

Data and software resources at the Satellite Situation Center

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RESUMEN

El Centro de Posicionamiento de Satélites (SSC) es una unidad del Centro Nacional de Datos de Ciencias Espaciales en GSFC. Una de las principales metas del SSC es permitir la predicción de las posiciones ventajosas de un vehículo espacial relativas a: (i) estructuras magnetosféricas o interplanetarias, (ii) la posición de otros satélites, o (iii) la posición de las instalaciones en tierra. Los recursos del Centro incluyen datos y programas de computadora para graficar órbitas de vehículos espaciales. Los programas incluyen principalmente órbitas centradas en la Tierra, pero también consideran despliegues heliocéntricos. Se pueden generar listados detallados de las características de la órbita de interés así como impresiones gráficas. Están disponibles archivos pre-computados con listados de interés general. Si se solicita, los programas son ejecutados por empleados del SSC, pero en el futuro estarán disponibles en forma transportable o ejecutable a control remoto por los usuarios, por medio de conexiones de redes. Se proporciona apoyo a los usuarios radicados fuera de los USA, a través del Centro Mundial de Datos A para Cohetes y Satélites, en NSSDC. Se ilustran en este trabajo las capacidades de varios de los programas actualmente en uso en el Centro. Finalmente, se discuten los accesos remotos al Centro.

PALABRAS CLAVE: Datos, programas, el SSC.

ABSTRACT

The Satellite Situation Center (SSC) is a unit of the National Space Science Data Center at GSFC. A key goal of SSC is to allow prediction of advantageous positions for a spacecraft, relative to: (i) magnetospheric or interplanetary features, (ii) the position of other spacecraft, or (iii) the position of ground facilities. The Center resources include data and software for plotting spacecraft orbits. The software emphasizes Earth-centered orbits, but heliocentric displays are also supported. Detailed listings of key orbit characteristics as well as graphical output may be generated. Pre-computed files with listings of wide interest are available online in a publicly accessible account. Programs are executed by SSC staff on request, but in the future will be available as portable software or executed remotely by users via network connections. Support to non-U.S. users is provided through the World Data Center A for Rockets and Satellites, co-located at NSSDC. The capabilities of several programs currently in use at the Center are illustrated. Finally, remote access to the Center is discussed.

KEY WORDS: Data, software, SSC.

1. HISTORY AND DEVELOPMENT OF THE SSC

In this section, we present a brief review of the SSC history and the software products developed in connection with the SSC efforts.

1. Creation of the SSC

The Satellite Situation Center (SSC) was created to fill a need of the International Magnetospheric Study for a tool to coordinate simultaneous observations by a multi-spacecraft system or a combination of satellites and ground based stations (Vette *et al.*, 1976; Sugiura and Vette, 1977; Teague *et al.*, 1982). The initial directives established for the SSC included five major responsibilities:

- (1) To prepare reports on predicted and actually achieved satellite positions.
- (2) To respond to inquiries regarding satellite positions, experiments, and especially planned projects.
- (3) To recommend periods of special interest.

(4) To compile and update information on satellite experiments.

(5) To issue periodic status summaries.

In 1971, a need was identified for a centralized facility with computer capabilities to serve the satellite community. The National Space Science Data Center/World Data Center A for Rockets and Satellites (NSSDC/WDC-A-R&S), located at NASA/Goddard Space Flight Center (GSFC), was recommended as the appropriate site for the SSC due to its prior involvement in the acquisition and archiving of scientific satellite data. The Director of GSFC, COSPAR and the Inter-Union Commission on Solar-Terrestrial Physics approved the project, an ad hoc advisory group for the SSC, reporting to the International Magnetospheric Study Steering Committee, was established in September 1971, and the SSC became a formal element of the IMS.

2. Development of SSC software

The first generation of SSC programs, written in FORTRAN-66 and running on a MODCOMP IV/25 com-

puter was limited to report/listing outputs. In December 1975 a computer system capable of interactive graphics was added to the SSC. Requests for products generated by the SSC increased drastically after the April 1977 launch of ESA-GEOS 1 and continued for the remainder of the IMS. In 1980 SSC programs were updated/ revised to be used as planning and/or analyses tools for the Dynamics Explorer mission. In 1985 the SSC software was ported to a MODCOMP Classic II/45 computer.

With the advent of more powerful computers, the SSC software has recently been ported into the VAX and UNIX environments. The latest upgrade was released in April 1991, and incorporates the Tsyganenko magnetic field models as recommended by the Inter-Agency Consultative Group (IACG) for Space Science. Version 1.4 to be released later this year will incorporate improved models for the magnetospheric regions (according to recommendations of the IACG), as well as X-window capabilities in the UNIX environment. Finally, it is anticipated that extensive use of SSC programs will take place during the planning and coordinating phases of the Global Geospace Science Mission/International Solar-Terrestrial Program (GGS/ISTP).

II. OVERVIEW OF SSC SOFTWARE LIBRARY

This section presents an overview of the SSC programs. First, we highlight some key uses of SSC programs; then proceed to a brief description of the SSC software library and its various applications.

The SSC programs can be of use both in planning missions and analyzing data once it is taken. The primary difference in these uses is that more information on the actual state of geospace is known once data is available. Programs resident in the SSC make extensive use of "models" of various regions/boundaries in the magnetosphere. During mission planning application of the programs, actual values for many of the model parameters are not available. Therefore, a continued goal in the upgrade and revision of SSC programs is to provide default "average" values for such parameters, and then offering the option of overriding the default if better values are available during the data analysis phase.

The SSC software library contains a variety of applications, which may be divided into three main categories.

