ORBITAL RADIATION FLUX PROGRAM

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Technical Report Abstract

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Abstract - Briefly summarize objectives, methods, results, & applications - Type single spaced.

The objective of this work was to develop the capability to predict the level of exposure to radiation for spacecraft in any orbit. The intended application was primarily for orbit selection. The objective was achieved through modifications to the Short Orbital Flux Integration Program (SOFIP) by Stassinopoulos.

This report constitutes a user's guide to the modified program SOFIP2. It describes the modifications, comprising the addition of orbit propagation and geomagnetic field calculations, the restructuring of the data handling, and the creation of a user interface subroutine. Input and output data are described together with a test case based on RADARSAT. A program listing is appended.

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1.0 INTRODUCTION

This work aims to provide a quick guide for utilization of the modified version of the SOFIP program, which now includes all the orbit propagation and the local Earth magnetic field calculation.

The SOFIP program, developed by Stassinpoulos and others [1], comprises several basic computations related to space radiation caused by trapped protons and electrons in the geomagnetic field. These particles mainly originate from the solar corona - the interstellar mean provides only a few fractions of the total number of particles - with substantial increases of the radiation flux during the solar storms, and consequently during the periods of high solar activity [2].

Radiation flux is defined as the number of particles of each type (protons, electrons, alpha particles, etc.), with a specific energy range, that traverse a unit area per unit time.

The radiation is time and position dependent, starting at low altitudes and extending to the high magnetosphere (70,000. km). The trapped particles travel from one pole to another, describing a spiral trajectory along the field lines. Due to the geomagnetic lines concentrating at the poles, the spiral radius and pitch angle (between the velocity and the magnetic field vectors) decrease until the particle ceases its longitudinal movement with a pitch angle of 90 degrees. It then starts to accelerate in the opposite direction, circulating over the field to the other pole.

The trapped particle phenomena is represented in terms of two variables: the magnetic field intensity B and the magnetic shell parameter L. The latter is a function of the field B, the Earth dipole moment M and the integral invariant I (approximately equal to the length of the field line between the two points where the particle reverses its longitudinal motion). Figure 1, extracted from ref. #2, shows the lines of constant L as a function of the geocentric distance R and the latitude λ, for a simplified Earth magnetic dipole representation.

The trapped protons concentrate near the Earth, with the highest intensity flux about 3,000 km and decreasing with altitude, whereas it disappears almost entirely at the geosynchronous altitude. The electrons peak with the same intensity inside two regions: at 2,500 km in the inner zone (where $1.2 < L < 2.8$) and at 29,000 km in the outer zone (where $3 < L < 11$). As the solar wind passes over the Earth it carries the geomagnetic lines, folds the field, and gives an asymmetric shape to the radiation belt. This is illustrated in Figure 2, taken from ref. #2.

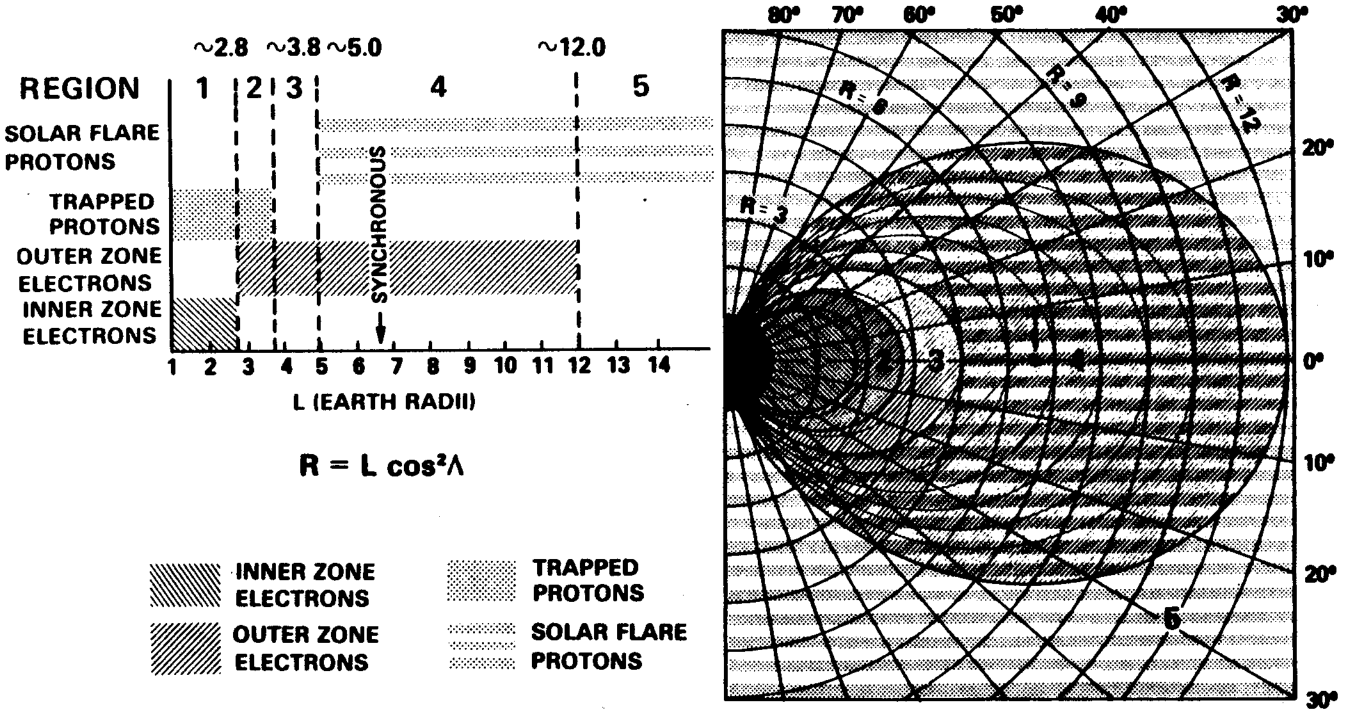
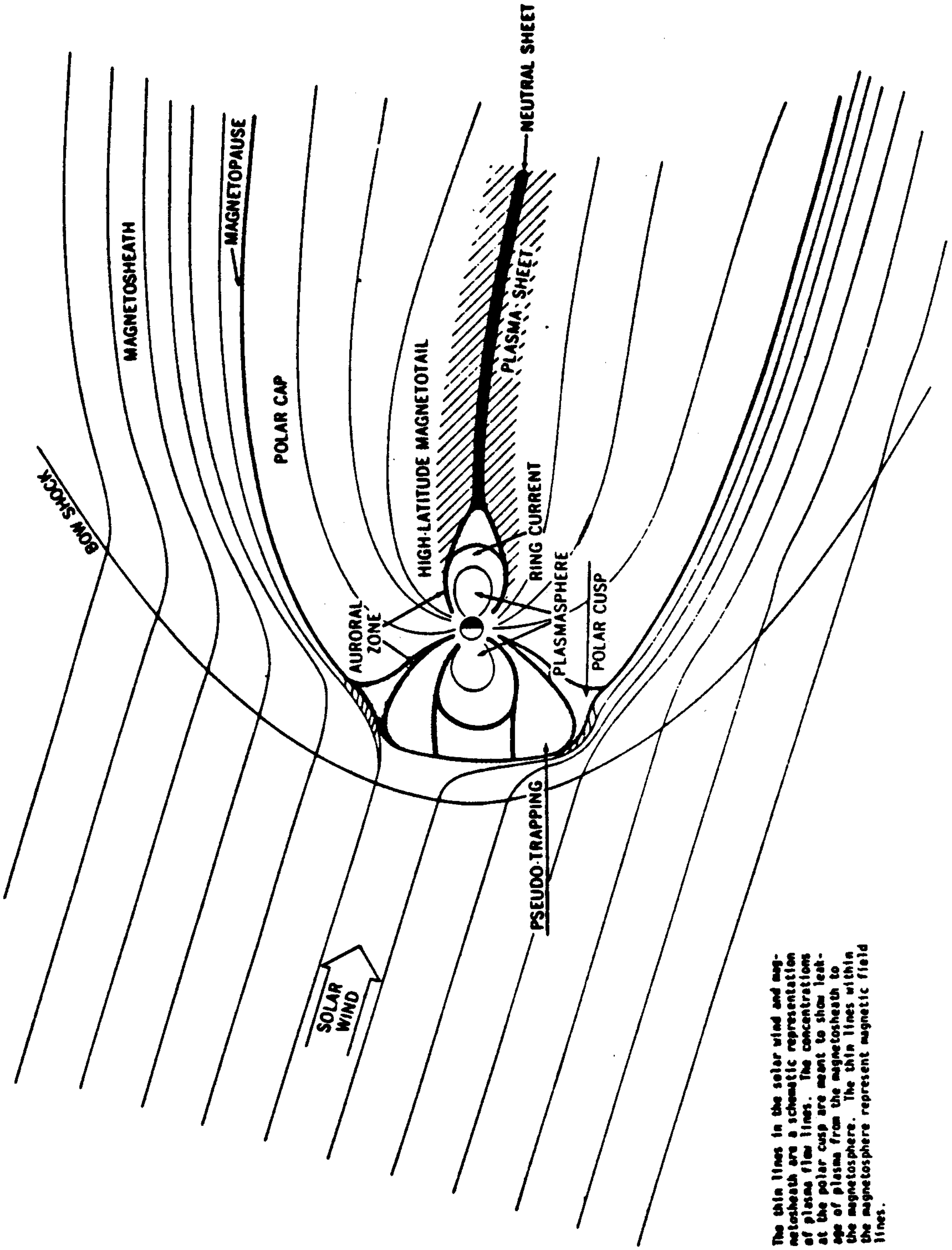


Fig. 1. Charged particle distribution in the magnetosphere. (Source: ref. #2)



The thin lines in the solar wind and magnetosheath are a schematic representation of plasma flow lines. The concentrations at the polar cusp are meant to show leakage of plasma from the magnetosheath to the magnetosphere. The thin lines within the magnetosphere represent magnetic field lines.

Fig. 2. Regions of the magnetosphere shown in the noon-midnight meridian plane. (Source: ref. #2)

Among the main applications of the radiation flux results are solar array design and specification, as well as degradation and lifetime estimation for the arrays.

The SOFIP program outputs the local radiation flux as well as the accumulated flux along the orbit. As the radiation depends on the field intensity and the spacecraft position at a given instant, these values must be provided to the program by an input file, created by another program, MAGMAIN. The input for MAGMAIN comprises the geocentric coordinates of the satellite (time, latitude, longitude and altitude), which is stored in a data file created by a third program, an orbit propagator. Then, to have a single table of results, the users need to run 3 different programs, with increasing loss of precision caused by the truncated storage values in the intermediate files.

The SOFIP2 is an improved version of the SOFIP program, which includes all the geomagnetic and orbit calculations. The radiation environment [1,2] and geomagnetic models were stored in data files, in substitution of the large memory consuming data statements.

Section 2 presents the new set of input parameters of the SOFIP2 program. The next section describes the SOFIP2 structure and the routines specially developed for interfacing the solar flux program with the orbit generator and the geomagnetic field routines. The program SORUN was developed to assist the user to create the input file for the SOFIP2 program. This is described in Section 4. Section 5 presents some conclusions of the work.

2.0 THE SOFIP2 PROGRAM

The main changes introduced to the SOFIP program are related to the input parameters. The output remains the same, as indicated in references #1 and #3. The syntax call for SOFIP2 is:

```
SOFIP2, <INPUTFILE>, <OUTPUTFILE1>, <OUTPUTFILE2>,
<+>
```

The input and output files names are necessary. If omitted, the program initializes the files to the screen.

INPUTFILE:

This file has all the input parameters for a complete execution of SOFIP2. The sequence of the variables is (in free format):

```
<BOF>
NAME ............................. 12 Characters
MODEL IPE IMM IOZ ................ Integers
YER AMO DAY HOU DTI TFI .......... 3 Integers, 3 Reals
EL1 EL2 EL3 EL4 EL5 EL6 .......... Reals
NRGYLV ITAPE NTABLS KPRINT ....... Integers
<EOF>
```

Variable description:

NAME	Satellite name identification (not used in calculations).
MODEL	Magnetic field selector (1-7). See ref. #4 and #5.
IPE	Proton (0) or electron (1) environment selector.
IMM	Solar minimum (0) or maximum (1) model.
IOZ	Electron low (0) or high (1) outer zone model.
YER	Initial year of propagation.
AMO	Month.
DAY	Day.
HOU	Hour (and decimal hours) of the day.
DTI	Time step size for propagation in hours (and decimals).
TFI	Total time of propagation in hours (and decimals).

EL1	Orbit perigee altitude in km.
EL2	Orbit apogee altitude in km.
EL3	Orbit inclination in degrees.
EL4	Right ascension of ascending node in degrees.
EL5	Perigee argument in degrees.
EL6	Mean anomaly at HOU hours.
NRGYLV	Threshold energy selector. See ref. #1 for details.
ITAPE	Data tape identifier (not used in calculations).
NTABLS	Number of copies of tables to be produced.
KPRINT	The results will be printed at every KPRINT*DTI.

Appendix A has a more detailed explanation of some of these parameters. Appendix B shows a test case, with examples of the INPUTFILE. The output files and tables are described and discussed in ref. #1 (pages 7-11) and #3., as already mentioned.

Note that the environment model chosen is automatically assigned by the program while running. The original procedures indicated in ref. #1 and #3 - uncommenting the COMMON statement, including the BLOCK DATA deck, compiling and linking the program -are no longer necessary. The environment model is selected by the IPE, IMM and IOZ input parameters as indicated in Table 1.

ENVIRONMENT MODEL	IPE	IMM	IOZ
1-AP8MIN	0	0	X
2-AP8MAX	0	1	X
3-AE5MIN and AEI7LO	1	0	0
4-AE5MIN and AEI7HI	1	0	1
5-AE6MAX and AEI7LO	1	1	0
6-AE6MAX and AEI7HI	1	1	1

Table 1. Input values of the environment selectors (X = not used).

