functions used:

   PACK/UNPACK

5. This routine is called by:

    Main routine

6. Core locations required:

    596 bytes

COMMENTS AND RESTRICTIONS

None

REFERENCES

None

3.2 COMMON BLOCK DESCRIPTIONS

The ERTS-B Stand-Alone Software Package uses nine COMMON blocks whose names, along with the names of routines that use these COMMON blocks, are:

CBMNVR

ERRLNG, OSCMN, READER

CBSTAT

Main Routine, CALSEC/SECCAL, COMPOS, COMPUT, CONVRT, CROSSP, DATOUT, DOTPRD, ERRLNG, LAGRIN/INTRPX, OSCMN, PACK/UNPACK, READER, SHIFT, STORE, SUBCAP, UNITV

CNVFCT

Main Routine, CALSEC/SECCAL, COMPOS, COMPUT, CONURT, OSCMN, SUBCAP

DUMP

Main Routine, Block Data, COMPOS, OSCMN, READER

ECONS

Main Routine, Block Data, COMPOS, COMPUT, CONVRT, OSCMN, READER, SUBCAP

ELEM

Main Routine, OSCMN, STORE

INDATA

Main Routine, READER

MORCON

Main Routine, Block Data, CONVRT, OSCMN, READER

RAS

Main Routine, CONVRT, OSCMN

Since COMMON blocks CBMNVR, CBSTAT, CNVFCT, ECONS, and RAS are taken directly from the DEBTAP program, they contain some dummy variables. The following variables describe the individual COMMON blocks:

1. COMMON/CBMNVR/REAL8(   ), INT4(13)

Variable Name	Dimension	Location (Real *8)	Description
BASLON	1	1	Base longitude in degrees
BASMLT	3	2	Base mean local time in hours, minutes, and seconds
DUM1	19	5	Dummy variables
REPTIM	1	24	Repeat cycle length in days
DUM2	31	25	Dummy variables

Variable Name	Dimension	Location (Integer *4)	Description
IDLE1	7	1	Dummy variables
NREVDY	1	8	Revolutions per day
IDLE2	4	9	Dummy variables
NUMREV	1	13	Number of revolutions per repeat cycle

2. COMMON/CBSTAT/INT4(400)

Variable Name	Dimension	Location (Integer *4)	Description
KTR	400	1	Subroutine/entry point counter 18 = CONVRT 100 = COMPUT 151 = OSCMN 200 = DATOUT 203 = CALSEC 208 = CROSSP 214 = DOTPRD 233 = LAGRIN 280 = SUBCAP 287 = UNITV 305 = SECCAL 307 = INTRPX 350 = READER 351 = SHIFT 352 = STORE 375 = COMPOS 398 = PACK 399 = UNPACK 400 = ERRLNG

3. COMMON/CNVFCT/REAL8(20)

Variable Name	Dimension	Location (Real *8)	Description
DEGPRD	1	1	Degrees per radian
DUM1	15	2	Dummy variables
PI	1	17	Pi
TWOPI	1	18	Pi times two
DUM2	2	19	Dummy variables

Data Values for COMMON/CNVFCT/

```
DATA PI      /3.141592653589793/D   00/
    ,TWOPI   /6.2831853071795863D   00/
    ,DEGPRD  /5.72957795130823  D + 01/
```

4. COMMON/DUMP/INT4(1)

Variable Name	Dimension	Location (Integer *4)	Description
L	1	1	Optional intermediate output indicator, defined by IWRITE 1) IWRITE = 0, L = 30 No intermediate output 2) IWRITE ≠ 0, L = 6 Intermediate output

5. COMMON/ECONS/REAL8(683)

Variable Name	Dimension	Location (Real *8)	Description
EMU	1	1	Gravity constant of Earth in km^3/sec^2
ERAD	1	2	Radius of Earth in km
DUM1	2	3	Dummy variables
ESQ	1	5	Square of the eccentricity of the oblate Earth
DUM2	676	6	Dummy variables
DERAD	1	682	Dynamic radius of Earth in km
PORAD	1	683	Polar radius of Earth in km

