Voyager SEDR Navigation Tape Processor Program

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Voyager SEDR processor program

Operating instructions for SEDR processor SEDRPR

Source:
- Main program: sedrpr.c
- Subroutine files: chaps.c, iched.c, blokio.c
- Other subroutines: lib370.a, magunix.o

author: D.Chenette
all these files currently under /usr/voyager/traj.

Execute module name: sedrpr

Instructions:

1. Log onto terminal and mount input tape (SEDR) and and output scratch tape (with write ring) (TRAJ)

2. Invoke program (type sedrpr or equivalent)

3. Respond to prompts for input and output tape unit numbers, as well as execution date and output tape name from terminal.

4. For SATURN SEDR addditional input required, see below. Program will (should) run to EOF on input tape.

5. At prompt from program, if additional input SEDR's are to be processed, manually rewind input tape and mount next tape of same type (type=Cruise/ Launch or Jupiter or Saturn). When next tape is ready, respond by typing 'c' for continue. To terminate processing at the end of any input tape respond to prompt with 's', for stop.

6. If all goes well, program will exit with the message ---NORMAL TERMINATION---. Otherwise the program will ABORT, generally explaining why it quit. Please mark aborted runs on output tape. Last physical record of aborted output tape (if any) may be incorrect.

Input tape format: JPL supplied Fixed Instrument SEDR see SIS 4-7008-1, Rev. B, 13 March, 1978.

Special SATURN input SEDR requirements:

If input SEDR is type SATURN, program will request additional input to specify magnetic field model.

input required, for Saturn SEDR only:

(a) Radius of Saturn in kilometers. If specified as negative or zero, will default to 60,000.0 km.

(b) Position of magnetic dipole center relative to center of Saturn. Cartesian position (X,Y,Z) in Saturn-centered body-fixed coordinates. If any of x,y,z, falls outside the range $-1 < x,y,z, < 1$ that value will default to zero.(units: Saturn radii)

(c) Magnetic dipole axis tilt angle in degrees. Angle between rotation axis and magnetic axis.

(d) Dipole tilt direction (degrees Saturn longitude).

Defaults for tilt angle and direction are zero degrees.

Output tape format: Trajectory tape.

Maximum physical record size: 8000 bytes

Format follows HEAO chapter/verse format (see attachments), with 101 chapter at the end of each physical record and 103 chapter at last record on tape. Program writes DEOF at end of output tape.

Brief description of source file functions:

1.	sedrpr.c	Main program handles most user interaction, I/O, and other functions common to processing of all chapters, as well as chapter 85 processing.
2.	iched.c	Reads in and converts SEDR tape header to chapter 69.
3.	chaps.c	Collection of subroutines, one for each chapter 70-78, which handle conversion and processing of data for each chapter.
4.	blokio.c	Does blocked tape I/O and appends chapters 101 or 103 as required.

Other useful related programs:

sedump	Converts and prints SEDR. Input unit number and number of records to process from terminal.
trdump	Reads and prints Trajectory tape which is produced by sedrpr. Required unit number is input from terminal. Will run until aborted.
sedrls	Converts and prints any 6 user selected parameters from SEDR tape. See separate writeup.

Voyager SEDR processor SEDRPR

List of Chapters for TRAJ tape 9 June,1980

Chapter number	Chapter name	Contents of TRAJ tape chapter
0	CNTRL	Standard HEAO control chapter format.
1	TIME	Input tape NAV block time
69	TGNID	Input tape and run ID record. one per input tape
70	HCM50	Sun centered coordinates, Earth mean ecliptic and equinox of 1950.0; Cruise/Launch input tape only
71	BCBHF	Body centered coordinates, Body-Sun line fixed, reference plane: eclipic of 1950.0: Cruise/Launch only.
72	HCHXQ	Sun centered coords, solar equator and equinox of date, C/L only.
73	JCM50	Jupiter centered coords, Earth mean ecliptic and equinox of 1950.0; Jupiter input tape only.
74	JCHJF	Jupiter centered coords, Sun-Jupiter line fixed, Jupiter equator of date; Jupiter input tape only.
75	JC3D	Jupiter centered coords; System III and magnetic dipole centered; Jupiter only
76	SCM50	Saturn centered coords, Earth mean ecliptic and equinox of 1950.; Saturn input tape only.
77	SCHSF	Saturn centered, Sun-Saturn line fixed Saturn equator of date; Saturn only
78	SCGD	Saturn centered, Saturn equator and magnetic dipole equator, Saturn only.
85	POINT	Spacecraft X,Y,Z to M50 coordinate transformation and Euler angles.
101	EOR	End of physical record chapter.
103	EOT	End of tape chapter.