3.0 THE SOFIP2 STRUCTURE

The largest modification in the SOFIP structure was the addition of the Earth magnetic field and orbit propagation subroutines, in substitution of the INPUTFILE2 file [3]. The magnetic field and magnetic lines are calculated by the INVARA subroutine [5], with 7 different field models. Therefore, the model's data statements of the ALLMAG subroutine were replaced by the EAMAFI.DAT data file, because of the large memory consumed during compilation and linking in the HP-System. The orbit propagation subroutines were provided by Kuga's ORBRT file [6,7], that considers the perturbation due to J2 (Earth oblateness).

Two subroutines were added to the main SOFIP2, interfacing it with orbit generation and the geomagnetic field calculation: INDATA and ORBPR. The ORBPR subroutine updates the orbit position at each call (using a time step of DTI hours), calculates the geocentric coordinates using SATPOS, SGMT and INEGEP subroutines [6], and provides the INVARA's calling. The INDATA routine initializes all the orbit propagation constants and obtains the time variations of the Keplerian elements.

Another routine, MODSEL, makes the proper calling to the AP8MAX, AP8MIN, AE6MAX, AE5MIN, AEI7HI and AEI7LO routines that read the corresponding environment model data files (AP8MAX.DAT, AP8MIN.DAT, AE6MAX.DAT, AE5MIN.DAT, AEI7HI.DAT and AEI7LO.DAT with the same elements of the SOFIP's block data) and put the values in common blocks. The SOFIP2 structure is shown in Figure 3, with the geomagnetic field and orbit generation blocks indicated.

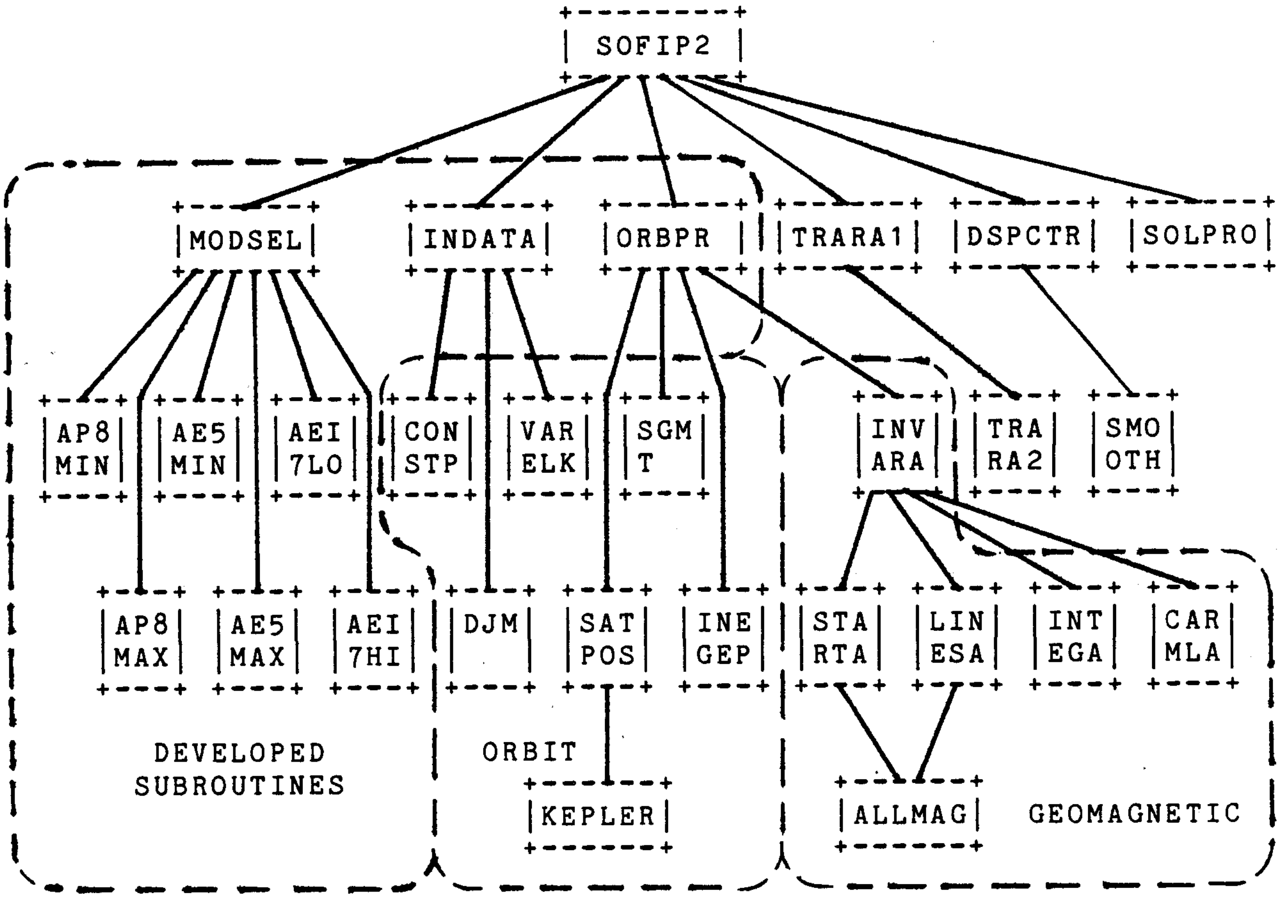


Fig. 3. SOFIP2 structure with orbit generation and magnetic field calculation.

Appendix C presents a listing of the SOFIP2 version and the newly developed subroutines (indicated in Figure 3). The orbit generation, geomagnetic field calculation modules and the SOFIP listings are found in references #7, #4 and #1, respectively.

4.0 THE SORUN AUXILIARY PROGRAM

Sometimes it is hard for users to remember all the input parameters of a program. In this case, the user needs to remember both the input parameters and the sequence in which they appear in the INPUTFILE file. In order to simplify the user's interaction with SOFIP, the SORUN program was developed, that helps the user to create an input file and to modify one or more of the parameters without changing the others in an existing file.

The program displays the current value of each parameter (even before the input file is created) and a brief description of its meaning. For all the inputs, a carriage return is recognized by the program as a "no change" input. The default name of the file is SOFDA.DAT, as shown in Figure 4. The default values are then read from the file indicated by DATA FILE NAME or the file name given by the user and displayed between arrows (--> <--).

Note that the environment model parameter is not the same as shown in Table-1. In fact, it corresponds to the number just left of the environment name in Table-1. The SORUN program, of course, makes all the conversions of one variable to another (IPE, IMM and IOZ).

```
DATA FILE NAME                       -->SOFDA.DAT      <--

SATELLITE NAME                       -->TEST 90/2000   <--

GEOMAGNETIC MODEL (1-7)              -->         5<--
         MODEL 1 HENDRICKS+CAIN GSFC   9/65
    MODEL 2 CAIN ET AL GSFC      12/66
    MODEL 3 CAIN+LANGEL POGO     10/68
    MODEL 4 CAIN+SWEENEY POGO     8/69
    MODEL 5 IGRF                  1965
    MODEL 6 LEATON MALIN EVANS    1965
    MODEL 7 HURWITZ USC+GS        1970

          SELECT ENVIRONMENT MODEL        -->       2<--
1-AP8MIN  2-AP8MAX  3-AE5MIN  4-AE5MIN  5-AE6MAX  6-AE6MAX
                      AEI7LO    AEI7HI    AEI7LO    AEI7HI
```

Fig. 4. The SORUN display.

```
YEAR FOR COMPUTATIONS                   -->    1974<--

MONTH                                   -->       2<--

DAY                                     -->       7<--

HOUR OF THE DAY (AND DECIMAL)           -->  0.0000<--

TIME INCREMENT IN HOURS (AND DECIMAL)   -->   .0333<--

TIME INTERVAL FOR COMPUTATIONS (HOUR)   --> 23.9900<--

PERIGEE ALTITUDE (KM)                   --> 2000.00<--

APOGEE ALTITUDE (KM)                    --> 2000.00<--

ORBIT INCLINATION (DEGREES)             -->   90.00<--

RIGHT ASC. OF ASCENDING NODE (DEGREES)  -->   37.00<--

PERIGEE ARGUMENT (DEGREES)              -->    0.00<--

MEAN ANOMALY (DEGREES)                  -->    0.00<--

THRESHOLD ENERGY SELECTOR               -->       4<--
   4-PROTONS   5-ELECTRONS

ORBIT TAPE IDENTIFIER                   -->    5116<--

NUMBER OF TABLES                        -->       3<--

NUMBER OF TIME INCR. FOR PRINTING       -->       1<--
```

Fig. 4.(cont.) The SORUN display

5.0 CONCLUSIONS

The changes introduced to the SOFIP program have improved the quality of the results without compromising the processing speed. Although the memory required was increased (because of the new dimensioning of the common blocks), the easier running of the program compensates.

In fact, for a better program performance, it would be necessary to write a new program, with modular subroutine blocks and a perfect integration between the parts (solar flux, geomagnetic field and orbit calculations).

LIST OF REFERENCES

[1] Stassinopoulos, E. G., J. J. Hebert, E. L. Butler and J. L. Barth, "SOFIP: A Short Orbital Flux Integration Program", NSSDC/WDC-A-R&S 79-01, National Space Science Data Center, Greenbelt, Maryland, January 1979.

[2] Tada, H. Y., J. R. Carter Jr., B. E. Anspaugh, and R. G. Downing, "Solar Cell Radiation Handbook", NASA, JPL Publication 82-69, November 82. (Chapter 5).

[3] Sanson, L., "Radiation Flux Calculation Programs", SPAR, Ste. Anne de Bellevue, June 1986. (SPAR/OSR84 00175).

[4] Stassinopoulos, E. G. and G. D. Mead, "ALLMAG, GDALMG, LINTRA: Computer Programs for Geomagnetic Field and Field-Line Calculations", NSSDC 72-12, National Space Science Data Center, Greenbelt, Maryland, February 1972.

[5] Hassit, A and C. E. McIlwain, "Computer Programs for Computation of B and L (May 1966) ", NSSDC 67-27, National Space Data Center, Greenbelt, Maryland, May 1967.

[6] Kuga, H. K., "Sun Angle Relative to the Ground Bellow the Satellite", SPAR, Ste. Anne de Bellevue, October 1984. (SPAR/RML-009-84-155).

[7] Kuga, H. K., "Shadow and Sun Angle Predictions and Energy Analysis for Solar Arrays", SPAR, Ste. Anne de Bellevue,August 1984. (SPAR/RML-009-84-91A).

[8] Hendricks, S. J., and J. C. Cain, "Magnetic Field Data for Trapped-Particle Evaluations", J. Geophys. Res. 71, 346-347, 1966.

[9] Cain, J. C., S. J. Hendricks, R. A. Langel and W. V. Hudson, "A Proposed Model for the International Geomagnetic Reference Field, 1965", J. Geomagn. Geoelec., 19, 335-355, 1967.

[10] Cain, J. C. and R. A. Langel, "The Geomagnetic Survey by the Polar Orbiting Geophysical Observatories OGO-2 and OGO-4 1965-1967", GSFC Report X-612-68-502, Greenbelt, Maryland, 1968.

[11] Cain, J. C. and R. E. Sweeney, "Magnetic Field Mapping of the Inner Magnetosphere", J. Geophys. Res., 75 4360-4362, 1970.

[12] IAGA Commission 2 Working Group 4 Analysis of the Geomagnetic Field, "International Geomagnetic Reference Field 1965.0", J. Geophys. Res., 74, 4407-4408, 1969.

[13] Leaton, B., S. R. C. Malin and M. J. Evans, "An Analytical Representation of the Estimated Geomagnetic Field and its Secular Change for the Epoch 1965.0", J. Geomagn. Geoelec., 17, 187-194, 1965.

[14] Hurwitz, L., "Mathematical Model of the 1970 Geomagnetic Field", ESSA Coast and Geodetic Survey, May 1970.

APPENDIX A

INPUT VARIABLES DESCRIPTION

Some of the input parameters need more detailed comments, as the geomagnetic and solar flux model selectors. In this appendix are given some aspects of these variables and reproduced important comments by the original authors.

About the geomagnetic models, reference #4 enphasizes that:

"Note that Table 2 gives both the epoch and the data range. The term 'data range' is used here to denote the time period during which geomagnetic data were obtained to define the model. The 'epoch' of a model which secular time-derivative terms is the zero of the time from which delta-t is calculated in order to add or subtract the time-derivative contribution to the main-field terms. Since in this sense the epoch is simply a numerical constant, it may or may not lie within the data range. All the Cain models, for example, are based on a epoch of 1960, for simplicity, even though the recent POGO models utilize data only from POGO satellites, the first of which was launched in 1965."

MO-DEL	Designation	Epoch	Data Range	NMAX	NOC	Earth	Ref.
1	GSFC 9/65	1960	1945-1964	9	99	Obl	[8]
2	GSFC 12/66	1960	1900-1965.8	10	120	Obl	[9]
3	POGO 10/68	1960	1965.8-1967.9	11	143	Obl	[10]
4	POGO 8/69	1960	1965.8-1968.4	10	120	Obl	[11]
5	IGRF 1965.0	1965		8	80	Obl	[12]
6	LME 1965	1965	1945-1964.5	8	80	Sph	[13]
7	USC&GS 1970	1970	1939-1968	12	168	Obl	[14]

Table 2. Geomagnetic field models in ALLMAG (source: [4])
NMAX - Maximum order of the model
NOC - Number of coefficients
Earth- Obl=Oblate, Sph=Spherical

"It is customary to set the input variable TM (N.A.: in the SOFIP2 version, TM is calculated with the YER, AMO and DAY values) equal to the time period for which one wishes to calculate the field. It is generally undesirable, however, to input a time more than a few years away from the data range of a given model, since to do so requires extrapolation well outside the time period over which data was obtained to define the model.