- (1) Database applications
- (2) Listing/Report generators
- (3) Graphics/Plotting applications

Database applications allow the user to view, modify and update the ephemeris database. Listing/Report programs allow generation of comprehensive reports identifying conditions suitable for coordinated observations between spacecraft and/or ground-base stations. Finally,

Plotting applications may be invoked to generate in plots of spacecraft trajectories for Earth orbiting satellites as well as heliocentric spacecraft. Plots may also be constructed to illustrate spacecraft position relative to magnetospheric or interplanetary features.

1. SSC Database

An extensive ephemeris database using common data format (CDF) has been accumulated. Existing CDF applications allow the user to view, modify and update the ephemeris database. Currently the database contains definitive and/or predictive information for the satellites/times listed in Table 1. Additions to the database are performed from time to time.

Table 1
SSC Database

Satellite Name	START TIME Year Day Hour	END TIME Year Day Hour	DATA TYPE
NOAA12	1991 182 0.0000	1992 183 8.0000	predictive
DMSPF8	1991 182 0.0000	1992 183 8.0000	predictive
DMSPF9	1991 182 0.0000	1992 183 8.0000	predictive
DE1	1981 215 10.633	1991 61 8.0000	definitive
SCATHA	1979 36 0.0000	1991 1 8.0000	definitive
ISEE1	1977 296 0.000	1987 269 6.6000	definitive
VIKING	1986 88 0.0000	1986 167 8.0000	definitive
OHZORA	1984 51 0.0000	1986 102 8.0000	definitive
OGO6	1969 156 0.0000	1970 1 8.0000	definitive
IRM	1984 256 0.0000	1986 242 8.0000	definitive
IMP8	1981 1 0.0000	1993 1 8.0000	definitive
GMS3	1986 84 0.0000	1986 182 0.0000	definitive
DE2	1981 216 0.0000	1983 50 12.3167	definitive
CRRES	1990 206 23.000	1991 137 8.0000	definitive
	1991 182 0.0000	1992 183 8.0000	predictive
CCE	1984 230 0.0000	1988 1 8.0000	definitive
AKEBONO	1989 54 0.0000	1991 138 8.0000	definitive
	1991 182 0.0000	1992 183 8.0000	predictive
ACTIVE	1989 272 0.0000	1991 138 8.0000	definitive

It must be noted that IMP8 data has been labelled as definitive beyond the present date; this fact is consistent with the essentially negligible variations in its orbit due to drag at such altitudes.

2. SSC Listing/Report Programs

Presently, the SSC listing/report library contains six programs. Brief descriptions of these applications follow here, while more detailed discussion of their capabilities and sample runs appear in the next section.

- (1) BQUERY - finds magnetic conjunctions between satellites and/or satellites and ground based stations.
- (2) DEPHM7 - lists satellite ephemeris data.

- (3) TRAJLST - traces magnetic field lines.
- (4) COORDS - tests/displays conversions among common coordinate systems used in space physics.
- (5) CONVT - displays conversions between Keplerian/ Cartesian elements.
- (6) TRAJ - generates subsatellite point and B-field foot print reports.

3. SSC Graphics/Plotting Programs

In analogy with the previous subsection, we present here brief descriptions of the graphics/plotting applications currently in use by SSC personnel and reserve more detailed discussion of their capabilities and sample runs to the next section. The SSC graphics/plotting library contains eight applications:

- (1) EARTH - plots projections of satellite orbits onto a map of the Earth's polar cap.
- (2) HELIO4 - plots heliocentric satellite orbits.
- (3) MCP - plots spacecraft trajectory projections with respect to model magnetopause/bow shock boundaries.
- (4) BAR - produces bar charts illustrating the occupation time of selected magnetospheric regions for high altitude spacecraft.

- (5) BARDE - produces bar charts illustrating the occupation time of selected magnetospheric regions for low altitude spacecraft.
- (6) BPLOT - generates plots of spacecraft distances from model bow shock/magnetopause for high altitude satellites.
- (7) NPLOT - plots spacecraft distances from a model neutral sheet for tail bound satellites.
- (8) TRAJ - produces plots of the subsatellite point and B-field foot print superimposed on a full or partial projection of the world.

III. LISTING PROGRAMS

In this section, we describe the features of each of the listing programs resident in the SSC software library. In addition, we provide sample runs of these applications, illustrating the general format of the reports which they generate.

1. BQUERY

This program generates listings of the times at which two or more satellites occupy the same magnetic flux tube. Alternatively, the program identifies periods when one or more spacecraft are inside the magnetic tube of force that rises over a selected ground-based station.

Table 2

Sample run for BQUERY

Run parameters								
Time: 1986 day 100 hour 0.00 - 1986 day 107 hour 23.00								
Conjunction search								
DE1	either hemisphere							
VIKING	either hemisphere							
Configuration								
Internal Model= DIPOLE External Model= TSYGANENKO 87								
NOWARP T87 Model SHORT IKP 4								
Moving 6.0 lat range 12.0 lon range								
0.100E+01 min-radius 0.100E+02 max-radius								
SATID	ddd	hh	mm	SLAT/ SLON	ALT >GEOID	GSEP	ARCLN	TLAT/ TLON
DE1	100	02	20	-12.0/285.1	4.144E+03	LAT:-53.9	1.204E+00	-50.6/284.0
	100	02	33	28.2/282.0	1.353E+03	LCN:280.8	3.330E+00	-57.2/277.7
VIKING	100	02	21	-50.4/275.1	8.582E+02	1.055E+00	1.554E-01	-54.5/274.5
	100	02	21	-50.4/275.1	8.582E+02	1.055E+00	1.544E-01	-54.5/274.5

Conjunctions are determined by tracing the magnetic field line passing through a selected, "lead" spacecraft and comparing the location of the footprint to either the position of the footprint corresponding to another satellite, or the location of a given ground station. The user may select the dimensions (extent in latitude and longitude) of the flux tube about the footprint of the lead spacecraft inside of which conjunctions occur. Furthermore, the user may select a representation for the magnetic field from a combination of internal and external field models available. Internal field models include a simple dipole model as well as more sophisticated models such as Barraclough, MAGSAT and various IGRF models. In addition, the user may include external field contributions according to the models of Olson and Pfitzer, Mead and Fairfield or Tsyganenko. Sample output from a search for conjunctions between the DE1 and VIKING spacecraft is shown in Table 2.