CHAPTER 0 CNTRL

#	VERSE Name	VERSE Length	ITEM Name	ITEM Length	RELATIVE INDEX in Verse	RELATIVE INDEX in Chap	ORIGIN Word	Comments
0	KEY	4	KEY	2	0	0	-	Key = 0
			spare	2	2	2	-	
1	VRSN	28	PVRS	8	0	4	-	8 char version date
			EXDT	8	8	12	-	8 char execution date
			TPNM	8	16	20	-	8 char tape name
			spare	4	24	28	-	
2	PNTR	32	CHNO	2	0	32	-	chapter # described here
			CHLN	2	2	34	-	chapter length
			VPNT	12*2	4	36	-	rel. verse indices in CHNO
			VRCN	2	28	60	-	# verses in CHNO
			spare	2	30	62	-	

total length: 64

Chapter 0 is repeated for each chapter on tape.

Typically 6 chapter 0's will appear,for
chapters 1,69 70,71,71 ,and 85.
or
73,74,75
or
76,77,78
or
...

All entrys integer or character

#	VERSE Name	VERSE Length	ITEM Name	ITEM Length	RELATIVE INDEX in Verse	RELATIVE INDEX in Chap	ORIGIN Word	Comments
0	KEY	2	KEY	2	0	0	-	KEY=1
1	TIME	18	SCN	2	0	2	3	s/c number 1,2,...5
			YEAR	2	2	4	1	Year (as 80) (I*2)
			DAY	2	4	6	2	Day of Year (I*2)
			MSEC	4	6	8	3,4,5,6	Millisec of day
			IVOL	4	10	12	-	15 min Vol number
			FVOL	4	14	16	-	Millisec into volume IVOL
			total length :		20			

All entries are integer

SCN = Spacecraft number

1 = Voyager1
2 = Voyager2
3 = PTM
4 = Sim1
5 = Sim2

Chapter 69		TGNID					
VERSE		ITEM		RELATIVE INDEX		ORIGIN	
# Name	Length	Name	Length	in Verse	in Chap	Word	Comments
0 KEY	2	KEY	2	0	0	-	KEY=69
1 HEAD	106	SCN	2	0	2	3x	see below
		ID	8	2	4	1-2	"VGR SEDR"
All entries		TID	8	10	12	4-5	8 char ID
interger or		SFGD	4	18	20	6	I*4,MMDDYY
character		SFGT	4	22	24	7	I*4,HHMMSS
		PVID	8	26	28	8-9	8 char ID
		PVGD	4	34	36	10	I*4,MMDDYY
		PVGT	4	38	40	11	I*4,HHMMSS
		NTID	8	42	44	12-13	8 char ID
		DBID	8	50	52	14-15	ID's from
		NTID	8	58	60	16-17	input tape
		DBID	8	66	68	18-19	|
		NTID	8	74	76	20-21	|
		DBID	8	82	84	22-23	|
		NTID	8	90	92	24-25	|
		DBID	8	98	100	26-27	|
2 USER	24	SKAL	4	0	108		distance scale
		XD	4	4	112	user	xyz position
All entries		YD	4	8	116	user	of dipole
R*4.		ZD	4	12	120	user	center for Saturn tape
		TILT	4	16	124	user	dipole tilt angle(deg)
		LONG	4	20	128	user	dipole tilt longitude (deg.)

total length : 132

SCN = 1 for V1; 2 for V2; 3 = PTM; 4 = sim 1; 5 = sim 2
SKAL = |149597900.0 km/AU for Launch/Cruise tape
| 71398.0 km/Jovian radii for Jupiter tape
| user input (60000.0 km/Saturn radii default) for Saturn.