Recent studies (Mead, 1972) have shown that such large extrapolations can lead to highly unreliable and often divergent results. If we desire to predict the characteristics of the field in 1973.0, for example, using a model such as POGO 10/68, whose data range is 1965.8-1967.9, it would be better to choose something like 1969.0 as a time input to the model, rather than 1973.0, which would require linear extrapolation over five years outside its data range.

There are two reasons why these large extrapolations are undesirable. First, most models assume that the secular variation is linear, whereas long-term studies ... clearly show that secular variations are often highly non-linear and that linear extrapolations many years into the future are unreliable. Secondly, several of the models have used a relatively short time period to determine the secular time derivatives. It appears that data ranges of at least five years are necessary to clearly establish the linear trends. ...

A few comments on each model are appropriate:

Model 1 (GSFC 9/65) was based mostly on surface survey data, with some additional localized satellite data from Vanguard 3 and Alouette. ...

Model 2 (GSFC 12/66) incorporates survey data back to 1900 and is the only model containing second time-derivative terms, thus making a quadratic fit to the secular variation. As such, it is probably the best single model fitting surface data over the period 1900-1965 ... However, more recent models give better predictions of the current field.

Model 3 (POGO 10/68) was the first model to use only satellite data (measurements of the field magnitude only; no directional data included). Its data range is very short (2.1 years), and therefore its time derivative terms are rather poorly determined. With this model, the variable TM should probably be limited to the time period 1964-1969.

Model 4 (POGO 8/69) is the most recently-published model from the Cain group as of this writing.

Model 5 (IGRF) is now internationally accepted as a reference field to use as a standard whenever comparisons are needed. Since it was derived from the components of many different models, no data range for it is given in Table 2.

Model 6 (LME 1965) was used for the preparation of world magnetic charts for the epoch 1965.0 published by the Hydrographic Office of the British Ministry of Defense. The LME model is the only one included in ALLMAG whose derivation neglected the oblateness of the earth (it assumed R=6371.2 km everywhere on the surface).

Model 7 (USC&GS 1970) is the American World Chart Model for 1970, and was used to prepare the magnetic charts issued by the U.S. Naval Oceanographic Office in 1970.

Models 6 and 7, based almost entirely on ground data, are probably preferable to use for predictions of the field at or near the Earth surface. Models 3-5 would probably be preferable to use in space applications."

The solar flux models also give rise to doubts. In reference #1 it is found that:

"SOFIP" is designed to use Vette's standardized models of the terrestrial trapped particle environment, as distributed by the National Space Science Data Center, Greenbelt, Maryland. New models are periodically being issued to replace older versions whenever additional data or information become available that permit a significant improvement in the environment description, or that indicate a change sufficiently important to warrant such an action. All models, both for protons and electrons, represent a static environment at a given fixed epoch. However, it was possible to infer from the data used in their construction a change in average quiet-time flux levels as a function of solar cycle. To date, a continuous temporal description of this cycle dependence has not been attempted. Instead, separate models were developed for solar minimum and solar maximum conditions for either species of particles.

Current at the time of this writing are the following models:

Particle	Solar Max	Solar Min
Protons	AP8-MAX (1970)	AP8-MIN (1964)
Electrons Inner Zone	AE6 (1980)	AE5 (1975)
Electrons Outer Zone	AEI7-HI (1980) AEI7-LO (1980)	

where the numbers in parentheses indicate the specific fixed epoch (year) for which they describe the average environment.

In regard to the outer zone electron models AEI7-HI and AEI7-LO it should be noted that:

(a) The version labelled "HI" favors Vampola's fits to the OV1-19 data, while the version labelled "LO" is representative of all the other outer zone data sets presently available at NSSDC.

(b) These models do not reflect solar cycle conditions and should be used indiscriminately for both min and max phases.

(c) They are interim models which recently replaced the solar min and max versions of the older AE4."

Ref. #1 gives also some comments about the NRGYLV parameter:

"NRGYLV is the threshold-energy selector. Its value is an index into the ENERGY array. The desired value of NRGYLV is most easily obtained by looking at the Composite Orbit Spectrum from a SOFIP run for the correct particle species, and counting down to the desired energy level. The usual values are: electrons, NRGYLV=5 (0.5 MeV); protons, NRGYLV=4 (5.0 MeV)."

Table 3 is a usefull guide to correlate the NRGYLV value with the threshold energy for protons and electrons.

	THRESHOLD ENERGY (MeV)	
NRGYLV	PROTONS	ELECTRONS
1	2.0	.1
2	3.0	.2
3	4.0	.3
4	5.0	.4
5	6.0	.5
6	8.0	.6
7	10.0	.7
8	15.0	.8
9	20.0	.9
10	25.0	1.0
11	30.0	1.3
12	35.0	1.5
13	40.0	1.8
14	45.0	2.0
15	50.0	2.3
16	55.0	2.5
17	60.0	2.8
18	70.0	3.0
19	80.0	3.3
20	90.0	3.5
21	100.0	3.8
22	125.0	4.0
23	150.0	4.3
24	175.0	4.5
25	200.0	4.8
26	250.0	5.0
27	300.0	5.5
28	350.0	6.0
29	400.0	6.5
30	500.0	7.0

Table 3. Threshold energy given by NRGYLV value

Finally, some words about the DTI, the time step size for orbit propagation. Ref #1 advises not to use trajectories with stepsizes less than one minute; it is internally truncated to an integer minute. Therefore, as the program makes an integration over the orbit, one must to choose the DTI value in a way to guarantee at least 20 points per orbit. It gives a stepsize of 5 minutes maximum for a 700 km altitude orbit.

APPENDIX B

TEST CASES

Some examples of INPUTFILE are given below:

```
<BOF>
RADARSAT
5 1 0 0
1965 12 20 14.6 0.1 16.4
777.5 777.5 98.5 346.0 0.0 0.0
4 1234 1 1
<EOF>

<BOF>
TEST 90/2000
5 0 1 0
1974 2 7 0.0 0.033333 23.99
2000.0 2000.0 90.0 37.0 0.0 0.0
4 5116 3 1
<EOF>
```

The second example gives close results to the T-3 table shown in ref. #1. The differences in the results are mainly due to the truncation values of B and L (geomagnetic field and geomagnetic line), in the intermediate files. Another difference is caused by the orbit period, which is calculated with the orbital elements at SOFIP2, rather than an input value in SOFIP.

The SOFIP2 outputs weren't changed; they are the same as SOFIP. For a better comprehension, one gives below the meaning of the outputs of a typical SOFIP2 running.

Initially, the program prints the values of the input parameters:

NAME - Same as NAME, described at Section 2.
INCL - Truncated value of EL3 (orbit inclination) in degrees.
IPRG - Truncated value of EL1 (perigee altitude) in km.
IAPG - Truncated value of EL2 (apogee altitude) in km.
ITAPE - Same as described at Section 2.
MODEL - Magnetic field model selector.
PERIOD - Orbital period in hours.
BLTIME - Decimal year, obtained from YEA, AMO and DAY.
NRGLEV - Value of NRGYLV.
NTABLS - Same as described at Section 2.
CUTOFF - Total time of propagation (same as TFI).
ISKIP - Not used in SOFIP2 version.
KPRINT - Same as described in Section 2.

Table 4 shows the printed values of the input elements, using the RADARSAT example as input file.

```
NAME   = RADARSAT
INCL   =  98
IPRG   =    777
IAPG   =    777
ITAPE  =   1234
MODEL  =  5
PERIOD=   1.674597
BLTIME= 1965.97
NRGLEV=  4
NTABLS=  1
CUTOFF=  16.40
ISKIP =  0
KPRINT=  1
```

Table 4. SOFIP2 printed input elements.

The first results (Table 5) contain the positional radiation flux for the protons (IPE = 0) or electrons (IPE = 1) with energy greater than the threshold energy (see Table 3), at each KPRINTth point of the orbit. The printed values are the geocentric coordinates of the spacecraft (longitude, latitude and altitude), the field magnitude B, the magnetic shell parameter L and the orbit time.

For each position the program also prints the instantaneous radiation flux, the time integrated flux (DTI times the instantaneous flux) and the orbital flux accumulated to this point (sum of all integrated flux values). Note that several nulls can appear at the positional flux column, depending on the spacecraft position and the adopted threshold energy selector. Ending this table, the percentage of the total time spent inside and outside the trapped particle radiation belt is printed out.

The next module (Table 6) presents 3 independent tables: the composite orbit spectrum, the solar protons results and the exposure index.

The composite orbit spectrum gives the averaged number of particles per unit area and and per unit time with energy greater than some selected values, for the analysed period. The difference integral flux represents the difference between two values of the averaged integral flux (preceding column). According to ref. #1, the averaged differential flux is obtained by fitting a cubic spline on the integral flux values and then calculating the differential at the selected energies. Therefore, this column will contain only null elements if there are less than ten non-zero values of the integral flux.

```
                         *****   PROTONS   (E) 5.00    MEV)   *****

 LONG.     LAT.     ALT.    FIELD     LINE    ORBIT    POSITIONAL   TIME-INTEG     ORBITAL
                             -B-       -L-     TIME       FLUX      PSTNL FLUX    FLUX(SUM)
 (DEG)     (DEG)    (KM)   (GAUSS)  (E.R.)    (HRS)   #/CM**2/SEC
  38.03     0.00    777.5   .23395   1.13    0.00000
  33.20    21.24    780.3   .26489   1.16     .10000   0.000E+00    0.000E+00    0.000E+00
  27.19    42.39    787.2   .32641   1.79     .20000   0.000E+00    0.000E+00    0.000E+00
  16.34    63.18    794.5   .36939   4.57     .30000   0.000E+00    0.000E+00    0.000E+00
 -32.40    80.59    798.3   .40069  63.07     .40000   0.000E+00    0.000E+00    0.000E+00
-124.28    70.65    796.5   .41716  16.75     .50000   0.000E+00    0.000E+00    0.000E+00
-140.60    50.30    790.2   .37586   2.94     .60000   0.000E+00    0.000E+00    0.000E+00
-147.67    29.22    782.6   .29364   1.48     .70000   0.000E+00    0.000E+00    0.000E+00
-152.77     8.00    777.9   .23688   1.13     .80000   0.000E+00    0.000E+00    0.000E+00
-157.49   -13.25    778.6   .25940   1.16     .90000   0.000E+00    0.000E+00    0.000E+00
-162.85   -34.45    784.4   .34612   1.69    1.00000   0.000E+00    0.000E+00    0.000E+00
-171.00   -55.44    792.0   .42856   4.08    1.10000   0.000E+00    0.000E+00    0.000E+00
 165.53   -75.22    797.5   .45486  34.96    1.20000   0.000E+00    0.000E+00    0.000E+00
  60.44   -77.39    797.9   .39124  17.46    1.30000   0.000E+00    0.000E+00    0.000E+00
  30.93   -58.12    792.9   .28854   4.09    1.40000   0.000E+00    0.000E+00    0.000E+00
  22.04   -37.19    785.3   .23162   2.12    1.50000   8.659E+02    3.117E+05    3.117E+05
  16.49   -16.00    779.1   .22368   1.38    1.60000   1.491E+02    5.367E+04    3.654E+05
  11.74     5.25    777.7   .22056   1.12    1.70000   0.000E+00    0.000E+00    3.654E+05
    .        .        .       .        .        .          .            .            .
    .        .        .       .        .        .          .            .            .
    .        .        .       .        .        .          .            .            .
 -15.06    24.51    781.2   .25971   1.32   15.80000   0.000E+00    0.000E+00    6.256E+06
 -19.98     3.28    777.6   .20320   1.16   15.90000   7.221E+01    2.600E+04    6.282E+06
 -24.75   -17.97    779.5   .18662   1.28   16.00000   2.485E+03    8.948E+05    7.177E+06
 -30.46   -39.14    786.0   .20033   1.60   16.10000   3.846E+03    1.385E+06    8.561E+06
 -39.99   -60.03    793.6   .26680   2.42   16.20000   2.106E+01    7.582E+03    8.569E+06
 -75.32   -78.77    798.1   .37621   5.70   16.30000   0.000E+00    0.000E+00    8.569E+06
-177.55   -73.56    797.2   .45107  16.53   16.40000   0.000E+00    0.000E+00    8.569E+06

***** PERCENT OF TOTAL LIFETIME SPENT INSIDE AND OUTSIDE TRAPPED PARTICLE RADIATION BELT ****

     INNER ZONE (1.0 <= L < 2.8)   :   58.54 %
                  OUTSIDE TRAPPING REGION (1.0 <= L < 1.1) :    3.66 %
                  INSIDE TRAPPING REGION  (1.1 <= L < 2.8) :   54.88 %
     OUTER ZONE (2.8 <= L <= 11.0) :   27.44 %
     EXTERNAL   (L > 11.0)         :   14.02 %
```

Table 5. Positional radiation flux table.

The solar protons table calculates the total fluence for a 12 month period (given by TAU) and for a confidence level of Q %. It lists also the number of anomalously large events NALE and the exposure factor (fraction of the propagation time spent in the solar flare protons region) used in the calculations of the table. Note that the fluence will be null if all the trajectory lies inside the geomagnetic shielding region (L < 5), as can be seen in Figure 1.

The exposure index table contains the total exposure duration time and the accumulated particles with energy greater than the threshold energy, for 9 different flux ranges.