2. DEPHM7

The original version of this program created reports of satellite ephemeris data. The program produces listings of spacecraft positions in a variety of coordinate systems; in addition, the magnetospheric regions where the spacecraft resides are identified according to various models. Initially, spacecraft positions were classified according to eight magnetospheric regions; however, motivated by specifications of the DE mission, the program was revised (and renamed DEPHM7) to specify the location of a spacecraft in terms of 20 magnetospheric regions.

Sample runs of DEPHM7, tabulating GEI, GSE and GSM coordinates for AKEBONO and listing regions occupied by IMP8 appear, respectively, in Tables 3 and 4.

Table 3.A

Sample run for DEPHM7

SATELLITE NAME: AKEBONO										
UNIVERSAL TIME					GEI COORDINATES					
YYYY	DDD	HH	MM	SS	X(RE)	Y(RE)	Z(RE)			
GSE COORDINATES					GSM COORDINATES					
X	Y	Z	LAT(DEG)	LT(H)	X	Y	Z	LAT(DEG)		
1991	182	0	0	0	0.58	0.88	0.47			
0.90	-0.73	0.08	4.1	9.4	0.90	-0.73	-0.01	-0.74		
1991	182	0	1	0	0.56	0.88	0.5			
0.93	-0.71	0.15	7.4	9.5	0.93	-0.72	0.06	2.74		
1991	182	0	2	0	0.53	0.88	0.62			
0.96	-0.68	0.22	10.6	9.6	0.96	-0.70	0.13	6.11		

The magnetospheric regions occupied by IMP8 in the sample run are: 1 = Interplanetary medium, 3 = Nightside magnetosheath, 6 = Neutral sheet, 7 = Mid-latitude tail, and 8 = High-latitude tail.

Table 3.B

Sample run for DEPHM7

SATELLITE NAME: IMP8										
In region	Days	Hrs	Mins	Enters	Ireg1	Ireg2	Day	Hr	Min	
1	7	1	14.103	3	0	1986	107	1	14.103	
3	1	8	58.945	8	0	1986	108	10	13.048	
8	0	10	0.381	7	0	1986	108	20	13.429	
7	0	10	29.407	8	0	1986	109	6	42.836	
8	0	17	56.144	7	0	1986	110	0	38.979	
7	0	7	1.908	6	0	1986	110	7	40.887	

As indicated before, Version 1.4 of the SSC software, to be released later this year, includes an updated/revised set of magnetospheric regions based on improved models for certain magnetospheric boundaries. One of the key features introduced by the revised region models is the ability to displace the location magnetopause and bow-shock boundaries in response to variations in the solar wind dynamic pressure. Displacement of the magnetopause boundary has been achieved by implementing the model of Sibeck *et al.*, 1991. Since a corresponding model for the bow-shock, including variations due to solar wind conditions, is not available, we have introduced a variation to the existing Fairfield, 1971 model (the variation to Fairfield's model was derived by SSC personnel in collaboration with D. H. Fairfield). The response to solar wind pressure changes is implemented in the modified Fairfield bow-shock model by imposing a constant ratio of 1.3 between the bow-shock and magnetopause (model of Sibeck *et al.*, 1991) standoff distances.

In addition, Version 1.4 will include a new scheme of labelling/identifying regions. Instead of a single indicator identifying the region occupied by a given spacecraft, two indicators will be used; the first to label the region occupied by the spacecraft, the second to identify the region on the Earth's surface where the footprint of the "dipole-field" magnetic line passes through the spacecraft maps.

3. TRAJLST

This program accepts manual input of the location and universal time of a spacecraft, and invoking user selected models for the internal and external magnetic field contributions traces the field line passing through the satellite to an altitude specified by the user. The output also includes the magnetic field according to the selected combination of internal and external models at the input location and time. The choice of internal and external field models is the same described earlier in connection with program BQUERY. Below, we illustrate TRAJLST output for tracings from an altitude of 35,000 km, latitude = 0° and longitude = 0° down to an altitude of 100 km. Tracings shown were done with dipole + Tsyganenko 89 model combinations under quiet and disturbed conditions.

Table 4
Sample run for TRAJLST

Quiet conditions: assuming $K_p = 0, 0^+$ in T89 model.
 SUBSAT L&L/TRACED L&L / ALT B BR BT BP 1 8
 0.0&0.0/59.2&-18.9/3.5e+4 9.3e-4 -2.37e-4 -8.84e-4 -1.7e-4
 MLT= 0.07

Disturbed conditions: assuming $K_p \geq 5^-$ in T89 model.
 SUBSAT L&L/TRACED L&L / ALT B BR BT BP 1 8
 0.0&0.0/55.7&-16.4/3.5e+4 8.19e-4 -5.74e-4 -5.74e-4 -1.1e-4
 MLT= 0.07

4. COORDS

This program provides transformations between the following commonly used coordinate systems:

GEO = Geographic coordinate system. The X-axis is in the Earth's equatorial plane but fixed with the rotation of the Earth so that it passes through the Greenwich meridian (0 longitude). The Z-axis is parallel to the rotation axis, while the Y-axis completes a right handed orthogonal set.