XD,YD,ZD = Saturnographic coordinates of magnetic dipole center in Saturn radii - user input, default = 0.0
TILT = angle between dipole direction and Saturn rotation axis, default = 0.0
LONG = Saturnographic longitude of direction of dipole tilt, default = 0.0

All data in verse HEAD is copied from SEDR header

Chapter 70 HCM50

Sun-centered coordinates
(M50) Earth mean 1950.0
ecliptic and equinox
Launch/Cruise input tapes
only

#	VERSE Name	Length	ITEM Name	Length	RELATIVE INDEX in Verse	in Chap	ORIGIN Word	Comments
0	KEY	4	Key	2	0	0	-	KEY=70 (I*2)
			spare	2	2	2		
1	VGR	40	X	4	0	4	13	Spacecraft X
			Y	4	4	8	14	Sun-centered M50
			Z	4	8	12	15	coordinates
			R	4	12	16	51	Sun-spacecraft range.
			LAT	4	16	20	arctan(Z/RE)	-90<LAT<90dg
			LON	4	20	24	arctan(Y/X)	0<LON<360deg
			RE	4	24	28	sqrt(xx+yy)	
			VX	4	28	32	16	Spacecraft V
			VY	4	32	36	17	Sun-centered M50
			VZ	4	36	40	18	coordinates
2	EARTH	28	X	4	0	44	31	Earth position
			Y	4	4	48	32	Sun-centered M50
			Z	4	8	52	33	coordinates
			R	4	12	56	50	Sun-Earth range
			LAT	4	16	60	LAT=arctan(Z/RE)	
			LON	4	20	64	LON=arctan(Y/X)	
			RE	4	24	68	RE=sqrt(xx+yy)	
3	JUPITR	28	X-RE	7*4	0/24	72/96	37,39,54	Juptr position
4	SATURN	28	X-RE	7*4	0/24	100/124	43,35,55	Saturn position
5	URANUS	28	X-RE	7*4	0/24	128/152		
6	NEPTUN	28	X-RE	7*4	0/24	156/180		

total length 184

Reference plane and direction: Earth mean ecliptic and equinox of 1950.0 (M50)

All coordinates Sun-centered.

All distances in kilometers, angles in degrees.
velocities in kilometers per second.
-90 < LAT < 90 deg 0 < LON < 360 deg

Chapter 71 BCBHF

Body centered coordinates
Body-Sun line fixed
Launch/Cruise input tapes only

#	VERSE Name	Length (bytes)	ITEM Name	Length	RELATIVE INDEX in Verse	in Chap	ORIGIN Word	Comments
0	KEY	4	KEY	2	0	0	-	KEY-71 (I*2)
			spare	2	2	2	-	
1	EHV	28	X	4	0	4	7 rotated	Body = Earth
			Y	4	4	8	8 rotated	s/c position
			Z	4	8	12	9	Earth
			R	4	12	16	49	centered
			LAT	4	16	20	LAT=arctan(Z/RE)	
			LON	4	20	24	LON=arctan(Y/X)	
			RE	4	24	28	RE=Sqrt(xx+yy)	
2	JHV	28	X-RE	7*4	0/24	32/56	19-21,52	Body=Jupiter s/c position
3	SHV	28	X-RE	7*4	0/24	60/84	25-27,53	Body=Saturn, s/c position
4	UHV	28	X-RE	7*4	0/24	88/112		
5	NHV	28	X-RE	7*4	0/24	116/140		
6	HANG	12	HJS3	4	0	144	106-78	Sys III Long of Sun-Jup. line
			PS3	4	4	148	106	Hour angle of Sys III prime merridian
			RAHJ	4	8	152	78	R.A. of Sun, Jupiter centered Jupiter true equinox and equator of date.

total length: 156

Reference plane: Earth mean ecliptic 1950.0

Reference direction: Sun-body line body = {Earth,Jupiter,Saturn}

Sun along X<0 , Y=0.

All distances in AU, angles in degrees.

Procedure for calculating Body centered, body-Sun line
fixed coordinates of Voyager in Chapter 71.