Finally, Table 7 presents the instantaneous peak flux encountered during each orbit. Other columns are the geocentric coordinates of the spacecraft (longitude, latitude and altitude), the orbit time at which the peak was encountered and the geomagnetic field and line at this position. The last column contains the accumulated flux per orbit. A pre-selected array, dimensioned to store the orbital peak flux, limits the program capability up to 50 orbits maximum.

```
                                           ****************    PROTONS    ****************
                                           ************************************************

                                                                  **** SOLAR PROTONS ****

                                                                 FOR TAU= 0,Q=90: NALE=1
**************** COMPOSITE ORBIT SPECTRUM ****************         WITH GEOMAG SHIELDING          ** EXPOSURE INDEX: ENERGY)5.000 MEV **
                                                                  (EXPOSR FACTOR= .27)

ENERGY     AVERAGED       DIFFERENCE     AVERAGED DIFF-          ENERGY      TOTAL            INTENSITY    EXPOSURE    TOTAL # OF
LEVELS   INTEGRAL FLUX  INTEGRAL FLUX    RENTIAL FLUX            LEVELS     FLUENCE            RANGES      DURATION    ACCUMULATED
)(MEV)    #/CM**2/SEC   #/CM**2/SEC/DE  #/CM**2/SEC/KEV          )(MEV)     #/CM**2          #/CM**2/SEC   (HOURS)     PARTICLES

2.000      2.028E+02      2.832E+01       2.945E-02                10.      4.481E+09          ZERO FLUX    14.000      0.000E+00
3.000      1.745E+02      1.784E+01       2.108E-02                20.      3.072E+09          1.E0-1.E1      .200      2.630E+03
4.000      1.566E+02      1.239E+01       1.555E-02                30.      2.107E+09          1.E1-1.E2      .400      6.973E+04
5.000      1.443E+02      9.307E+00       1.102E-02                40.      1.444E+09          1.E2-1.E3     1.000      1.352E+06
6.000      1.349E+02      1.245E+01       8.103E-03                50.      9.904E+08          1.E3-1.E4      .800      7.144E+06
8.000      1.225E+02      1.015E+01       5.556E-03                60.      6.791E+08          1.E4-1.E5     0.000      0.000E+00
10.00      1.123E+02      1.207E+01       3.959E-03                70.      4.656E+08          1.E5-1.E6     0.000      0.000E+00
15.00      1.003E+02      9.856E+00       2.274E-03                80.      3.193E+08          1.E6-1.E7     0.000      0.000E+00
20.00      9.042E+01      6.025E+00       1.558E-03                90.      2.189E+08          1.E7-OVER     0.000      0.000E+00
25.00      8.440E+01      5.472E+00       1.207E-03               100.      1.501E+08              TOTAL    16.400      8.569E+06
30.00      7.892E+01      4.160E+00       9.626E-04               110.      1.029E+08
35.00      7.476E+01      3.889E+00       8.304E-04               120.      7.057E+07
40.00      7.088E+01      3.641E+00       7.541E-04               130.      4.839E+07
45.00      6.724E+01      3.413E+00       7.059E-04               140.      3.310E+07
50.00      6.382E+01      3.244E+00       6.656E-04               150.      2.275E+07
55.00      6.058E+01      3.046E+00       6.271E-04               160.      1.560E+07
60.00      5.753E+01      5.555E+00       5.893E-04               170.      1.070E+07
70.00      5.198E+01      4.922E+00       5.219E-04               180.      7.334E+06
80.00      4.706E+01      4.375E+00       4.638E-04               190.      5.029E+06
90.00      4.268E+01      3.901E+00       4.189E-04               200.      3.448E+06
100.0      3.878E+01      8.971E+00       3.873E-04
125.0      2.981E+01      6.706E+00       3.055E-04
150.0      2.310E+01      5.077E+00       2.333E-04
175.0      1.803E+01      3.885E+00       1.785E-04
200.0      1.414E+01      5.560E+00       1.391E-04
250.0      8.580E+00      3.312E+00       8.456E-05
300.0      5.269E+00      2.017E+00       5.120E-05
350.0      3.252E+00      1.224E+00       3.113E-05
400.0      2.028E+00      1.230E+00       1.912E-05
500.0      7.983E-01      7.983E-01       7.422E-06
```

Table 6. The composite orbit spectrum, solar protons and exposure index.

Table 7. Orbital peak flux results.

```
                    *************************     PROTONS     ***************************
                    ** TABLE OF PEAK AND TOTAL FLUXES PER PERIOD : ENERGY >  5.0  MEV **
                    ********************************************************************

PERIOD    PEAK FLUX          POSITION AT WHICH ENCOUNTERED     ORBIT TIME     FIELD(B)     LINE(L)     TOTAL FLUX
NUMBER    ENCOUNTERED        LONGITUDE  LATITUDE  ALTITUDE                                             PER ORBIT
          #/CM**2/SEC          (DEG)      (DEG)     (KM)        (HOURS)       (GAUSS)      (E.R.)      #/CM**2/ORBIT

   1      8.659E+02           22.040     -37.19    785.34       1.50000       .23162        2.12       3.654E+05
   2      1.725E+03           -4.619     -31.97    783.52       3.20000       .20932        1.69       8.377E+05
   3      4.134E+03          -31.153     -26.74    781.85       4.90000       .18495        1.35       2.302E+06
   4      2.338E+03          -57.596     -21.50    780.39       6.60000       .18080        1.21       1.677E+06
   5      1.713E+02          -78.399     -37.45    785.43       8.20000       .22244        1.38       8.987E+04
   6      0.000E+00          -88.718       4.99    777.66       8.40000       .24844        1.23       0.000E+00
   7      2.212E+01           43.053     -44.60    788.07      11.10000       .26971        2.81       7.963E+03
   8      4.611E+02           22.835     -28.70    782.45      12.70000       .22861        1.76       2.122E+05
   9      1.564E+03           -3.741     -33.93    784.19      14.40000       .21127        1.75       7.645E+05
```