MAG = Geomagnetic coordinates. Z is parallel to the magnetic dipole axis. Y is perpendicular to the geographic poles. Finally, X completes a right-handed orthogonal set.

GEI = Geocentric Equatorial Inertial system. X points from Earth to the first point of Aries (the position

of the Sun at the vernal equinox). Z is parallel to the rotation axis, and Y completes the right-handed orthogonal set.

GSE = Geocentric Solar Ecliptic system. X points from Earth to the Sun, Y is chosen to be in the ecliptic plane pointing towards dusk (thus opposing planetary motion). The Z-axis is parallel to the ecliptic pole. Relative to an inertial system this system has a yearly rotation.

GSM = Geocentric Solar Magnetospheric system. X points from Earth to the Sun, Y is perpendicular to the Earth's magnetic dipole so that the X-Z plane contains the dipole axis. Positive Z is in same sense as northern magnetic pole.

SM = Solar Magnetic coordinates. Z is parallel to the north magnetic pole and Y is perpendicular to the Earth-Sun line towards dusk.

Given an input position and date/time in any of the above coordinate systems, COORDS produces listing of the corresponding position in all other systems.

5. CONVT

This program allows conversion of orbital elements between Keplerian, Cartesian and Velocity sets. The program may be executed for Earth-centered as well as heliocentric element sets. Table 5 lists output from a sample run for a geocentric satellite with Keplerian elements at epoch given by year = 1980, day = 100, hour = 12, min = 0, sec = 0.00. The semi-major axis is assumed to be 30,000 km, while the eccentricity = 0.02; finally, the inclination is taken to be 10° .

Table 5
Sample run for CONVT

Anomalies (degs):
 True = 0.000000 Eccentric = 0.000000 Jtype = 1

X,Y,Z (re) = 0.46094799D+01 0.00000000D+00 0.00000000D+00
 X,Y,Z (kms) = 0.29400000D+05 0.00000000D+00 0.00000000D+00
 X,Y,Z DOT (km/s) = 0.00000000D+00 0.36622450D+01 0.64575261D+00

R = 0.2940000D+05 km, Dec and RA = 0.0000000D+00 0.3600000D+03 degs
 Geo lat, lon= 0.000 342.115 Period(hr)= 0.14364475D+02

Latitude of perigee = 0.00 degs.
 UT time of next apogee is year 1980 day 100 hour 19.182
 Local time of next apogee = 22.76 hrs.
 East longitude of next apogee = 54.098 degs.

Perigee ht = 0.23021840D+05 km Apogee ht = 0.24221840D+05 km
 Precession of perigee and node = 0.8501D-01 -0.4350D-01 deg per day
 Min apo drift= -0.1647 deg/5 rev or -0.4929 deg/day

6. TRAJ

This program generates listings of the subsatellite point as well as the magnetic field footprint of a spacecraft. The functionality is similar to that of TRAJLST but instead of manual input of the spacecraft position, TRAJ searches the database for the positions of the satellite during the interval selected. At intervals of one or more minutes, the database is queried to obtain the location of the spacecraft, and the magnetic field line passing through the satellite is traced down to a user selected altitude. The user may choose among several models for both the internal and external magnetic field contributions as described before.

A sample tracing for the DEI spacecraft assuming a dipole internal field model and no external field model is presented in Table 6. The output includes latitude and longitude of the subsatellite point, latitude and longitude of the magnetic footprint, altitude of the spacecraft as well as the magnetic field information at the satellite position.

Table 6

Sample run for TRAJ

DEI	Day: 100	Time 05:00	MODEL INT 1	EXT 9
TIME / SUBSAT	L&L / TRACED	L&L / ALT /		
	B , BR , BT ,	BP		
5:00/-5.288e+1	&6.583e+1/7.728e+1	&1.290e+0 /2.085e+4/		
	7.23e-3	6.95e-3 -1.91e-3 -5.76e-4		
5:01/-5.319e+1	&6.559e+01/7.729e+01	&4.396e-1 /2.092e+4/		
	7.18e-3	6.91e-3 -1.88e-3 -5.74e-4		
5:02/-5.350e+1	&6.535e+1/7.726e+1	&-2.644e-1 /2.0996e+4/		
	7.14e-3	6.87e-3 -1.85e-3 -5.72e-4		

This concludes the brief review of the report generator programs resident in the SSC software library; in the following section, we present the corresponding review of the graphics applications which complete the SSC repertoire.

IV. GRAPHICS PROGRAMS

In analogy to the description of listing programs in Section III, we present here descriptions and sample runs of all plotting applications resident in the SSC software library.

1. EARTH

This program generates projections of satellite trajectories onto a map of the polar cap. Trajectory segments in the northern (geomagnetic) hemisphere are represented by solid lines, while those in the southern hemisphere are delineated by dashed lines. Tick marks and the corresponding time labels may be placed, interactively, anywhere along the trajectories. Figure 1 includes a sample plot generated by EARTH for DEI and VIKING orbits.