Data Values for COMMON/CNVFCT/

```
DATA   EMU    /3.986012        D + 05/
      ,ERAD   /6.378165        D + 03/
      ,DERAD  /6.378155        D + 03/
      ,PORAD  /6.378784        D + 03/
      ,ESQ    /6.693421622966D - 03/
```

6. COMMON/ELEM/REAL8(600)

Variable Name	Dimension	Location (Real *8)	Description
X	100	1	Position vector of a point in km
Y	100	101	
Z	100	201	
XDOT	100	301	Velocity vector of a point in km/sec
YDOT	100	401	
ZDOT	100	501	

7. COMMON/INDATA/REAL8(11), INT4(4)

Variable Name	Dimension	Location (Real *8)	Description
TITLE	10	1	Title of ERTS-B in format 10A8
DELMIN	1	11	Tentative step size in minutes

Variable Name	Dimension	Location (Integer *4)	Description
NCNT	1	1	Number of points to be used for averaging
IEPYMD	1	2	Optional epoch in YYMMDD and HHMMSS
IEPHMS	1	3	
IWRITE	1	4	Intermediate output selector 1) IWRITE = 0, L = 30 No intermediate output 2) IWRITE ≠ 0, L = 6 Intermediate output

8. COMMON/MORCON/REAL8(5)

Variable Name	Dimension	Location (Real *8)	Description
CJ2	1	1	2nd harmonic constant

Variable Name	Dimension	Location (Real *8)	Description
CJ4	1	2	4th harmonic constant
SPD	1	3	Seconds per day
WE	1	4	Earth's rotational velocity in rad/sec
ECCMIN	1	5	Minimum eccentricity acceptable for subroutine CONVRT

Data Values for COMMON/MORCON/

```
DATA      CJ2/+1.0823          D-03/
         ,CJ4/-1.8000          D-06/
         ,   WE/7.292115146    D-05/
         ,  SPD/8.64           D+04/
         ,ECCMIN/5.0           D-04/
```

9. COMMON/RAS/REAL8(31)

Variable Name	Dimension	Location (Real *8)	Description
OSC	6	1	Osculating elements
RMN	6	7	Mean elements
DOT	3	10	Secular terms
PART	6	16	Partial derivatives of secular terms
DRL DRLA DRLI	1 1 1	22 23 24	Latus Rectum and its derivatives in deg/rev, deg/rev-km, and deg/rev-deg
OMGDT DOMGDA DOMGDI	1 1 1	25 26 27	Omega term and its derivatives in deg/rev, deg/rev-km, and deg/rev-deg
OVERLP	1	28	Overlap in vertical projection by percentage
RPTCYL	1	29	Repeat cycle error in nautical miles
TIMMLT	1	30	Mean local time
RNO	1	31	Mean motion in rad/sec

VII. OUTPUT

Output is on a single page as shown in Figure 8.

The following variables are nodal parameters:

X Y Z	Position vector
XDOT YDOT ZDON	Velocity vector
HT	Height above surface
LAT	Latitude in degrees
LON	Longitude in degrees
V	Magnitude of velocity
GAM	Flight path angle
AZ	Azimuth
SMA	Semi-major axis
ECC	Eccentricity
AINC	Inclination
LAN	Longitude of descending node in degrees
APF	Argument of perigee
SML	Semi-latus rectum
RCA	Point of closest approach
APR	Apocenter radius
PER	Period
TA	True anomaly
EA	Eccentric anomaly
MA	Mean anomaly
HCA	Height of closest approach (= APR - radius of Earth)
HCAN	HCA/1.852 in nautical miles

APHN	APH/1.852 in nautical miles

The following variables are mean elements:

SMA		semi-major axis
ECC	Averaged	eccentricity
INC		inclination

LAN	Longitude
APF	Perigee
MA	Mean anomaly
DLR	Semi-latus rectum
DLRDA	Derivative of semi-latus rectum with respect to semi-major axis
DLRDI	Derivative of semi-latus rectum with respect to inclination
DOMGDA	Derivative of omega with respect to semi-major axis
DOMGDI	Derivative of omega with respect to inclination
RPTCYL	Repeat cycle
APGH	Apocenter radius
PRGH	Pericenter radius
ERRLON	Error in longitude
ERRMLT	Error in mean local time