Definitions:

$\vec{B}$ Sun-centered, M50 position vector of body

$\vec{H}$ Body-centered, M50 position vector of Sun

$\vec{V}$ Body-centered, M50 position vector of Voyager

unprimed frame - M50
primed frame - body-Sun line fixed

Body-Sun line fixed frame defined by:

$Hz' = Hz, \quad Hy' = 0, \quad Hx' < 0$

Thus $\begin{pmatrix} Hx' \\ Hy' \\ Hz' \end{pmatrix} = \begin{pmatrix} A & C & 0 \\ -C & A & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} Hx \\ Hy \\ Hz \end{pmatrix}$; $AA+CC=1$

$Hx' = AHx + CHy \qquad Hy' = AHy - CHx$

$A = -Hx \quad$ and $\quad C = -Hy$

or since $H = -B$

$A = Bx \qquad C = By$

and

$Vx' = (BxVx + ByVy)/\mathrm{sqrt}(BxBx+ByBy)$
$Vy' = (ByVx + BxVy)/\mathrm{sqrt}(BxBx+ByBy)$
$Vz' = Vz$

Chapter 72 HCHXQ

Sun-centered coordinates
Sun ecliptic and equinox of date
Cruise/Launch input tapes only

#	VERSE Name	Length	ITEM Name	Length	RELATIVE INDEX in Verse	in Chap	ORIGIN Word	Comments
0	KEY	4	KEY	2	0	0	-	KEY=72 (I*2)
			spare	2	2	2	-	
1	VGR	28	X	4	0	4	X=RE*cos(LON)Voyager	
			Y	4	4	8	Y=RE*sin(LON) position	
			Z	4	8	12	Z=R*sin(LAT) Sun-cntrd.	
			R	4	12	16	51	solar eclip-
			LAT	4	16	20	99	tic and equi-
			LON	4	20	24	98	nox of date
			RE	4	24	28	RE=Rcos(LAT)	
2	EARTH	28	X-RE	7*4	0/24	32/56	50,101,100	Earth position
3	JUPITR	28	X-RE	7*4	0/24	60/84	54,103,102	Jupiter position
4	SATURN	28	X-RE	7*4	0/24	88/112	55,105,104	Saturn position
5	URANUS	28	X-RE	7*4	0/24	116/140		
6	NEPTUN	28	X-RE	7*4	0/24	144/168		

total length 172

Reference plane: Solar equator of date as defined by JPL

Reference direction: Solar equinox of date DPTRAJ

All distances in AU, angles in degrees.

Solar equinox of date is along the decending node of the solar equatorial plane on the ecliptic plane i.e. at an ecliptic longitude near 255 degrees.

Inclination of solar ecliptic = equatorial plane relative to ecliptic plane i ~ 7.25 degrees.

Chapter 73 JCM50

Jupiter centered coordinates
Earth mean ecliptic and equinox
0f 1950.0 Jupiter input tape only

#	VERSE Name	Length	ITEM Name	Length	RELATIVE INDEX in Verse	in Chap	ORIGIN Word#	Comments
0	KEY	4	KEY	2	0	0	-	KEY=73 (I*2)
			spare	2	2	2	-	
1	VGRH	40	X	4	0	4	13	Spacecraft X
			Y	4	4	8	14	SUN-CENTERED
			R	4	12	16	173	M50 coords.
			LAT	4	16	20	LAT=arctan(Z/RE)	
			LON	4	20	24	LON=arctan(Y/X)	
			RE	4	24	28	RE=sqrt(xx+yy)	
			VX	4	28	32	16	Spacecraft V
			VY	4	32	36	17	SUN-CENTERED
			VZ	4	36	40	18	M50 coords.
2	VGR	40	X-VZ	10*4	0/36	44/80	19-21,176 22-24	s/c posit. velocity Jupiter cent. M50
3	SUN	28	X-RE	7*4	0/24	44/108	-55,-56,-57 175	Sun position Jupiter cent. M50
4	EARTH	28	X-RE	7*4	0/24	112/136	61-63	Earth posit. Juptr center.
5	IO	28	X-RE	7*4	0/24	140/164	67-69,177	Io position, Jupitr cent.

total length: 168

VERSE 1 is Sun-centered, Verses 2-5 are Jupiter centered

Reference plane and direction: Earth mean ecliptic and equinox of 1950.0

All distances in kilometers, angles in degrees, velocities in kilometers per second.