APPENDIX C

LISTING OF SOFIP2 PROGRAM AND SUBROUTINES

```
FTN77,J,D
$CDS ON
$FILES 0,10
$EMA /PRELMO/,/ELOZON/
      PROGRAM SOFIP2
C **********************************************************************SOFIP001
C ************    SHORT ORBITAL FLUX INTEGRATION PROGRAM     ***********SOFIP002
C *******    FOR USE WITH NSSDC'S STANDARD ENVIRONMENT MODELS    *******SOFIP003
C **********************************************************************SOFIP004
C ** DESIGNED AND TESTED BY STASSINOPOULOS, HEBERT, BUTLER, & BARTH   **SOFIP005
C ** CODE 601, NASA/GODDARD SPACE FLIGHT CENTER; GREENBELT, MD. 20771 **SOFIP006
C ** SINGLE PRECISION DECK FOR FORTRAN IV   (EBCDIC,029 PUNCH)       **SOFIP007
C ** TRAJECTORY INPUT FROM UNFORMATTED BINARY OR BCD FORMATTED TAPE   **SOFIP008
C **********************************************************************SOFIP009
C ***                                                                   SOFIP010
C ***  INPUT PARAMETERS:                                                SOFIP011
C ***  * NAME  : 12-CHARACTER MISSION (OR PROJECT) NAME                 SOFIP012
C ***  * INCL  : APPROXIMATE INCLINATION OF ORBIT PLANE IN DEGREES (I*4)SOFIP013
C ***  * IPRG  : APPROXIMATE PERIGEE ALTITUDE IN KILOMETERS        (I*4)SOFIP014
C ***  * IAPG  : APPROXIMATE APOGEE ALTITUDE IN KILOMETERS         (I*4)SOFIP015
C ***  * MODEL : NUMBER OF FIELD-MODEL USED IN B/L CALCULATION     (R*4)SOFIP016
C ***  * PERIOD: MATHEMATICAL PERIOD OF ORBIT IN HOURS             (R*4)SOFIP017
C ***  * BLTIME: EPOCH OF FIELD-MODEL USED IN B/L CALCULATION      (R*4)SOFIP018
C ***  * NRGYLV: THRESHOLD-ENERGY SELECTOR FOR RUNNING PRINTOUT    (I*4)SOFIP019
C ***  * ITAPE : B/L ORBIT TAPE IDENTIFIER, < 10000                (I*4)SOFIP020
C ***  * NTABLS: # OF OUTPUT-TABLE SETS PER TRAJECTORY             (I*4)SOFIP021
C ***  * CUTOFF: ORBIT DURATION IN DECIMAL HOURS                   (R*4)SOFIP022
C ***  * ISKIP : POSITION SKIPPING CONTROL                         (I*4)SOFIP023
C ***  * KPRINT: RUNNING PRINTOUT CONTROL                          (I*4)SOFIP024
C ***                                                                   SOFIP025
C ***  INPUT VARIABLES:                                                 SOFIP026
C ***  * PSNTIM:  POSITIONAL TIME (DECIMAL HOURS)                       SOFIP027
C ***  * PSNLON:       "     LONGITUDE (DEGREES)                        SOFIP028
C ***  * PSNLAT:       "     LATITUDE (DEGREES)                         SOFIP029
C ***  * PSNALT:       "     ALTITUDE (KILOMETERS)                      SOFIP030
C ***  * PSNB  :       "     FIELD MAGNITUDE (GAUSS)                    SOFIP031
C ***  * PSNL  :       "     SHELL PARAMETER (EARTH RADII)              SOFIP032
C **********************************************************************SOFIP033
C *** TO READ BCD FORMATTED ORBIT TAPES, UNCOMMENT LINES 132,137,& 143. SOFIP034
C *** COMMENT OUT LINES 133-134,138-139,& 144.                          SOFIP035
C *** TO READ UNFORMATTED BINARY ORBIT TAPES, UNCOMMENT LINES 133-134,  SOFIP036
C *** 138-139,& 144.  COMMENT OUT LINES 132,137,& 143.                  SOFIP037
C *** ********************  BLOCK 0: INITIALIZATION  *******************SOFIP038
      IMPLICIT INTEGER*4 (I-N)

      REAL*8 EL(6),DEL(6),DJ,TM,HO,DT,PER,CUT,VT1,VO1,VA1,VH1,VB1,VL1
      REAL*8 VTM,VON,VAT,VHI,VBM,VLM

      REAL*8 MODLAB(4,7),MODLBL(4),BINDMY(5),XLABEL(3,2),PROTLB(2)
      REAL AP8,MAX,MIN,LOW,MAC,ADUMMY(6),MOD7
      REAL ENERGY(31,2),SPNRG(20),FIRNGS(11)
      INTEGER*4 NRGRNG(10,2),IZONE(120),NRBITO
      REAL TYPLBL(3,2)
      CHARACTER*4 NAME(3)
      CHARACTER I1FILE*20,I2FILE*20,O1FILE*20,O2FILE*20,FLAG*2
      CHARACTER O3FILE*24,O4FILE*24,O5FILE*24
C
      DIMENSION FLUXES(30),ALGFLX(30),ALNFLX(30),DIFSPC(30),EXPFLX(10), SOFIP060
     $PKVALU(50,8),AIFLXS(30),ENRNGS(11),EXPTIM(10),IYMD(3),LCOUNT(4),  SOFIP061
     $DIFFLX(30),PKFLX(50),PKTIM(50),PTIME(4),                          SOFIP062
```

```
     $PKLON(50),PKLAT(50),PKALT(50),PKB(50),PKL(50),TAUFLX(50),F(20)      SOFIP063
C     COMMON /AP8MAC/DESCR(8),LIST(1)                                     SOFIP039
C     COMMON /AE6MAX/DESCR(8),LIST(1)                                     SOFIP 40
C     COMMON /AEI7HI/DESCR7,LIST7(1)                                      SOFIP041
C     COMMON /AEI7LO/DESCR7,LIST7(1)                                      SOFIP042
C     COMMON /AE5MIN/DESCR(8),LIST(1)                                     SOFIP043
C     COMMON /AP8MIC/DESCR(8),LIST(1)                                     SOFIP044


      COMMON /PRELMO/ DESCR(8),LIST(6689)
      COMMON /ELOZON/ DESCR7(8),LIST7(4374)


      EQUIVALENCE(PKVALU(1,1),PKFLX(1)),(PKVALU(1,2),PKLON(1)),(PKVALU(1SOFIP064
     $,3),PKLAT(1)),(PKVALU(1,4),PKALT(1)),(PKVALU(1,5),PKTIM(1)),(PKVALSOFIP065
     $U(1,6),PKB(1)),(PKVALU(1,7),PKL(1)),(PKVALU(1,8),TAUFLX(1))       SOFIP066
            DATA MODLAB/'HENDRICK','S&CAIN 9','9-TERM G','SFC 9/65',' CSOFIP045
     $AIN ET','.AL. 120','-TERM GS','FC 12/66',' CAIN&LA','NGEL 143','-TSOFIP046
     $ERM PO','GO 10/68',' CAIN&SW','EENEY 12','0-TERM P','OGO 8/69','  SOFIP047
     $  IGRF',' 1965.0 ','80-TERM ','10/68   ',' LEATON ','MALIN EV','ANSOFIP048
     $S 80-T','ERM 1965','   HURWI','TZ US C&','GS 168-T','ERM 1970'/,  SOFIP049
     $AP8/' AP8'/,MAX/'MAX '/,MIN/'MIN '/,LOW/'S LO'/,                    SOFIP050
     $MAC/'MAC'/,MOD7/'LO-7'/                                            SOFIP051
      DATA ENERGY/2.,3.,4.,5.,6.,8.,10.,15.,20.,25.,30.,35.,40.,          SOFIP052
     $45.,50.,55.,60.,70.,80.,90.,100.,125.,150.,175.,200.,250.,300.,    SOFIP053
     $350.,400.,500.,0.,.1,.2,.3,.4,.5,.6,.7,.8,.9,1.,1.25,1.5,1.75,2., SOFIP054
     $2.25,2.5,2.75,3.,3.25,3.5,3.75,4.,4.25,4.5,4.75,5.,5.5,6.,6.5,7., SOFIP055
     $0.0/,SPNRG/10.,20.,30.,40.,50.,60.,70.,80.,90.,100.,110.,120.,    SOFIP056
     $130.,140.,150.,160.,170.,180.,190.,200./                           SOFIP057
      DATA NRGRNG/1,3,5,7,12,20,22,26,30,31,1,5,8,10,12,13,14,           SOFIP058
     $22,30,31/,IZONE/10*1,17*2,93*3/,NRBITO/1/                          SOFIP059
      DATA TYPLBL/'  PR','OTON','S   ','ELEC','TRON','S HI'/,            SOFIP067
     $FIRNGS/'0.E0','1.E0','1.E1','1.E2','1.E3','1.E4','1.E5',            SOFIP068
     $'1.E6','1.E7','OVER',' '/,XLABEL/'PRNRGY','PRINTG','PRDIFF'        SOFIP069
     $,'ELNRGY','ELINTG','ELDIFF'/,PROTLB/'SPNRGY','SPFLUX'/             SOFIP070
    1 FORMAT('1NAME  = ',3A4/' INCL  = ',I3/' IPRG  = ', I6/' IAPG  = ',SOFIP071
     $I6/' ITAPE = ',I6/' MODEL = ',I2/' PERIOD= ',F9.6/                 SOFIP072
     $' BLTIME= ',F7.2/' NRGLEV= ',I2/' NTABLS= ',I2/' CUTOFF= ',F6.2/  SOFIP073
     $' ISKIP = ',I2/' KPRINT= ',I2//)                                   SOFIP074
    2 FORMAT('1',131('*')/' * SOFIP : SHORT ORBITAL FLUX INTEGR. PROGRAMSOFIP075
     $ FOR STANDARD NSSDC PROTON AND ELECTRON ENVIR. MODELS (SPECIES CONSOFIP076
     $SIDERED SEPARATELY) *'/' * MAGNETIC PARAMETERS B AND L COMPUTED WISOFIP077
     $TH GEOMAGN. FIELD MODEL',I3,': ',4A8,' * COEFF. UPDATED TO:',F7.1,SOFIP078
     $' *'/' * PROJECT :',3A4,' * INCLIN=',I3,'DEG * PERIG=',I5,'KM * APSOFIP079
     $OG=',I6,'KM * B/L TAPE=TD',I4,' * PERIOD=',F7.3,'HRS * SOLAR ',A3,SOFIP080
     $'IMUM      *'/' * FOR INFORMATION OR EXPLANATION CONTACT E.G. STASSSOFIP081
     $INOPOULOS AT NASA-GSFC,CODE 601, GREENBELT, MARYLAND 20771, TEL.(3SOFIP082
     $01)-344-8067 *'/1X,131('*')//)                                     SOFIP083
    3 FORMAT(2('1'/12('0'/)/53X,28('*')/53X,'**',6X,3A4,6X,'**'/53X,'**'SOFIP084
     $,I3,'DEG/',I5,'KM/',I6,'KM **'/53X,28('*')/))                      SOFIP085
    4 FORMAT (3A4,7X,I3,7X,I6,4X,I6,4X,I2,8X,F9.6,1X,F7.2/I2,7X,I4,      SOFIP086
     $6X,I2,8X,F6.2,4X,I2,8X,I2)                                         SOFIP087
    5 FORMAT(6E18.8)                                                     SOFIP088
    6 FORMAT(3A4)


C
       I1FILE = '1'
       O1FILE = '1'
```

```
      O2FILE = '1'
C
      CALL RCPAR(1I,I1FILE)
      CALL RCPAR(2I,O1FILE)
      CALL RCPAR(3I,O2FILE)
      CALL RCPAR(4I,FLAG)
C
      OPEN(5,FILE=I1FILE)
      OPEN(6,FILE=O2FILE)
C
      IF (FLAG.NE.'+') GOTO 8
C
       O3FILE = O1FILE//'.COS'
       O4FILE = O1FILE//'.SPR'
       O5FILE = O1FILE//'.EXI'
       OPEN(7,FILE=O3FILE)
       OPEN(8,FILE=O4FILE)
       OPEN(9,FILE=O5FILE)
C
      GOTO 9
C
    8 OPEN(7,FILE=O1FILE)
C
    9 CONTINUE
C

C
C *** ********************  BLOCK 1: INITIALIZATION  *******************SOFIP089
C  10 READ(5,4,END=999) NAME,INCL,IPRG,IAPG,MODEL,PERIOD,BLTIME,NRGYLV, SOFIP090
C    $ITAPE,NTABLS,CUTOFF,ISKIP,KPRINT                                  SOFIP091
C      READ STATEMENT HAS BEEN CHANGED TO PERMIT MORE FLEXIBILITY
C

   10 READ(5,6,END=999) NAME
      CALL MODSEL(MODEL)
      CALL INDATA(EL,DEL,DJ,HO,DT,CUT,TM,PER,IPRG,IAPG)
      READ(5,*,END=999) NRGYLV,ITAPE,NTABLS,KPRINT
      INCL = EL(3)*57.2958
      PERIOD = PER
      CUTOFF = CUT
      BLTIME = TM

C     READ(5,*,END=999) INCL,IPRG,IAPG,MODEL,PERIOD,BLTIME
C     READ(5,*,END=999) NRGYLV,ITAPE,NTABLS,CUTOFF,ISKIP,KPRINT
C
      ITYPE=1                                                           SOFIP092
C     WRITE(6,3) (NAME,INCL,IPRG,IAPG,I=1,2)                            SOFIP093
      NORBIT=1                                                          SOFIP094
      IPASS=1                                                           SOFIP095
      IPRINT=KPRINT                                                     SOFIP096
      ASSIGN 110 TO NGO2                                                SOFIP097
      L=0                                                               SOFIP098
      LSUM=0                                                            SOFIP099
      EXPFCT=0.0                                                        SOFIP100
      XAMNIM=MAX                                                        SOFIP101
      ISWTCH=1                                                          SOFIP102
      IF(DESCR(1).EQ.AP8) GO TO 15                                      SOFIP103
      ITYPE = 2                                                         SOFIP104
      ASSIGN 120 TO NGO2                                                SOFIP105
      IF(DESCR(2).NE.MAX) XAMNIM=MIN                                    SOFIP106
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      IF(DESCR7(2).EQ.MOD7) TYPLBL(3,2)=LOW                             SOFIP107
      GO TO 17                                                          SOFIP108
   15 IF(DESCR(2).NE.MAC)  XAMNIM=MIN                                   SOFIP109
   17 DO 20 I=1,4                                                       SOFIP110
      LCOUNT(I)=0                                                       SOFIP111
   20 MODLBL(I) = MODLAB(I,MODEL)                                       SOFIP112
      TAU = PERIOD                                                      SOFIP113
      FLXSUM = 0.0                                                      SOFIP114
      OFLXSM = 0.0                                                      SOFIP115
      PEAK = -1.0                                                       SOFIP116
      DO 30 NRNG=1,10                                                   SOFIP117
      ENRNGS(NRNG) = ENERGY(NRGRNG(NRNG,ITYPE),ITYPE)                   SOFIP118
      EXPTIM(NRNG) = 0.0                                                SOFIP119
   30 EXPFLX(NRNG) = 0.0                                                SOFIP120
      DO 35 NRGSP=1,20                                                  SOFIP121