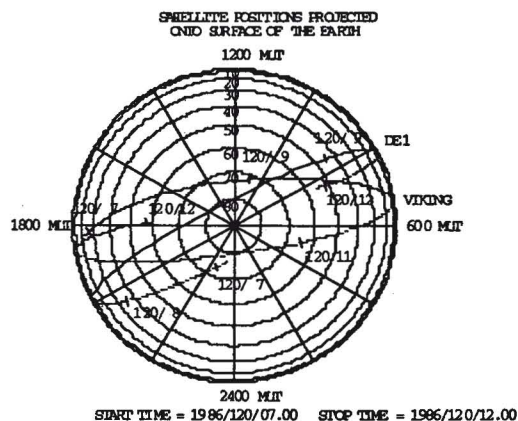


Fig. 1. Sample run for EARTH.

2. HELIO4

This program provides plots of the ecliptic plane projected trajectories of heliospheric spacecraft, planets and comets, constructed from prestored orbital element sets. Trajectories are computed assuming a two-body interaction only between the sun and the planet, comet or satellite. Options exist for true projection of the orbit, in which case the Earth is moving, and the polar plot shows the projected radial distance and ecliptic longitude. Alternatively, the user may select a stationary Earth option in which case the plot represents radial distance and the Earth-Sun-Object angle.

At users' request, interplanetary magnetic field lines, so called Archimedian spirals, can be superposed on either moving or stationary Earth plots. Furthermore, the user may interactively place time tick marks anywhere along the trajectory. Table 7 contains a listing currently exiting precomputed orbital elements.

Table 7

Planets, comets and satellites with precomputed orbital elements

Earth	Venus	HELIOS-A	PIONEER 10
Jupiter	Comet G-S	HELIOS-B	PIONEER 11
Mars	Comet G-Z	ICE	SAKIGAKE
Mercury	Comet HMP	PIONEER 6	SUISEI
Neptune	Halley's Comet	PIONEER 7	ULYSSES
Saturn	GALILEO	PIONEER 8	VOYAGER 1
Pluto	GIOTTO	PIONEER 9	VOYAGER 2
Uranus			

Figure 2 illustrates a sample plot generated by HELIO4 assuming a stationary-Earth run and depicting projections

of the ICE spacecraft and Halley's Comet trajectories within 3 A.U. between the years 1985 and 2000.

START TIME = 1985/001/00.00 STOP TIME = 2000/001/00.00

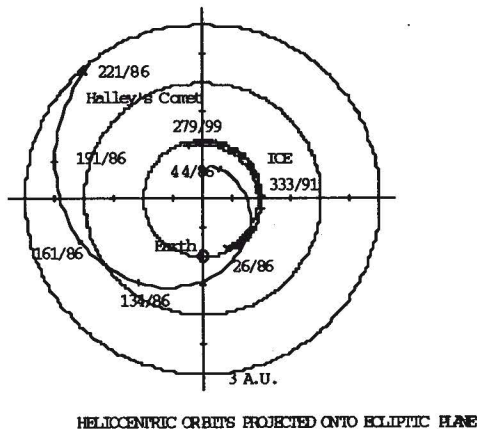


Fig. 2. Sample heliocentric trajectories.

3. MCP

This program actually includes several applications. The first two of these generate plots of spacecraft trajectories in the GSE and SM coordinate systems. Trajectories may be projected onto the X-Y or X-R planes, where

$$R = \sqrt{Y^2 + Z^2}$$

For the GSE plot, (symmetric) magnetopause and bow shock boundaries (according to Fairfield's 1971 models) are included for reference. Work is currently underway to replace the existing boundary definitions to the revised magnetopause and bow shock models described earlier in connection with the DEPHM7 application. Figure 3.A. illustrates a sample GSE plot generated by MCP for IMP8 and ISEE1 trajectories during the PROMIS interval.

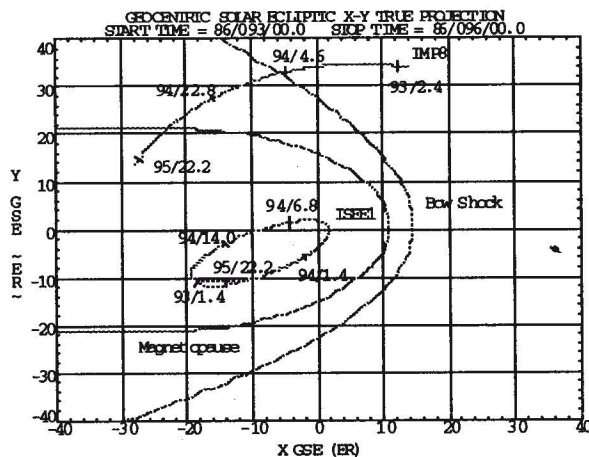


Fig. 3.A. Sample GSE ecliptic projection plot produced by MCP.

Time ticks may be placed anywhere along the trajectory to give an estimate of the time at which "model" boundaries are crossed.

An alternative application of the MCP program is to generate (Cartesian) plots of magnetic latitude versus magnetic local time with superimposed model regions for the auroral ovals and cleft. As with other applications, time ticks may be placed anywhere along the satellite trajectory. Figure 3.B. below illustrates this magnetic-latitude vs. magnetic local time plotting feature of the MCP program.

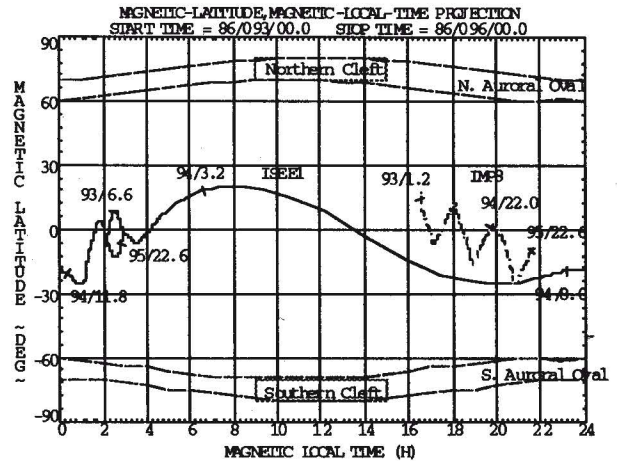


Fig. 3.B. Sample MLAT vs. MLT plot generated by MCP.

