798

VOYAGER 1
RADIO OCCULTATION
OPACITY & PHASE PROFILES SATURN'S RINGS
77-084A-02J
77-084A-02K
77-084A-02L

VOYAGER 1

RADIO OCCULTATION

OPACITY AND PHASE PROFILES SATURN'S RINGS

77-084A-02J
77-084A-02K
77-084A-02L

This data set consists of 3 magnetic tapes. The tape are 9 track, 6250 BPI with the first file written in ASCII, which is a documentation file. The D and C tapes were created on the IBM computer.

77-084A-02J
===========

D#	C#	FILES	DATE OF DATA INVERSION
D-063857	C-024094	4	05/22/84
			Data Resolution: 5000m

77-084A-02K
===========

D#	C#	FILES	DATE OF DATA INVERSION
D-074237	C-032432	4	08/03/84
			Data Resolution: 1000m

77-084A-02L
===========

D#	C#	FILES	DATE OF DATA INVERSION
D-108706	C-032801	4	03/17/85
			Data Resolution: 400m

All file formats are described in the documentatin file.

File 1: Documentation - ASCII 132 byte records.
File 2: Simulated Impulse Response
Record 0 - ASCII data
Subsequent records - VAX BINARY.
File 3: Sinulated Step Response
Same as file 1.
File 4: X- and S-Band Opacity & Phase Profiles
with error bounds - VAX BINARY.

MM-084A-02J,K,L

FATAR DETAIL REPORT   C-033801

```
BLOCK  LNGTH/  MESSAGE/                1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80
NUMBER DISPL   BLOCK TYPE                      (COLUMN GRID IS VALID ONLY FOR CHARACTER FORMATTED DATA)

     1     80  PRINT REQUESTED         53544550 20524553 504F4E53 00000000  BD377B1A 0E341CFE C0375B89 19358BA5
       +00033                          C2373E6B 92353754 C037A429 ED3517A3  BB37D419 04361586 BB37BE6D E935A518
       +00065                          BC37BD03 0436823C B737AADC 0B36B092

     2     80  PRINT REQUESTED         F4C90024 484142B7 763B9D77 7872693A  67656E31 64657834 30306D2E 696E7465
       +00033                          6772616C 20202020 20202020 20202020  20202020 20202020 20202020 20202020
       +00065                          20202020 20202020 00000000 D04DCCDA

     3     80  PRINT REQUESTED         F4C9000B 48417679 823C6807 7872693A  67656E31 64657834 30306D2E 696E7465
       +00033                          6772616C 20202020 20202020 20202020  20202020 20202020 20202020 20202020
       +00065                          20202020 20202020 00000000 D04DCCDA

  5000     80  PRINT REQUESTED         F34900F2 47BB5A06 FFBED2FF 7872693A  67656E31 64657834 30306D2E 696E7465
       +00033                          6772616C 20202020 20202020 20202020  20202020 20202020 20202020 20202020
       +00065                          20202020 20202020 00000000 D04DCCDA

  5001     80  PRINT REQUESTED         F449000B 47BB5A06 FFBED2FF 7872693A  67656E31 64657834 30306D2E 696E7465
       +00033                          6772616C 20202020 20202020 20202020  20202020 20202020 20202020 20202020
       +00065                          20202020 20202020 00000000 D04DCCDA

  5002     80  PRINT REQUESTED         F4490024 47BB5A06 FFBED2FF 7872693A  67656E31 64657834 30306D2E 696E7465
       +00033                          6772616C 20202020 20202020 20202020  20202020 20202020 20202020 20202020
       +00065                          20202020 20202020 00000000 D04DCCDA

* * * * * * *  END OF FILE       3  -- FILE CONTAINED    5002 BLOCKS

* * * * * * *  START FILE        4

     1    600  PRINT REQUESTED         564F5941 47455220 31205241 44494F20  4F434355 4C544154 494F4E20 44415441
       +00033                          20544150 45203B20 53435241 2D535441  4E464F52 44000000 00000000 00000000
       +00065                          00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000
       +00097                          55000300 11000000 00000000 00000000  00440000 80430000 00000000 00000000
       +00129                          00000000 00000000 00000000 48430000  48460000 48430000 4C437CBB 868A16A7
       +00161                          7F4025FE CF31D7E7 E2BC3213 4D148A18  44BC178D 34283B89 E23C3213 4D148A18
       +00193                          7F4070FE 2DCBF250 2DB82CA4 134FF73B  443C178D 34283B89 2DB82CA4 134FF73B
       +00225                          7F40B4FF 8C96264D 1FC09B0B A1A926BE  4840BD99 424DB741 BD234703 9F7141D4
       +00257                          47C0883D 8B316F57 1DC088F7 517D8A73  EE3EF216 0AD9C37C BA3EE990 7F7F0FB9
       +00289                          933E0CEB E596F073 7E40A043 E7F763EC  7D401CD5 51D219DC CABE8BFA 4E715C87
       +00321                          ABBEBDD3 0AB40616 BD3E0C29 20A29072  7E409710 62E5C30A A5BE6080 9AC72841
       +00353                          BA3E62EE 97249F52 943ECA3A 8A09A7D8  7E40D441 FC9A5052 06001C00 55001400
       +00385                          08000500 00000000 00000000 C8440000  48440000 00000000 2B40F19C 2E72EBE9
       +00417                          BA40C925 084A633E 664D0424 00000000  41555832 3A5B5041 554C2E58 522E494E
       +00449                          565D5850 344B5245 5346462E 50414B3B  41555832 3A5B5041 554C2E53 522E494E
       +00481                          565D5350 344B5245 53462E50 414B3B31  41555832 3A5B5041 554C2E58 522E504F
       +00513                          4C5D5850 324B2E50 4F4C3B31 20202020  41555832 3A5B5041 554C2E53 522E504F
       +00545                          4C5D5350 324B2E50 4F4C3B31 20202020  113E8CEC 6756F534 053F80C3 89A46044
       +00577                          854DB083 00000000 0A4E6448 00000000  00000000 01000000

     2    600  PRINT REQUESTED         48430000 48460000 00000000 00000000  00000000 00000000 00000000 00000000
       +00033                          00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000
       +00065                          00000000 00000000 00000000 00000000  FB4287C8 05437359 FD42BE2B 0443C053
```