   35 F(NRGSP)=0.0                                                      SOFIP122
      DO 40 NRG=1,30                                                    SOFIP123
      AIFLXS(NRG)=0.0                                                   SOFIP124
      ALNFLX(NRG) = 0.0                                                 SOFIP125
      DIFSPC(NRG) = 0.0                                                 SOFIP126
   40 FLUXES(NRG) = 0.0                                                 SOFIP127
C *** WRITE OUT INPUT PARAMETERS                                        SOFIP128
      WRITE(6,1)NAME,INCL,IPRG,IAPG,ITAPE,MODEL,PERIOD,BLTIME,NRGYLV,   SOFIP129
     $NTABLS,CUTOFF,ISKIP,KPRINT                                        SOFIP130
C *** ***********************   BLOCK 2: INPUT  ************************SOFIP131

      ICDT = 0
      VT1  = 0.D0
      CALL ORBPR(EL,DEL,DJ,HO,TM,VT1,MODEL,VO1,VA1,VH1,VB1,VL1)
      PSNTM1 = VT1
      PSNLN1 = VO1
      PSNLT1 = VA1
      PSNAL1 = VH1
      PSNB1  = VB1
      PSNL1  = VL1


C     READ(4,5,END=400,ERR=10)PSNTM1,PSNLN1,PSNLT1,PSNAL1,PSNB1,PSNL1   SOFIP132
C     READ(4,END=400,ERR=10)PSNTM1,PSNLN1,DUMMY,PSNLT1,DUMMY,PSNAL1,    SOFIP133
C    $DUMMY,PSNB1,DUMMY,PSNL1,DUMMY                                     SOFIP134
      TMLAST = PSNTM1                                                   SOFIP135

   50 ICDT = ICDT + 1
      VTM  = ICDT*DT
      CALL ORBPR(EL,DEL,DJ,HO,TM,VTM,MODEL,VON,VAT,VHI,VBM,VLM)
      PSNTIM = VTM
      PSNLON = VON
      PSNLAT = VAT
      PSNALT = VHI
      PSNB   = VBM
      PSNL   = VLM

      IF(PSNTIM.GT.CUTOFF) GOTO 400

C  50 DO 60 ISKP=1,ISKIP                                                SOFIP136
C     READ(4,5,END=400,ERR=10) PSNTIM,PSNLON,PSNLAT,PSNALT,PSNB,PSNL    SOFIP137
C     READ(4,END=400,ERR=10)PSNTIM,PSNLON,DUMMY,PSNLAT,DUMMY,PSNALT,    SOFIP138
C    $DUMMY,PSNB,DUMMY,PSNL,DUMMY                                       SOFIP139
C  60 CONTINUE                                                          SOFIP140
C     IF(PSNTIM.LE.CUTOFF) GO TO 65                                     SOFIP141
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C *** DUMMY READ LOOP TO READ TO END OF FILE                            SOFIP142
C  66 READ(4,5,END=400,ERR=10) ADUMMY                                   SOFIP143
C  66 READ(4,END=400,ERR=10) BINTIM,BINDMY                              SOFIP144
C     GO TO 66                                                          SOFIP145
C  65 CONTINUE                                                          SOFIP146
C *** *********************  BLOCK 3: CALCULATIONS  ********************SOFIP147
C *** CALCULATE KPSTEP (NUMBER OF MINUTES BETWEEN POINTS ON B/L TAPE)   SOFIP148
      GO TO (70,80), IPASS                                              SOFIP149
   70 KPSTEP = INT((PSNTIM-TMLAST)/.0166667+0.1)- 6                     SOFIP150
   80 TMLAST = PSNTIM                                                   SOFIP151
C *** TEST L-VALUE  & BYPASS FLUX CALCULATIONS IF WARRANTED             SOFIP152
      IF(PSNL.GT.0.0.AND.PSNL.LT.12.0) GO TO NGO2,(110,120)             SOFIP153
      DO 100 NRG=1,30                                                   SOFIP154
  100 FLUXES(NRG) = 0.0                                                 SOFIP155
      GO TO 170                                                         SOFIP156
C *** OBTAIN COMMON LOGARITHM OF POSITIONAL FLUXES (ALGFLX)             SOFIP157
C *** PROTONS                                                           SOFIP158
  110 CALL TRARA1(DESCR,LIST,PSNL,PSNB,ENERGY(1,1),ALGFLX(1),30)        SOFIP159
      GO TO 140                                                         SOFIP160
C *** ELECTRONS                                                         SOFIP161
  120 IF(INT(100.0*PSNL+0.2).LE.280) GO TO 130                          SOFIP162
      CALL TRARA1(DESCR7,LIST7,PSNL,PSNB,ENERGY(1,2),ALGFLX(1),30)      SOFIP163
      GO TO 140                                                         SOFIP164
  130 CALL TRARA1(DESCR,LIST,  PSNL,PSNB,ENERGY(1,2),ALGFLX(1),30)      SOFIP165
C *** CONVERT LOG-FLUX TO FLUX                                          SOFIP166
  140 DO 150 NRG=1,30                                                   SOFIP167
      FLUXES(NRG) = 10.0**ALGFLX(NRG)                                   SOFIP168
  150 IF(FLUXES(NRG).LT.1.001) FLUXES(NRG) = 0.0                        SOFIP169
C *** SUM FLUXES FOR (A) RUNNING PRINTOUT, (B) TABULAR OUTPUT           SOFIP170
      FLXSUM = FLXSUM+FLUXES(NRGYLV)*FLOAT(KPSTEP)*60.                  SOFIP171
      DO 160 NRG=1,30                                                   SOFIP172
  160 AIFLXS(NRG) = AIFLXS(NRG)+FLUXES(NRG)                             SOFIP173
  170 CONTINUE                                                          SOFIP174
C *** ********************  RUNNING PRINTOUT MODULE  *******************SOFIP175
      GO TO (200,210),IPASS                                             SOFIP176
  200 WRITE (6,2) MODEL,MODLBL,BLTIME,NAME,INCL,IPRG,IAPG,ITAPE,PERIOD, SOFIP177
     $XAMNIM                                                            SOFIP178
      WRITE (6,201)(TYPLBL(I,ITYPE),I=1,3), ENERGY(NRGYLV,ITYPE)        SOFIP179
  201 FORMAT('0',21X,'***** ',3A4,'(E)',G9.3,'MEV)   *****'//    ' LONGSOFIP180
     $.    LAT.    ALT.   FIELD    LINE   ORBIT    POSITIONAL  TIME-INTESOFIP181
     $G    ORBITAL'/' ',T28,'-B-',T37,'-L-     TIME        FLUX     PSTNL SOFIP182
     $FLUX   FLUX(SUM)'/'  (DEG)     (DEG)    (KM)  (GAUSS)  (E.R.)   (HRS)SOFIP183
     $    #/CM**2/SEC')                                                 SOFIP184
      WRITE(6,202)PSNTM1,PSNLN1,PSNLT1,PSNAL1,PSNB1,PSNL1               SOFIP185
  202 FORMAT(' ',T41,F9.5,T2,F7.2,1X,F6.2,1X,F8.1,1X,F8.5,1X,F5.2,T50,  SOFIP186
     $7(2X,1PE10.3))                                                    SOFIP187
  210 IF(MOD(IPRINT,KPRINT).NE.0) GO TO 220                             SOFIP188
      TIFLUX = FLUXES(NRGYLV)*FLOAT(KPSTEP)*60.                         SOFIP189
      WRITE(6,202)PSNTIM,PSNLON,PSNLAT,PSNALT,PSNB,PSNL,                SOFIP190
     $FLUXES(NRGYLV),TIFLUX,FLXSUM                                      SOFIP191
  220 IPRINT=IPRINT+1                                                   SOFIP192
C *** *****************  ORBIT L-ZONE BREAKDOWN MODULE  ****************SOFIP193
C *** *******  THIS MODULE MUST BE USED WITH PERCENT TIME MODULE  ******SOFIP194
C *** STORE TIME IN INNER & OUTER ZONE, EXTERNAL                        SOFIP195
      IF(PSNL.LT.0.0.OR.PSNL.GT.11.0) GO TO 250                         SOFIP196
      IZ = IZONE(INT(PSNL/.1))                                          SOFIP197
      LCOUNT(IZ) = LCOUNT(IZ) + 1                                       SOFIP198
      GO TO 260                                                         SOFIP199
  250 LCOUNT(4) = LCOUNT(4)+1                                           SOFIP200
  260 CONTINUE                                                          SOFIP201
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C *** **********************  EXPOSURE INDEX MODULE  *******************SOFIP202
C *** STORE FLUXES AND TIMES IN INTENSITY RANGES                         SOFIP203
      GO TO(270,280),IPASS                                              SOFIP204
  270 ISWTCH=ISWTCH+1                                                   SOFIP205
  280 INTRNG = (8-INT(1.0-SIGN(0.5,ALGFLX(NRGYLV)-7.0)) *               SOFIP206
     $(7-INT(ALGFLX(NRGYLV)))) * INT(1.0+SIGN(0.5,                      SOFIP207
     $FLUXES(NRGYLV)-1.0009))+1                                         SOFIP208
      EXPFLX(INTRNG)=EXPFLX(INTRNG)+FLUXES(NRGYLV)*60.0*FLOAT(          SOFIP209
     $KPSTEP)                                                           SOFIP210
      EXPFLX(10)=EXPFLX(10)+FLUXES(NRGYLV)*60.0*FLOAT(KPSTEP)           SOFIP211
      EXPTIM(INTRNG) = EXPTIM(INTRNG) + FLOAT(KPSTEP) * .0166667        SOFIP212
      EXPTIM(10) = EXPTIM(10) + FLOAT(KPSTEP) * .0166667                SOFIP213
C *** ***************  PEAK AND TOTALS PER ORBIT MODULE  ***************SOFIP214
C *** DETERMINE ORBIT NUMBER AND TOTAL FLUXES PER ORBIT                 SOFIP215
      IF(PSNTIM.LT.TAU) GO TO 300                                       SOFIP216
      PEAK = -1.0                                                       SOFIP217
      TAUFLX(NORBIT) = FLXSUM-OFLXSM                                    SOFIP218
      OFLXSM = FLXSUM                                                   SOFIP219
      NRBITO=NORBIT                                                     SOFIP220
      NORBIT = NORBIT+1                                                 SOFIP221
      TAU = NORBIT * PERIOD                                             SOFIP222
      IF(NORBIT.LE.50) GO TO 300                                        SOFIP223
      WRITE(6,301)                                                      SOFIP224
  301 FORMAT('0ERROR: NORBIT EXCEEDS LIMIT OF 50.  ************')       SOFIP225
      STOP                                                              SOFIP226
C *** DETERMINE FLUX PEAKS AND POSITIONS PER ORBIT                      SOFIP227
  300 IF(FLUXES(NRGYLV).LE.PEAK) GO TO 310                              SOFIP228
      PKFLX(NORBIT) = FLUXES(NRGYLV)                                    SOFIP229
      PKTIM(NORBIT) = PSNTIM                                            SOFIP230
      PKLON(NORBIT) = PSNLON                                            SOFIP231
      PKLAT(NORBIT) = PSNLAT                                            SOFIP232
      PKALT(NORBIT) = PSNALT                                            SOFIP233
      PKB(NORBIT) = PSNB                                                SOFIP234
      PKL(NORBIT) = PSNL                                                SOFIP235
      PEAK = FLUXES(NRGYLV)                                             SOFIP236
  310 CONTINUE                                                          SOFIP237
C *** ******************  GEOMAGNETIC SHIELDING MODULE  *****************SOFIP238
C *** *******  THIS MODULE MUST BE USED WITH SOLAR PROTON MODULE  ******SOFIP239
      IF(INT(PSNL).GE.5.OR.PSNL.LE.0.0) L=L+1                           SOFIP240
C *** ************  BLOCK 4: LOOPING  (READ-LOOP ENDS HERE)  ***********SOFIP241
      IPASS=2                                                           SOFIP242
      GO TO 50                                                          SOFIP243
C *** ******************  BLOCK 5: OUTPUT PREPARATION  *****************SOFIP244
C *** COMPOSITE ORBIT SPECTRUM                                          SOFIP245
  400 AFCTRS = (KPSTEP*1440.0) / (PSNTIM*86400.0)                       SOFIP246
      DO 410 NRG=1,30                                                   SOFIP247
      AIFLXS(NRG) = AIFLXS(NRG)*AFCTRS                                  SOFIP248
      IF(AIFLXS(NRG).LE.0.0) GO TO 440                                  SOFIP249
      ALNFLX(NRG) = ALOG(AIFLXS(NRG))                                   SOFIP250
  410 CONTINUE                                                          SOFIP251
  440 DO 450 NRG=1,29                                                   SOFIP252
  450 DIFFLX(NRG) = AIFLXS(NRG)-AIFLXS(NRG+1)                           SOFIP253
      DIFFLX(30) = AIFLXS(30)                                           SOFIP254
C *** **********************  PERCENT TIME MODULE  *********************SOFIP255
C *** **  THIS MODULE MUST BE USED WITH ORBIT L-ZONE BREAKDOWN MODULE  *SOFIP256
C *** CALCULATE AND PRINT PERCENT TIME TABLE                            SOFIP257
      LSUM=LCOUNT(1) + LCOUNT(2) + LCOUNT(3) + LCOUNT(4)                SOFIP258