4. BAR

This program, useful for high-latitude spacecraft, generates bar charts of the time intervals when a spacecraft (up to 3 different satellites may be included in a single run) is in one of the following magnetospheric regions:

- (1) interplanetary medium
- (2) magnetosheath
- (3) magnetosphere
- (4) magnetotail
- (5) cusp

Figure 4 illustrates the bar graphs generated by the BAR application for day 96 of 1986 with data from the IRM, ISEE1 and IMP8 satellites.

The X-axis at the bottom of the lowest panel lists time in hours of the day. The lowest line in each panel identifies local time; proceeding upward, the next line identifies spacecraft latitude; values on the third line up (when present) provide a measure of the distance to the "model" neutral sheet in Earth radii (a bar over the r indicates the spacecraft is below the neutral sheet). Finally, the top line in each panel labels the region where the satellite resides; vertical lines are used to indicate the time when a spacecraft has moved onto a different region.

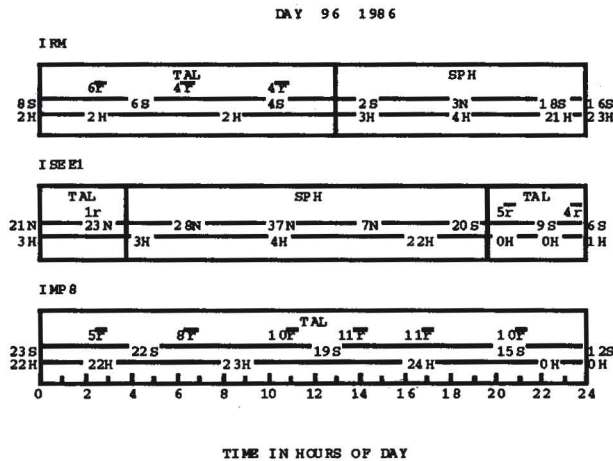


Fig. 4. Sample plot generated by BAR.

5. BARDE

This program is the counterpart to BAR, but for low-latitude spacecraft. It may be used to generate bar charts of the time intervals when a spacecraft (up to 3 different satellites may be included in a single run) is in one of the following magnetospheric regions:

- (1) magnetosphere
- (2) plasmopause
- (3) plasmasphere
- (4) plasmatrough
- (5) auroral zone
- (6) polar cap
- (7) cleft

Once again using data from the PROMIS interval, we illustrate the use of BARDE for a 90 minute interval with the CCE, VIKING and DE1 spacecraft. Figure 5 identifies the regions occupied by each of these satellites during the selected interval. Labels on the right-hand side of each

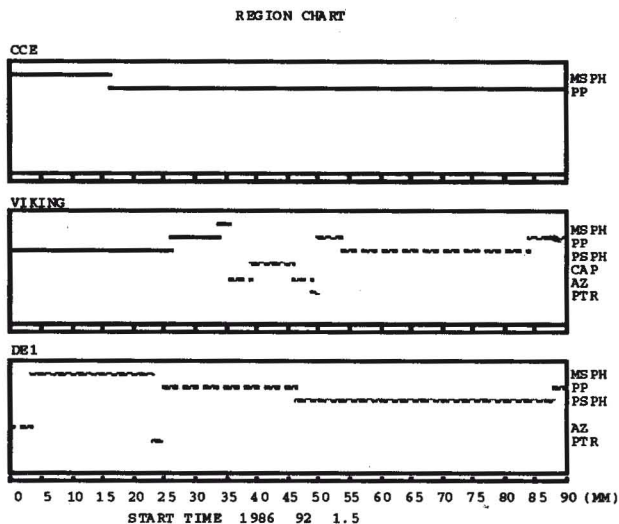


Fig. 5. Sample plot produced by BARDE.

panel identify the regions while the "type" of line used to draw the bars identifies the portion within each region where the satellite resides. For regions 1-3 (magnetosphere, plasmopause and plasmasphere) a solid line indicates the spacecraft is located on the day side while a dashed line corresponds to satellite positions on the night side (the boundary between day/night has been defined as the $X_{GSE} = 0$ plane). Alternatively, for regions 4-7 (plasmatrough, auroral zone, polar cap and cleft) solid and dashed lines correspond, respectively, to satellite positions in the northern and southern (magnetic) hemispheres.

6. BPLOT

This program generates plots illustrating the relative position between a high-altitude spacecraft and model magnetopause and bow shock boundaries. Presently, BPLOT invokes the Fairfield (1971) models for the location of the magnetopause and bow shock; however work is under way to revise these models as previously described to incorporate motion of the boundaries in response to variations in the solar wind dynamic pressure. The plot depicted in Figure 6.A. provides a sample of the output produced by BPLOT for the IMP8, ISEE1 and IRM spacecraft.