Chapter 74 JCHJF

Juipter centered coordinates
Sun-Jupiter line fixed, Jupiter
equator of date Jupiter input
tape only

#	VERSE Name	Length	ITEM Name	Length	RELATIVE INDEX in Verse	in Chap	ORIGIN Word	Comments
0	KEY	4	KEY	2	0	0	-	KEY=74 (I*2)
			spare	2	2	2	-	
1	VGR	28	X	4	0	4	REcos(LON)	Spacecraft X
			Y	4	4	8	REsin(LON)	Juptr centrd.
			Z	4	8	12	Rsin(LAT)	Sun-Juptr line
			R	4	12	16	176	fixed,Jupiter
			LAT	4	16	20	204	equator of
			LON	4	20	24	203	date
			RE	4	24	28	RE=Rcos(LAT)	
2	SUN	28	X-RE	7*4	0/24	32/56	175,206	Sun position Jup.centered
3	IO	28	X-RE	7*4	0/24	60/84	177,208,207	Io position, Jup.centered
4	EUROPA	28	X-RE	7*4	0/24	88/112	178,210,209	Europa pos. Jup.centered
5	GANYMD	28	X-RE	7*4	0/24	166/140	179,212,211	Ganymede pos
6	CLISTO	28	X-RE	7*4	0/24	144/168	180,214,213	Callisto pos

total length: 172

Reference plane: Jupiter equator of date

Reference direction: Sun along Y=0 X>0
X-axis along Jupiter to Sun line.
Rotation to Sun-Jupiter line by LON = LON-LONsun

All positions Jupiter centered.

All distances in Jupiter radii (1Rj = 71398.0km)
angles in degrees.

NOTE: Sun LON is system III longitude of Jupiter-Sun-line!
i.e. system III longtude of real noon on Jupiter.

Chapter 75 JC3D

Jupiter centered coordinates
System III and magentic dipole
Jupiter input tape only.

#	VERSE Name	Length	ITEM Name	Length	RELATIVE INDEX in Verse	in Chap	ORIGIN Word#	Comments
0	KEY	4	KEY	2	0	0	-	KEY=75 (I*2)
			spare	2	2	2	-	
1	VGR3	40	X	4	0	4	139	Spacecraft X
			Y	4	4	8	140	Jup.centered
			Z	4	8	12	141	System III
			R	4	12	16	176	coordinates
			LAT	4	16	20	157	arctan(Z/RE)
			LON	4	20	24	159	360deg-arctan Y/X
			RE	4	24	28		RE=sqrt(xx+yy)
			VX	4	28	32	142	Spacecraft V
			VY	4	32	46	143	Jup. centered
			VZ	4	36	40	144	Sys.III coords
2	IO3	28	X-RE	7*4	0/24	44/68	145-147,177	Io position,
							160,162	Sys III
	VGRD	44	X	4	0	72	221	Spacecraft
			Y	4	4	76	222	position
			Z	4	8	80	223	Jup.centered
			R	4	12	84	233	Magnetic dipole
			LAT	4	16	88	235	coordinates
			LON	4	20	92	236	arctan(Y/X)
			RE	4	24	96		RE=sqrt(xx+yy)
			L	4	28	100		L=R/(cos(LAT)**2)
			VX	4	32	104	224	
			VY	4	36	108	225	
			VZ	4	40	112	226	
4	IOD	32	X-L	8*4	0/28	116/144	227-229	Io position
							234,237	magnetic
							238	dipole coords

total length: 148

Reference plane: Jupiter equator or magnetic dipole equator
of date. (see attachments)
Reference direction: System III prime meridian or Jupiter
magnetic mevidian (see attchments)

Note that Sys III longitude increase westward, magnetic, eastward.

All distances in Jovian radii (1Rj = 71398.0km)
angles in degrees, velocities in Rj per second.

Chapter 76 SCM50 Saturn centered coordinates
Earth mean ecliptic and equinox
of 1950.0 Saturn input tape only.