      IF(LSUM.EQ.0) GO TO 470                                           SOFIP259
      DO 460 IL=1,4                                                     SOFIP260
  460 PTIME(IL)=FLOAT(LCOUNT(IL)*KPSTEP)*1.66667/TMLAST                 SOFIP261
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      PTIZ=PTIME(1)+PTIME(2)                                            SOFIP262
      WRITE(6,401)PTIZ,(PTIME(II),II=1,4),PSNTIM                        SOFIP263
  470 CONTINUE                                                          SOFIP264
  401 FORMAT('0***** PERCENT OF TOTAL LIFETIME SPENT INSIDE AND OUTSIDE SOFIP265
     $TRAPPED PARTICLE RADIATION BELT ****'//6X,'INNER ZONE (1.0 (= L ( SOFIP266
     $2.8)  : ',F6.2,' %'/18X,'OUTSIDE TRAPPING REGION (1.0 (= L ( 1.1) SOFIP267
     $: ',F6.2,' %'/18X,'INSIDE TRAPPING REGION  (1.1 (= L ( 2.8) : ',  SOFIP268
     $F6.2,' %'/6X,'OUTER ZONE (2.8 (= L (= 11.0) : ',F6.2,' %'/6X,'EXTESOFIP269
     $RNAL   (L ) 11.0)             : ',F6.2,' %'//' TOTAL ORBIT TIME IS :',SOFIP270
     $F8.2,' HOURS')                                                    SOFIP271
C *** *****************  DIFFERENTIAL SPECTRUM MODULE  *****************SOFIP272
      CALL DSPCTR(ALNFLX(1),ENERGY(1,ITYPE),DIFSPC(1))                  SOFIP2C
C *** ****  THIS MODULE MUST BE USED WITH GEOMAG. SHIELDING MODULE  ****SOFIP275
      T=12.                                                             SOFIP2
      IQ=90
      ISWTCH=ISWTCH+2                                                   SOFIP279
      IF(L.LE.0) GO TO 510                                              SOFIP280
      CALL SOLPRO(T,IQ,F,INALE)                                         SOFIP281
      EXPOTM=FLOAT(L*KPSTEP)*.0166667                                   SOFIP282
      EXPFCT=(EXPOTM/PSNTIM)                                            SOFIP283
      DO 500 J=1,20                                                     SOFIP284
      F(J)=F(J)*EXPFCT                                                  SOFIP285
  500 CONTINUE                                                          SOFIP286
  510 CONTINUE                                                          SOFIP287
C *** **********************  OUTPUT PUNCH MODULE  *********************SOFIP288
C *** PUNCHES ENERGY, INTEG AND DIFF FLUX, SOLAR PROTONS IF PRESENT     SOFIP289
C
C     PUNCH OUTPUT MODULE MODIFIED ON THE REQUEST OF THE USER (FLAG='+')
C     IT GIVES MORE INFORMATION IN THREE DIFFERENT FILES.
C
      IF (FLAG.NE.'+') GOTO 520
C
       WRITE(7,1)NAME,INCL,IPRG,IAPG,ITAPE,MODEL,PERIOD,BLTIME,NRGYLV,
     $ NTABLS,CUTOFF,ISKIP,KPRINT
       WRITE(7,606) (TYPLBL(K,ITYPE),K=1,3),(ENERGY(N,ITYPE),AIFLXS(N),
     $ DIFFLX(N),DIFSPC(N),N=1,30)
C
       WRITE(8,1)NAME,INCL,IPRG,IAPG,ITAPE,MODEL,PERIOD,BLTIME,NRGYLV,
     $ NTABLS,CUTOFF,ISKIP,KPRINT
       WRITE(8,607) IT,IQ,INALE,EXPFCT,(SPNRG(N),F(N),N=1,20)
C
       WRITE(9,1)NAME,INCL,IPRG,IAPG,ITAPE,MODEL,PERIOD,BLTIME,NRGYLV,
     $ NTABLS,CUTOFF,ISKIP,KPRINT
       WRITE(9,608) (TYPLBL(K,ITYPE),K=1,3),ENERGY(NRGYLV,ITYPE),
     $  (FIRNGS(N), EXPTIM(N),EXPFLX(N),N=1,9)
C
 606  FORMAT(1X,16('*'),3X,3A4,2X,16('*')/,1X,49('*')/,1X,11('*'),'  COM
     $POSITE ORBIT SPECTRUM ',11('*')///,T1,'ENERGY  ',
     $'   AVERAGED     DIFFERENCE       AVERAGED DIFFE-'/' ',T1,'LEVELS
     $ INTEGRAL FLUX  INTEGRAL FLUX     RENTIAL FLUX'/' ',T1,  ')(MEV)
     $  #/CM**2/SEC  #/CM**2/SEC/DE    #/CM**2/SEC/KEV'//30(' ',T1,
     $G9.4,T6,'     ',E10.4,5X,E10.4,7X,E10.4/))
C
  607 FORMAT(1X,
     $'**** SOLAR PROTONS ****'//,2X,'FOR TAU=',I2,',Q=',I2,': NALE=',
     $I1/,2X,'WITH GEOMAG SHIELDING'/,3X,'(EXPOSR FACTOR=',F4.2,')'//
     $,3X,'ENERGY        TOTAL'/,3X,
     $'LEVELS        FLUENCE'/,3X,')(MEV)       #/CM**2'//,20(3X,F4.0,7X,
     $E10.4/) )
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C
 608  FORMAT(1X,16('*'),3X,3A4,2X,16('*')/,1X,49('*')/,1X,6('*'),' EXPO
     $SURE INDEX: ENERGY)',G9.3,'MEV *****'//,1X,'INTENSITY    EXPOSURE
     $TOTAL # OF'/,2X,' RANGES      DURATION   ACCUMULATED'/,1X,
     $'#/CM**2/SEC  (HOURS)    PARTICLES'//,9(1X,A4,6X,F10.3,1X,E13.4/))
C
      GOTO 530
  520 CONTINUE
C
      WRITE(7,605) NAME,INCL,IPRG,IAPG,MODEL,BLTIME                     SOFIP290
      WRITE(7,602)((ENERGY((II-1)*6+JJ,ITYPE),JJ=1,6),XLABEL(1,ITYPE),IISOFIP291
     $,II=1,5)                                                          SOFIP292
      WRITE(7,602)((AIFLXS((II-1)*6+JJ),JJ=1,6),XLABEL(2,ITYPE),II,II=1,SOFIP293
     $5)                                                                SOFIP294
      WRITE(7,602)((DIFSPC((II-1)*6+JJ),JJ=1,6),XLABEL(3,ITYPE),II,II=1,SOFIP295
     $5)                                                                SOFIP296
      IF(L.LE.0) GO TO 600                                              SOFIP297
      WRITE(7,603) IQ,T,INALE,EXPFCT                                    SOFIP298
      WRITE(7,604)((SPNRG((II-1)*5+JJ),JJ=1,5),PROTLB(1),II,II=1,4)     SOFIP299
      WRITE(7,604)((F((II-1)*5+JJ),JJ=1,5),PROTLB(2),II,II=1,4)         SOFIP300
  600 CONTINUE                                                          SOFIP301
C
  530 CONTINUE
C
  602 FORMAT(1P6E12.4,A6,I2)                                            SOFIP302
  603 FORMAT('SOLAR PROTONS  #ENERGIES=20   Q=',I2,'  TAU=',F4.1,       SOFIP303
     $'  NALE=',I1,'  EXPFCTR=',F5.2)                                   SOFIP304
  604 FORMAT(1P5E12.4,12X,A6,I2)                                        SOFIP305
  605 FORMAT(3A4,1X,I2,'//',I5,'-',I6,1X,'I(#/CM**2-SEC) D(#/CM**2-SEC-KESOFIP306
     $V) MOD/TM=',I1,'/',F6.1)                                          SOFIP307
C *** ********************  OUTPUT TABLES MODULE 1  ********************SOFIP308
      DO 900 NTBL=1,NTABLS                                              SOFIP309
      WRITE(6,2) MODEL,MODLBL,BLTIME,NAME,INCL,IPRG,IAPG,ITAPE,PERIOD,  SOFIP310
     $XAMNIM                                                            SOFIP311
      GO TO (710,700,730,720),ISWTCH                                    SOFIP312
C *** COMPOSITE ORBIT SPECTRUM AND EXPOSURE INDEX                       SOFIP313
  700 WRITE (6,701) (TYPLBL(K,ITYPE),K=1,3),ENERGY(NRGYLV,ITYPE),       SOFIP314
     $(ENERGY(N,ITYPE),AIFLXS(N),DIFFLX(N),DIFSPC(N),FIRNGS(N),         SOFIP315
     $FIRNGS(N+1),EXPTIM(N),EXPFLX(N),N=1,10),(ENERGY(N,ITYPE),AIFLXS(N)SOFIP316
     $,DIFFLX(N),DIFSPC(N),N=11,30)                                     SOFIP317
  701 FORMAT ('+',41X,16('*'),3X,3A4,2X,16('*')/' ',41X,49('*')////'0', SOFIP318
     $T18,15('*'),' COMPOSITE ORBIT SPECTRUM ',15('*'),T80,'** EXPOSURE SOFIP319
     $INDEX:ENERGY)',G9.2,T112,'MEV **'/'0',T18,'ENERGY     AVERAGED    SOFIP320
     $   DIFFERENCE     AVERAGED DIFFE-        INTENSITY    EXPOSURE   TOSOFIP321
     $TAL # OF'/' ',T18,'LEVELS   INTEGRAL FLUX   INTEGRAL FLUX    RENTISOFIP322
     $AL FLUX',10X,'RANGES      DURATION   ACCUMULATED'/' ',T18,')(MEV) SOFIP323
     $  #/CM**2/SEC     #/CM**2/SEC/DE  #/CM**2/SEC/KEV       #/CM**2/SECSOFIP324
     $   (HOURS)      PARTICLES'/'0',T18,0PG9.4,T23,'    ',1PE9.3,7X,   SOFIP325
     $1PE9.3,8X,1PE9.3,T81,2A4,T81,'ZERO FLUX',1X,0PF10.3,1X,1PE13.3/8('SOFIP326
     $ ',T18,0PG9.4,1PE9.3,7X,1PE9.3,8X,1PE9.3,T81,A4,'-',A4,1X,0PF10.3,SOFIP327
     $1X,1PE13.3/),' ',T18,0PG9.4,1PE9.3,7X,1PE9.3,8X,1PE9.3/' ',T81,2A4SOFIP328
     $,T81,'     TOTAL',1X,0PF10.3,1X,1PE13.3,20(T18,0PG9.4,1PE9.3,7X,   SOFIP329
     $1PE9.3,8X,1PE9.3/' '))                                            SOFIP330
      GO TO 750                                                         SOFIP331
C *** COMPOSITE ORBIT SPECTRUM ONLY                                     SOFIP332
  710 WRITE (6,702) (TYPLBL(K,ITYPE),K=1,3),(ENERGY(N,ITYPE),AIFLXS(N), SOFIP333
     $DIFFLX(N),DIFSPC(N),N=1,30)                                       SOFIP334
  702 FORMAT ('+',41X,16('*'),3X,3A4,2X,16('*')/' ',41X,49('*')////'0', SOFIP335
     $T40,15('*'),' COMPOSITE ORBIT SPECTRUM ',15('*')/'0',T40,'ENERGY  SOFIP336
     $   AVERAGED     DIFFERENCE        AVERAGED DIFFE-'/' ',T40,'LEVELS SOFIP337
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     $  INTEGRAL FLUX  INTEGRAL FLUX     RENTIAL FLUX'/' ',T40,')(MEV)  SOFIP338
     $  #/CM**2/SEC  #/CM**2/SEC/DE    #/CM**2/SEC/KEV'//30(' ',T41,    SOFIP339
     $0PG9.4,T46,'     ',1PE9.3,6X,1PE9.3,8X,1PE9.3/))                  SOFIP340
      GO TO 750                                                         SOFIP341
C *** COMPOSITE ORBIT SPECTRUM WITH SOLAR PROTONS AND EXPOSURE INDEX     SOFIP342
  720 WRITE(6,703)(TYPLBL(K,ITYPE),K=1,3),IT,IQ,INALE,ENERGY(NRGYLV,    SOFIP343
     $ITYPE),EXPFCT,(ENERGY(N,ITYPE),AIFLXS(N),DIFFLX(N),DIFSPC(N),SPNRGSOFIP344
     $(N),F(N),FIRNGS(N),FIRNGS(N+1),EXPTIM(N),EXPFLX(N),N=1,10),(ENERGYSOFIP345
     $(N,ITYPE),AIFLXS(N),DIFFLX(N),DIFSPC(N),SPNRG(N),F(N),N=11,20),   SOFIP346
     $(ENERGY(N,ITYPE),AIFLXS(N),DIFFLX(N),DIFSPC(N),N=21,30)           SOFIP347
  703 FORMAT('+',41X,16('*'),3X,3A4,2X,16('*')/' ',41X,49('*'))///'0',  SOFIP348
     $62X,'**** SOLAR PROTONS ****'//63X,'FOR TAU=',I2,',Q=',I2,': NALE=SOFIP349
     $',I1/3X,15('*'),' COMPOSITE ORBIT SPECTRUM ',15('*'),5X,'WITH GEOMSOFIP350
     $AG SHIELDING',8X,'** EXPOSURE INDEX: ENERGY)',G9.4,T125,' MEV **'/SOFIP351
     $64X,'(EXPOSR FACTOR=',F4.2,')'//3X,'ENERGY     AVERAGED       DIFFSOFIP352
     $ERENCE     AVERAGED DIFF-       ENERGY       TOTAL          INTENSOFIP353
     $SITY    EXPOSURE   TOTAL # OF'/3X,'LEVELS   INTEGRAL FLUX  INTEGRASOFIP354
     $L FLUX    RENTIAL FLUX         LEVELS      FLUENCE          RANGESOFIP355
     $S       DURATION   ACCUMULATED'/3X,')(MEV)     #/CM**2/SEC  #/CM**2/SOFIP356
     $SEC/DE   #/CM**2/SEC/KEV        )(MEV)       #/CM**2          #/CM**2SOFIP357
     $/SEC    (HOURS)       PARTICLES'//T4,0PG9.4,T9,'       ',1PE9.3,6X,   SOFIP358
     $1PE9.3,7X,1PE9.3,11X,0PF4.0,7X,1PE9.3,T95,2A4,T95,'ZERO FLUX',    SOFIP359
     $0PF11.3,1PE14.3/8(T4,0PG9.4,T9,'       ',1PE9.3,6X,1PE9.3,7X,1PE9.3SOFIP360
     $,11X,0PF4.0,7X,1PE9.3,9X,A4,'-',A4,0PF11.3,1PE14.3/),T4,0PG9.4,T9,SOFIP361
     $'       ',1PE9.3,6X,1PE9.3,7X,1PE9.3,11X,0PF4.0,7X,1PE9.3,T95,2A4, SOFIP362
     $T95,'    TOTAL',0PF11.3,1PE14.3/10(T4,0PG9.4,T9,'       ',1PE9.3,6XSOFIP363
     $,1PE9.3,7X,1PE9.3,11X,0PF4.0,7X,1PE9.3/),10(T4,0PG9.4,T9,'       ',SOFIP364
     $1PE9.3,6X,1PE9.3,7X,1PE9.3/))                                     SOFIP365
      GO TO 750                                                         SOFIP366
C *** COMPOSITE ORBIT SPECTRUM WITH SOLAR PROTONS                         SOFIP367
  730 WRITE(6,704)(TYPLBL(K,ITYPE),K=1,3),IT,IQ,INALE,EXPFCT,(ENERGY(N, SOFIP368
     $ITYPE),AIFLXS(N),DIFFLX(N),DIFSPC(N),SPNRG(N),F(N),N=1,20),       SOFIP369
     $(ENERGY(N,ITYPE),AIFLXS(N),DIFFLX(N),DIFSPC(N),N=21,30)           SOFIP370
  704 FORMAT('+',41X,16('*'),3X,3A4,2X,16('*')/' ',41X,49('*'))///T93,  SOFIP371
     $'**** SOLAR PROTONS ****'//T93,'FOR TAU=',I2,',Q=',I2,': NALE=',  SOFIP372
     $I1/19X,15('*'),' COMPOSITE ORBIT SPECTRUM ',15('*'),18X,'WITH GEOMSOFIP373
     $AG SHIELDING'/T94,'(EXPOSR FACTOR=',F4.2,')'//19X,'ENERGY     AVERSOFIP374
     $AGED        DIFFERENCE      AVERAGED DIFF-',20X,'ENERGY        TOTAL'SOFIP375
     $/19X,'LEVELS   INTEGRAL FLUX  INTEGRAL FLUX    RENTIAL FLUX',22X, SOFIP376
     $'LEVELS        FLUENCE'/19X,')(MEV)     #/CM**2/SEC  #/CM**2/SEC/DE  SOFIP377
     $ #/CM**2/SEC/KEV',20X,')(MEV)       #/CM**2'//20(T20,0PG9.4,T25,'  SOFIP378
     $    ',1PE9.3,6X,1PE9.3,7X,1PE9.3,24X,0PF4.0,7X,1PE9.3/),10(T20,   SOFIP379
     $0PG9.4,T25,'       ',1PE9.3,6X,1PE9.3,7X,1PE9.3/))                SOFIP380