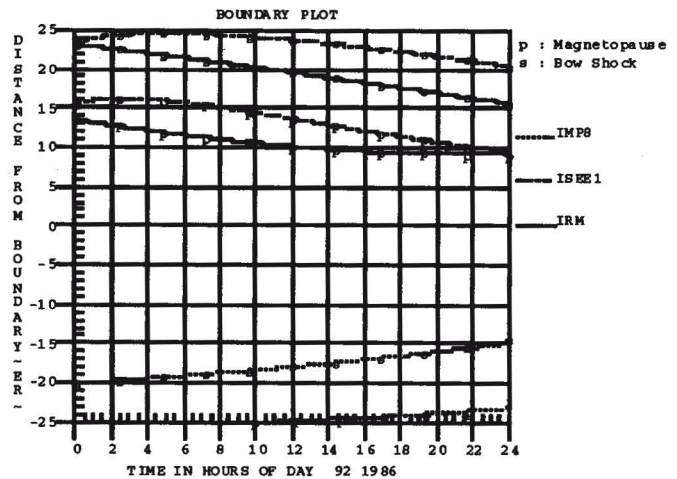


Fig. 6.A. Sample run with BPLOT.

In order to complement the preceding figure, BPLOT also generates plots of the ecliptic-projected longitude and latitude as functions of time for the same 24 hour period. The corresponding graph for the IMP8, ISEE1 and IRM satellites appears in Figure 6.B.

7. NPLOT

Plots generated by NPLOT illustrate the position of a tail going spacecraft relative to a model neutral sheet during a 24 hour interval. Originally, the neutral sheet was defined as a strip $4 R_E$ wide centered about the solar magnetospheric equator. The revised version of NPLOT, to be released later this year will replace that model with the neutral sheet model of Fairfield (1980).

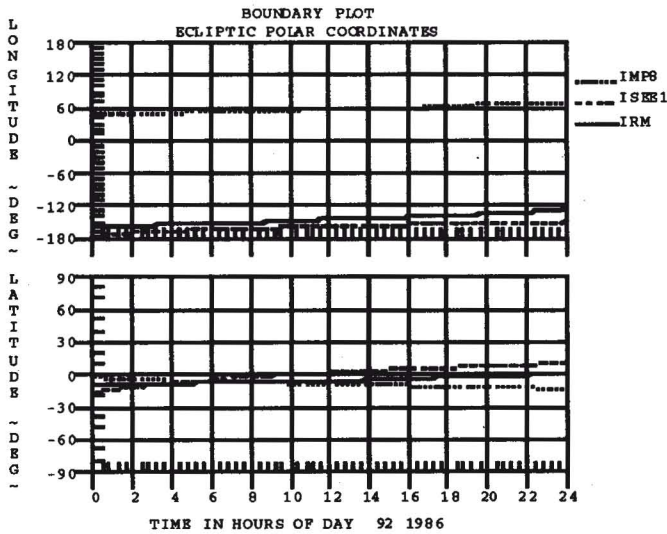


Fig. 6.B. Sample run with BPLOT.

Charts generated by a sample run of NPLOT using data from the IMP8 and ISEE1 spacecraft appear in Figures 7.A. and 7.B. The first frame produced by NPLOT shows the spacecraft distance from the "model" neutral sheet.

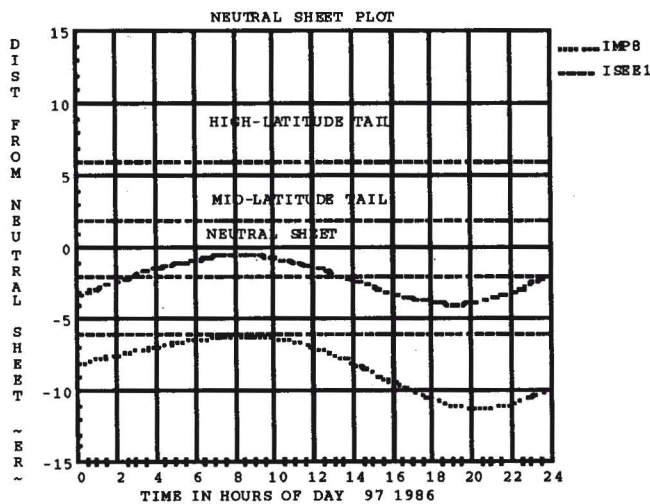


Fig. 7.A. Sample run with NPLOT.

The user may include labels for the various regions within the geomagnetic tail (the existing version divides the tail into three regions: neutral sheet, mid-latitude tail and high-latitude tail).

The second frame generated by NPLOT illustrates the variation of the X_{GSM} and Y_{GSM} coordinates of the spacecraft during the same 24 hour interval. At times when the X_{GSM} coordinate is greater than $-10 R_E$, the spacecraft is not considered in the tail region, and those points are omitted from the plots. The second frame corresponding to the sample run with IMP8 and ISEE1 follows,

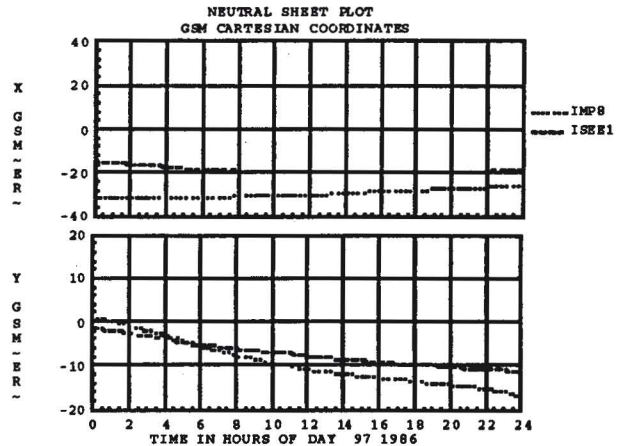


Fig. 7.B. Sample run with NPLOT.