#	VERSE Name	Length	ITEM Name	Length	RELATIVE INDEX in Verse	in Chap	ORIGIN Word#	Comments
0	KEY	4	KEY	2	0	0	-	KEY=76 (I*2)
			spare	2	2	2	-	
1	VCRH	40	X	4	0	4	13	Spacecraft
			Y	4	4	8	14	position,
			Z	4	8	12	15	SUN-CENTERED
			R	4	12	16	82	M50
			LAT	4	16	20	arctan(X/RE)	inertial
			LON	4	20	24	arctan(Y/X)	coordinates
			RE	4	24	28	sqrt(xx+yy)	
			VX	4	28	32	16	Spacecraft V
			VY	4	32	36	17	SUN-CENTERED
			VZ	4	36	40	18	M50 coords.
2	VCR	40	X-VZ	10*4	0/36	44/80	19-21,83	s/c position
							22-24	velocity
								Saturn center
3	SUN	28	X-RE	7*4	0/24	84/108	-37,-38	Sun position
							-39,85	Sat.centered
4	EARTH	28	X-RE	7*4	0/24	112/136	43-45	Ear.position
								Sat.centered
5	TITAN	28	X-RE	7*4	0/24	140/164	49-51	Titan positio.
							86	Saturn center.
								M50

total length: 168

Verse 1 is Sun centered, Verses 2-5 are Saturn centered.

Reference plane and direction: Earth mean ecliptic and
equinox of 1950.0

All distances in kilometers, angles in degrees,
velocities in kilometers per second.

Chapter 77 SCHSF Saturn centered coordinates Sun-Saturn line fixed Saturn equator of date Saturn input tape only.

#	VERSE Name	Length	ITEM Name	Length	RELATIVE INDEX in Verse	in Chap	ORIGIN Word#	Comments
0	KEY	4	KEY	2	0	0	-	KEY=77 (I*2)
			spare	2	2	2	-	
1	VGR	28	X	4	2	2	REcos(LON)	Spacecraft
			Y	4	4	8	REsin(LON)	Position
			Z	4	8	12	RE sin (LON)	
			R	4	12	16	83	
			LAT	4	16	20	104	
			LON	4	16	20	103	
			RE	4	24	28	Rcos(LAT)	
2	SUN	28	X-RE	7*4	0/24	32/56	85,106	Sun position
3	TITAN	28	X-RE	7*4	0/24	60/84	86,108,107	Titan positi

total length: 88

Reference plane: Saturn equator of date
Reference direction: Sun along Y=0, X=0
X-axis along Saturn to Sun line.
Rotation to Sun-Saturn line by LON = LON - LONsun

All positions Saturn centered.

All distances in Saturn radii: 1Rs = user input - see chapter 69

NOTE: Sun LON is Saturn longitude of the Saturn-Sun line i.e. Saturn longitude of real noon on Saturn.

Chapter 78 SCGD

Saturn centered coordinates
Saturn true prime meridian
and equator of date or
magnetic dipole. Saturn
input tape only.

#	VERSE Name	Length	ITEM Name	Length	RELATIVE IDEX in Verse	in Chap	ORIGIN Word#	Comments
0	KEY	4	KEY	2	0	0	-	KEY=78 (I*2)
			spare	2	2	2	-	
1	VGRG	40	X	4	0	4	67	Spacecraft X
			Y	4	4	8	68	Sat.centered
			Z	4	8	12	69	Saturn true
			R	4	12	16	83	prime merid-
			LAT	4	16	20	76	ion and equa-
			LON	4	20	24	77	tor of date.
			RE	4	24	28	sqrt(xx+yy)	Saturnographic
			VX	4	28	32	70	Spacecraft V
			VY	4	32	36	71	Saturn centr
			VZ	4	36	40	72	Saturnograph
								coords.
2	TITANG	28	X-RE	7*4	0/24	44/68	73,75,86	Titan position
							78,79	Saturnographic
3	VGRD	44	X	4	0	72	VGRG coordinates	
			Y	4	4	76	translated to	
			Z	4	8	80	magnetic dipole center	
			R	4	12	84	and rotated to magne-	
			LAT	4	16	88	tic dipole axes.(see	
			LON	4	16	92	attachment).	
			RE	4	24	92	L=R/(cos(LAT)**2)	
			L	4	28	100	velocity rotated to	
			VX	4	32	104	magnetic dipole	
			VY	4	36	108	axes.	
			VZ	4	40	112	Titan position,dipole	
4	TITAND	32	X-L	8*4	0/28	116/144	coordinates	

total length: 148

Reference plane: Saturn equator of date or magnetic dipole
equator of date. (see attachment)
Reference direction: Saturn true prime meridian or dipole
meridian (see attachment)
Note that Saturn longitudes increase westward.
All distances in Saturn Radii (1Rs-user input, see chapter 69
60000km default).

angles in degrees, velocities in Rs per second.