  750 CONTINUE                                                          SOFIP381
C *** *********************  OUTPUT TABLES MODULE 2  *********************SOFIP382
C *** PEAK AND TOTAL FLUXES PER PERIOD                                  SOFIP383
      WRITE(6,2) MODEL,MODLBL,BLTIME,NAME,INCL,IPRG,IAPG,ITAPE,PERIOD,  SOFIP384
     $XAMNIM                                                            SOFIP385
      WRITE(6,801)(TYPLBL(K,ITYPE),K=1,3),ENERGY(NRGYLV,ITYPE),         SOFIP386
     $(N,(PKVALU(N,K),K=1,8),N=1,NRBITO)                                SOFIP387
  801 FORMAT(                   '+',T35,24('*'),3X,3A4,2X,27('*')/' ',T35, SOFIP388
     $'** TABLE OF PEAK AND TOTAL FLUXES PER PERIOD : ENERGY )',G9.2,T97SOFIP389
     $,    'MEV **'/' ',T35,68('*')//'0',13X,'PERIOD     PEAK FLUX      POSOFIP390
     $SITION AT WHICH ENCOUNTERED    ORBIT TIME     FIELD(B)     LINE(L)  SOFIP391
     $  TOTAL FLUX'/' ',13X,'NUMBER      ENCOUNTERED      LONGITUDE  LATITUDSOFIP392
     $E  ALTITUDE',41X,'PER ORBIT'/  ' ',23X,'#/CM**2/SEC ',2(5X,'(DEG)'SOFIP393
     $),6X,'(KM)',7X,'(HOURS)',6X,'(GAUSS)      (E.R.)      #/CM**2/ORBIT'SOFIP394
     $//(' ',14X,I4,1PE14.3,0PF13.3,F10.2,F12.2,F13.5,F12.5,F10.2,1PE15.SOFIP395
     $3))                                                               SOFIP396
C *** ******************  BLOCK 6: PROGRAM TERMINATION  ******************SOFIP397
  900 CONTINUE                                                          SOFIP398
      GO TO 10                                                          SOFIP399
  999 STOP                                                              SOFIP400
      END                                                               SOFIP401
```

```
      SUBROUTINE INDATA(EL,DEL,DJ,HO,DT,TF,TM,PER,IPRG,IAPG)

C
C        THE SUBROUTINE INDATA READ THE ORBITAL PARAMETERS.
C     OUTPUTS: EL     KEPLERIAN ELEMENTS (METERS AND RAD)
C              DEL    TIME VARIATIONS OF THE ELEMENTS
C              DJ     MODIFIED JULIAN DATE
C              HO     HOUR OF THE DAY
C              DT     TIME INCREMENT (HOURS)
C              TF     TIME INTERVAL FOR PROPAGATION (HOURS)
C              TM     DECIMAL YEAR FOR B-L CALCULATIONS
C              PER    ORBITAL PERIOD (HOURS)
C              IPRG   PERIGEE ALTITUDE IN KM
C              IAPG   APOGEE ALTITUDE IN KM
C
C    AUTHOR:   VALDEMIR CARRARA  FEB/87
C
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION EL(6),DEL(6)
      COMMON /CONSTA/ PI,PIT2,PID2,RAD,DEG
      COMMON /CEARTH/ RE,GM,FLAT,TETP

      CALL CONSTP

      READ(5,*,END=999) YE,AM,DA,HO,DT,TF
      READ(5,*,END=999) EL
      DJ    = DJM(YE,AM,DA)
      IPRG  = EL(1)
      IAPG  = EL(2)
      SM    = (EL(1) + EL(2))/2.D0 + RE/1.D03
      EL(2)= (EL(2) - EL(1))/2.D0/SM
      EL(1)= SM*1.D03
      EL(3)= EL(3)*RAD
      EL(4)= EL(4)*RAD
      EL(5)= EL(5)*RAD
      EL(6)= EL(6)*RAD
      DJ    = DJM(YE,AM,DA)
      TM    = YE + (DJ - DJM(YE,1.D0,1.D0))/3.6525D02
      PER   = PIT2*SQRT(EL(1)/3.98D14)*EL(1)/3.6D03

      CALL VARELK(EL,DEL)

      RETURN

  999 STOP
      END
```

```
      SUBROUTINE ORBPR(EL,DEL,DJ,HO,TM,DM,MODL,ALON,ALAT,ALT,BB,FL)
C
C        THE SUBROUTINE ORBPR OBTAINS THE MEAN ORBITAL ELEMENTS
C       AT THE GIVEN TIME DM, USING AN ANALITICAL ORBIT-PROPAGA-
C       TOR. AT THIS POINT, IT ALSO CALCULATES  THE  GEOMAGNETIC
C       FIELD AND GEOMAGNETIC LINE, USING THE SUBROUTINE  INVARA
C       (STASSINOPOULOS, E. G. AND MEAD, G. D. "ALLMAG,  GDALMG,
C       LINTRA: COMPUTER  PROGRAMS  FOR  GEOMAGNETIC  FIELD  AND
C       FIELD-LINE CALCULATIONS", NSSDC 72-12, GREENBELT,  MARY-
C       LAND, FEB.1972).
C
C       INPUTS: EL   KEPLERIAN ELEMENTS (METERS AND RADS)
C               DEL  TIME VARIATIONS OF THE ELEMENTS
C               DJ   MODIFIED JULIAN DATE
C               HO   HOUR OF DAY AT THE BEGINING OF CALCULATION
C               TM   DECIMAL YEAR FOR B-L COMPUTATIONS
C               DM   TIME FOR POSITIONING EVALUATIONS
C               MODL GEOMAGNETIC MODEL SELECTOR (1-7)
C
C       OUTPUTS:ALON LONGITUDE OF THE POINT IN DEGREES
C               ALAT GEOCENTRIC LATITUDE (DEGREES)
C               ALT  ALTITUDE ABOVE THE ELLIPSOID IN KM
C               BB   GEOMAGNETIC FIELD
C               FL   GEOMAGNETIC LINE
C
C       SUBROUTINES CALLED IN THIS SUBPROGRAM:
C               SATPOS
C               SGMT
C               INEGEP
C               INVARA
C
C       AUTHOR: VALDEMIR CARRARA  FEB./1987
C
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION EL(6),DEL(6),ER(6),XI(6),XG(6),GE(6)
      COMMON/CONSTA/ PI,PIT2,PID2,RAD,DEG
      COMMON/CEARTH/ RE,GM,FLAT,TETP

      DS    = DM*.36D04
      ER(1)= EL(1)
      ER(2)= EL(2)
      ER(3)= EL(3)
      ER(4)= DMOD(EL(4)+DEL(4)*DS,PIT2)
      ER(5)= DMOD(EL(5)+DEL(5)*DS,PIT2)
      ER(6)= DMOD(EL(6)+DEL(6)*DS,PIT2)

      CALL SATPOS(ER,XI)
```

```
      SUBROUTINE MODSEL(MODEL)
C
C         THE SUBROUTINE MODSEL  READS DATA  INPUTS TO CHOOSE THE
C     APROPRIATE GEOMAGNETIC FIELD AND RADIATION MODELS.
C
C     OUTPUTS: MODEL  NUMBER OF THE MAGNETIC FIELD MODEL (1-7)
C
C     AUTHOR : VALDEMIR CARRARA   02/87
C

      MODEL = 1
      IPE   = 0
      IMM   = 0
      IOZ   = 0
      READ(5,*,END=999) MODEL,IPE,IMM,IOZ
      IF(IPE.EQ.1) GOTO 30
      IF(IPE.NE.0) GOTO 200
      IF(IMM.EQ.1) GOTO 20
      IF(IMM.NE.0) GOTO 200
      CALL AP8MIN
      GOTO 120

   20 CONTINUE
      CALL AP8MAX
      GOTO 120

   30 CONTINUE
      IF(IMM.EQ.1) GOTO 60
      IF(IMM.NE.0) GOTO 200
      CALL AE5MIN
      GOTO 80

   60 CONTINUE
      CALL AE6MAX

   80 CONTINUE
      IF(IOZ.EQ.1) GOTO 100
      IF(IOZ.NE.0) GOTO 200
      CALL AEI7LO
      GOTO 120

  100 CONTINUE
      CALL AEI7HI

  120 RETURN

  200 WRITE(6,6000) IPE,IMM,IOZ
 6000 FORMAT('  >> ERROR IN THE INPUT DATA OF THE MODEL SELECTION ',
     1       3I5)
  999 STOP
      END
```

```
      GW    = SGMT(DJ,HO*.36D04+DS)

      CALL INEGEP(GW,XI,XG)

C** APROXIMATION FOR GEOCENTRIC LATITUDE AND ALTITUDE

      XY2   = XG(1)*XG(1) + XG(2)*XG(2)
      XYS   = SQRT(XY2)
      ALON  = DATAN2(XG(2)/XYS,XG(1)/XYS)*DEG
      XY3   = XG(3)*XG(3)
      RV2   = XY2 + XY3
      FM2   = 1.D0 - FLAT
      FM2   = 1.D0/FM2/FM2 - 1.D0
      ALT   = (SQRT(RV2) - RE/SQRT(1.D0+FM2*XY3/RV2))*1.D-03
      ALAT  = DATAN2(XG(3),XYS)*DEG

      CALL INVARA(MODL,TM,ALAT,ALON,ALT,0.01D0,BB,FL)

      RETURN

      END
```

```
$EMA /PRELMO/
      SUBROUTINE AP8MIN
C
C       THE SUBROUTINE AP8MIN READS THE 'AP8MIN.DAT' DATA  FILE
C      AND STORES IN A COMMON BLOCK
C
C      DATA FILE UTILIZED: AP8MIN.DAT
C
C      AUTHOR: VALDEMIR CARRARA  03/87
C
      IMPLICIT INTEGER*4 (I-N)
      DOUBLE PRECISION NAME

      COMMON /PRELMO/ NAME,EPOCH,SCAE,SCAL,SCAB,SCAF,LENGTH,
     1 LI(6689)

      OPEN(UNIT=18,FILE='AP8MIN.DAT')

      READ(18,8010,END=999) NAME
      READ(18,8020,END=999) EPOCH,SCAE,SCAL,SCAB,SCAF,LENGTH
      LT    = LENGTH + 1
      KL    = LT/10 + 1

      DO 100 IJ = 1,KL
      IS    = 10*(IJ-1)+1
      IE    = IS+9
      IF(IE.GT.LT) IE = LT
      IF(IS.GT.LT) GOTO 100
      READ(18,8000,END=999) (LI(II),II=IS,IE)
  100 CONTINUE

      CLOSE(UNIT=18)

      RETURN

  999 STOP

 8000 FORMAT(1X,10(I6,','))
 8010 FORMAT(1X,A8)
 8020 FORMAT(1X,5F10.2,I8)

      END
```

```
$EMA /PRELMO/
      SUBROUTINE AP8MAX
C
C        THE SUBROUTINE AP8MAX READS THE 'AP8MAX.DAT' DATA  FILE
C      AND STORES IN A COMMON BLOCK
C
C      DATA FILE UTILIZED: AP8MAX.DAT
C
C      AUTHOR: VALDEMIR CARRARA  03/87
C
      IMPLICIT INTEGER*4 (I-N)
      DOUBLE PRECISION NAME

      COMMON /PRELMO/ NAME,EPOCH,SCAE,SCAL,SCAB,SCAF,LENGTH,
     1 LI(6689)

      OPEN(UNIT=18,FILE='AP8MAX.DAT')

      READ(18,8010,END=999) NAME
      READ(18,8020,END=999) EPOCH,SCAE,SCAL,SCAB,SCAF,LENGTH
      LT   = LENGTH + 1
      KL   = LT/10 + 1

      DO 100 IJ = 1,KL
      IS   = 10*(IJ-1)+1
      IE   = IS+9
      IF(IE.GT.LT) IE = LT
      IF(IS.GT.LT) GOTO 100
      READ(18,8000,END=999) (LI(II),II=IS,IE)
  100 CONTINUE

      CLOSE(UNIT=18)

      RETURN

  999 STOP

 8000 FORMAT(1X,10(I6,','))
 8010 FORMAT(1X,A8)
 8020 FORMAT(1X,5F10.2,I8)

      END
```

```
$EMA /PRELMO/
      SUBROUTINE AE5MIN
C
C        THE SUBROUTINE AE5MIN READS THE 'AE5MIN.DAT' DATA  FILE
C     AND STORES IN A COMMON BLOCK
C
C     DATA FILE UTILIZED: AE5MIN.DAT
C
C     AUTHOR: VALDEMIR CARRARA  03/87
C
      IMPLICIT INTEGER*4 (I-N)
      DOUBLE PRECISION NAME

      COMMON /PRELMO/ NAME,EPOCH,SCAE,SCAL,SCAB,SCAF,LENGTH,
     1 LI(6689)

      OPEN(UNIT=18,FILE='AE5MIN.DAT')

      READ(18,8010,END=999) NAME
      READ(18,8020,END=999) EPOCH,SCAE,SCAL,SCAB,SCAF,LENGTH
      LT    = LENGTH + 1
      KL    = LT/10 + 1

      DO 100 IJ = 1,KL
      IS    = 10*(IJ-1)+1
      IE    = IS+9
      IF(IE.GT.LT) IE = LT
      IF(IS.GT.LT) GOTO 100
      READ(18,8000,END=999) (LI(II),II=IS,IE)
  100 CONTINUE

      CLOSE(UNIT=18)

      RETURN

  999 STOP

 8000 FORMAT(1X,10(I6,','))
 8010 FORMAT(1X,A8)
 8020 FORMAT(1X,5F10.2,I8)

      END
```

```
$EMA /PRELMO/
      SUBROUTINE AE6MAX
C
C         THE SUBROUTINE AE6MAX READS THE 'AE6MAX.DAT' DATA  FILE
C       AND STORES IN A COMMON BLOCK
C
C       DATA FILE UTILIZED: AE6MAX.DAT
C
C       AUTHOR: VALDEMIR CARRARA  03/87
C
      IMPLICIT INTEGER*4 (I-N)
      DOUBLE PRECISION NAME

      COMMON /PRELMO/ NAME,EPOCH,SCAE,SCAL,SCAB,SCAF,LENGTH,
     1 LI(4936)

      OPEN(UNIT=18,FILE='AE6MAX.DAT')

      READ(18,8010,END=999) NAME
      READ(18,8020,END=999) EPOCH,SCAE,SCAL,SCAB,SCAF,LENGTH
      LT   = LENGTH + 1
      KL   = LT/10 + 1

      DO 100 IJ = 1,KL
      IS   = 10*(IJ-1)+1
      IE   = IS+9
      IF(IE.GT.LT) IE = LT
      IF(IS.GT.LT) GOTO 100
      READ(18,8000,END=999) (LI(II),II=IS,IE)
  100 CONTINUE

      CLOSE(UNIT=18)

      RETURN

  999 STOP

 8000 FORMAT(1X,10(I6,','))
 8010 FORMAT(1X,A8)
 8020 FORMAT(1X,5F10.2,I8)

      END
```

```
$EMA /ELOZON/
      SUBROUTINE AEI7LO
C
C        THE SUBROUTINE AEI7LO READS THE 'AEI7LO.DAT' DATA  FILE
C     AND STORES IN A COMMON BLOCK
C
C     DATA FILE UTILIZED: AEI7LO.DAT
C
C     AUTHOR: VALDEMIR CARRARA  03/87
C
      IMPLICIT INTEGER*4 (I-N)
      DOUBLE PRECISION NAME

      COMMON /ELOZON/ NAME,EPOCH,SCAE,SCAL,SCAB,SCAF,LENGTH,
     1 LI(4374)

      OPEN(UNIT=18,FILE='AEI7LO.DAT')

      READ(18,8010,END=999) NAME
      READ(18,8020,END=999) EPOCH,SCAE,SCAL,SCAB,SCAF,LENGTH
      LT    = LENGTH + 1
      KL    = LT/10 + 1

      DO 100 IJ = 1,KL
      IS    = 10*(IJ-1)+1
      IE    = IS+9
      IF(IE.GT.LT) IE = LT
      IF(IS.GT.LT) GOTO 100
      READ(18,8000,END=999) (LI(II),II=IS,IE)
  100 CONTINUE

      CLOSE(UNIT=18)

      RETURN

  999 STOP

 8000 FORMAT(1X,10(I6,','))
 8010 FORMAT(1X,A8)
 8020 FORMAT(1X,5F10.2,I8)

      END
```

```
$EMA /ELOZON/
      SUBROUTINE AEI7HI
C
C       THE SUBROUTINE AEI7HI READS THE 'AEI7HI.DAT' DATA  FILE
C     AND STORES IN A COMMON BLOCK
C
C     DATA FILE UTILIZED: AEI7HI.DAT
C
C     AUTHOR: VALDEMIR CARRARA  03/87
C
      IMPLICIT INTEGER*4 (I-N)
      DOUBLE PRECISION NAME
      COMMON /ELOZON/ NAME,EPOCH,SCAE,SCAL,SCAB,SCAF,LENGTH,
     1 LI(4374)

      OPEN(UNIT=18,FILE='AEI7HI.DAT')

      READ(18,8010,END=999) NAME
      READ(18,8020,END=999) EPOCH,SCAE,SCAL,SCAB,SCAF,LENGTH
      LT   = LENGTH + 1
      KL   = LT/10 + 1

      DO 100 IJ = 1,KL
      IS   = 10*(IJ-1)+1
      IE   = IS+9
      IF(IE.GT.LT) IE = LT
      IF(IS.GT.LT) GOTO 100
      READ(18,8000,END=999) (LI(II),II=IS,IE)
  100 CONTINUE

      CLOSE(UNIT=18)

      RETURN

  999 STOP

 8000 FORMAT(1X,10(I6,','))
 8010 FORMAT(1X,A8)
 8020 FORMAT(1X,5F10.2,I8)

      END
```