8. TRAJ

The final application in the SSC graphics library is the plotting version of program TRAJ. This program provides plots of the subsatellite points and the magnetic footpoints of selected spacecraft. Plots may be superposed on full or partial projection of the world's coastline. The user may select from the series of internal and external magnetic field models described before. Time ticks may be placed anywhere along the subsatellite point or footpoint lines. Sample tracings for the DE1 satellite, assuming a dipole internal field and no external field, are illustrated in Figure 8.

The following section identifies some additional resources available at SSC for heliospheric spacecraft, and the final section discusses computation requests and access to SSC applications.

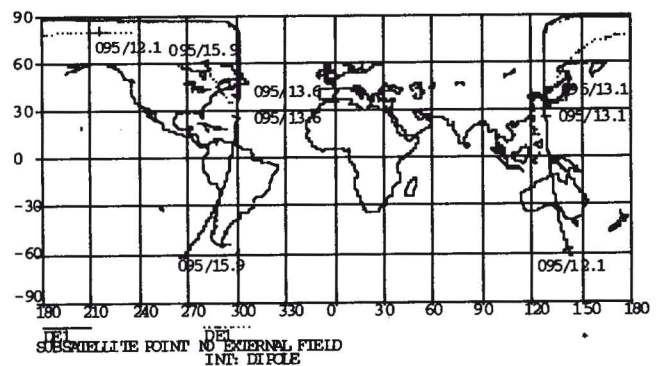


Fig. 8. Sample plot generated by TRAJ.

V. ADDITIONAL SSC RESOURCES (Heliospheric Spacecraft)

In addition to the plots generated with program HELIO4, on-line files with daily resolution of 1989-1999 trajectory information (Cartesian) for all heliospheric spacecraft are available. These and many other precomputed

files for heliospheric spacecraft for the 1990's currently reside in an ANONYMOUS (publicly accessible) account on a VAX machine at NSSDC. Users on a DECnet node may access the NSSDC VAX via the command

```
COPY NSSDCA::ANON_DIR: [ACTIVE.HELIO]JHK.RP **
```

Those in nodes other than DECnet may access files via FTP as follows. At the prompt, type

```
FTP NSSDCA.GSFC.NASA.GOV
```

At the next prompt, type

```
ANONYMOUS
```

At the message

```
PASSWORD (NSSDCA.GSFC.NASA.GOV:ANONYMOUS) :,
```

press return. At the next prompt, type

```
GET ANON_DIR: [000000.ACTIVE.HELIO]JHK.RP FILE.LIST
```

At the following prompt, type

```
QUIT
```

The file JHK.RP contains an annotated list of all pre-computed files with brief descriptions, and an executable code.

VI. DATA/COMPUTATION REQUESTS AND REMOTE ACCESS TO SSC

To date, use of SSC applications has been limited to SSC personnel. Users from the scientific community submit requests for specific reports and/or plots; these requests are processed at SSC and output sent to the requester. Now that the SSC programs have been ported into the VAX and UNIX environments, plans are underway for distribution of the software. Request for computations with SSC programs may be addressed to:

Requesters **WITHIN** the United States
send order to:
Satellite Situation Center
National Space Science Data Center
Code 933.4
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771
U.S.A.

Requesters **OUTSIDE** the United States
send order to:
Satellite Situation Center
World Data Center A for Rockets and Satellites
Code 930.2
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771
U.S.A.

For technical assistance or additional information regarding SSC products please contact:

Prof. R. Parthasarthy,
Telephone #: (301) 286 - 8105
Fax #: (301) 286 - 4952
E-mail: (DECNET) NCF::SARDI
(Internet) SARDI@ncf.gsfc.nasa.gov

BIBLIOGRAPHY

FAIRFIELD, D. H. 1971. Average and unusual locations of the earth's magnetopause and bow shock. *JGR*, 76, 6700-6716.

FAIRFIELD, D. H., 1980. A statistical determination of the shape and position of the geomagnetic neutral sheet. *JGR*, 85, 775-780.

MEAD, G. D. and D. H. FAIRFIELD, 1975. A Quantitative Magnetospheric Model Derived from Spacecraft Magnetometer Data. *JGR*, 80, 523-534.

OLSON, W. P. and K. A. PFITZER, 1974. A Quantitative Model of the Magnetospheric Magnetic Field. *JGR*, 79, 3739-3748.

SIBECK, D. G., R. E. LOPEZ and E. C. ROELOF, 1991. Solar Wind Control of the Magnetopause Shape, Location and Motion. *JGR*, 96, 5489.

SUGIURA, M. and J. I. VETTE, 1977. The IMS Satellite Situation Center. *EOS Transactions of the American Geophysical Union*, 58, 70-74.

TEAGUE, M. J., D. M. SAWYER and J. I. VETTE., 1982. The Satellite Situation Center. In: The IMS Source Book. Guide to the International Magnetospheric Study Data Analysis, C. T. Russell and D. J. Southwood, Eds., American Geophysical Union, Washington, D.C., U.S.A., pp. 112-116.

TSYGANENKO, N. A., 1987. Global Quantitative Models of the Geomagnetic Field in Cislunar Magnetosphere for Different Disturbance Levels. *Planet. Space Sci.*, 35, 1347-1358.

TSYGANENKO, N. A., 1989. A Magnetospheric Magnetic Field Model with a Warped Tail Current Sheet. *Planet. Space Sci.*, 37, 5-20.

VETTE, J. I., R. H. HILBERG and M. J. TEAGUE, 1976. Identification of Satellites Possibly Active During the IMS and their Orbital Configurations. In: The Scientific Satellite Programme During the International Magnetospheric Study. Knott and Battrick, Eds., D. Reidel Publishing Company, Dordrecht-Holland, pp. 45-59.