Saturn magnetic coordinates:

User input specifications:

$\vec{D}$ = (X ,Y ,Z) = position of dipole center in Saturnographic coordinates (Saturn radii)

t = TILT = dipole tilt angle relative to Saturn rotation axis (dipole axis colatitude) (degrees from north)

L = LONG = Saturnographic longitude of dipole tilt derection for a centered dipole this would be the longitude of the north magnetic pole. (+ west) (degrees,positive west).

NOTE: by IAU/JPL standard conventions, planetory longitudes are measured positive westward.

Magnetic coordinate system definition:

$\vec{Z}m$ - along magnetic dipole axis (positive north).

$\vec{X}m$ - perpendicular to Zm in the plane formed by the magnetic dipole axis and a vector parallel to the planet's rotation axis

$\vec{Y}m = \vec{Z}m \times \vec{X}m$ - completes the right-handed system.

magnetic longitude increases positive eastword = tan^{-1} (Y/X)

Procedure:

Rotations:

(a) rotate about the rotation axis (+Z) by -L

(b) rotate about +Ym by t

Rotation matrix from Saturnographic to Magnetic coordinates

$$\underset{\sim}{R} = \begin{pmatrix} \cos L \cos t & -\sin L \cos t & -\sin t \\ \sin L & \cos L & 0 \\ \cos L \sin t & -\sin L \sin t & \cos t \end{pmatrix}$$

Finally: $\vec{X}mag = \underset{\sim}{R}(\vec{X}graphic - \vec{D})$

$\vec{V}mag = \underset{\sim}{R}\vec{V}graphic$

Chapter 85 POINT

One such chapter output for each readable pointing vector block.

#	VERSE Name	VERSE Length	ITEM Name	ITEM Length	RELATIVE INDEX in Verse	RELATIVE INDEX in Chap	ORIGIN Word#	Comments
0	KEY	2	KEY	2	0	0	-	KEY=85 (I*2)
1	TIME	10	SCN	2	0	2	-	Spacecraft number (I*2)
			YEAR	2	2	4	1	Year (as 82) (I*2)
			DAY	2	4	6	2	Day of Year (I*2)
			MSFC	4	6	8	3,4,5,6	millsec of day (I*4)
2	USCV	36	XX	4	0	12	12	Voyager +X axis
			XY	4	4	16	13	s/c centered
	All entries		XZ	4	8	20	14	M50 coords.
	R * 4		YX	4	12	24	15	Voyager +Y axis
			YY	4	16	28	16	s/c centered
			YZ	4	20	32	17	M50 coords.
			ZX	4	24	36	18	Voyager +Z axis
			ZY	4	28	40	19	s/c centered
			ZZ	4	32	44	20	M50 coordinates
3	EULER	12	PHI	4	0	48	-	1st Euler angle
			THETA	4	4	52	-	2nd Euler angle
			PSI	4	8	56	-	3rd Euler angle

total length: 60

PHI = arctan (XZ/-YZ) units: radians

THETA = arccos (ZZ) = arctan [sqrt(1-(ZZ*ZZ))/ZZ] units: radians

PSI = arctan (ZX/ZY) units: radians

NOTE: EULER ANGLES are given in RADIANS.

Transformation matrix from Voyager X,Y,Z coordinates to M50 (Earth mean ecliptic and equinox 1950.0) coordinates:

$$R = \begin{pmatrix} XX & YX & ZX \\ XY & YY & ZY \\ XZ & YZ & ZZ \end{pmatrix}$$

Chapter 101 EOR flags end of physical record on tape.

Item Name	Length	Relative Index	Comments
KEY	2	0	KEY = 101
RECNO	2	2	Record number on tape

total length: 4

Chapter 103 EOT flags end of last physical record on tape

Item Name	Length	Relative Index	Comments
KEY	2	0	KEY = 103
RECNO	2	2	Record number on tape

total length: 4