Year 85
Month 03
day 17
03/17/85

77-084A-02J,K,L

p-2

FATAR DETAIL REPORT   D07427

```
BLOCK  LNGTH/  MESSAGE/           1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80
NUMBER DISPL   BLOCK TYPE                (COLUMN GRID IS VALID ONLY FOR CHARACTER FORMATTED DATA)

     2    80   PRINT REQUESTED     C3C80050 39416DEA 21BF73BD 73637274  63683A78 316B7265 7372632E 73747020
        +00033                     20202020 20202020 20202020 20202020  20202020 20202020 20202020 20202020
        +00065                     20202020 20202020 FB4D3A1A 00000000

     3    80   PRINT REQUESTED     C2C80056 3741EA48 D2BE0A5A 73637274  63683A78 316B7265 7372632E 73747020
        +00033                     20202020 20202020 20202020 20202020  20202020 20202020 20202020 20202020
        +00065                     20202020 20202020 FB4D3A1A 00000000

   400    80   PRINT REQUESTED     C148005C 80340000 2FB502F0 73637274  63683A78 316B7265 7372632E 73747020
        +00033                     20202020 20202020 20202020 20202020  20202020 20202020 20202020 20202020
        +00065                     20202020 20202020 FB4D3A1A 00000000

   401    80   PRINT REQUESTED     C2480056 80340000 56B52F91 73637274  63683A78 316B7265 7372632E 73747020
        +00033                     20202020 20202020 20202020 20202020  20202020 20202020 20202020 20202020
        +00065                     20202020 20202020 FB4D3A1A 00000000

   402    80   PRINT REQUESTED     C3480050 80340000 5FB53F47 73637274  63683A78 316B7265 7372632E 73747020
        +00033                     20202020 20202020 20202020 20202020  20202020 20202020 20202020 20202020
        +00065                     20202020 20202020 FB4D3A1A 00000000

* * * * * * *  END OF FILE     3  -- FILE CONTAINED     402 BLOCKS

* * * * * * *  START FILE      4

     1   600   PRINT REQUESTED     564F5941 47455220 31205241 44494F20  4F434355 4C544154 494F4E20 44415441
        +00033                     20544150 45203B20 53435241 2D535441  4E464F52 44000000 00000000 00000000
        +00065                     00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000
        +00097                     54000800 03000000 00000000 00000000  00450000 00440000 00000000 00000000
        +00129                     00000000 00000000 00000000 A0420000  A0450000 48430000 4C437CBB 868A16A7
        +00161                     7F4025FE CF31D7E7 E2BC3213 4D148A18  44BC178D 34283B89 E23C3213 4D148A18
        +00193                     7F4070FE 2DCBF250 2DB82CA4 134FF73B  443C178D 34283B89 2DB82CA4 134FF73B
        +00225                     7F40B4FF 8C96264D 1FC09B0B A1A926BE  4840BD99 424DB741 BD234703 9F7141D4
        +00257                     47C0883D 8B316F57 1DC088F7 517D8A73  EE3EF216 0AD9C37C BA3EE990 7F7F0FB9
        +00289                     933E0CEB E596F073 7E40A043 E7F763EC  7D401CD5 51D219DC CABE8BFA 4E715C87
        +00321                     ABBEBDD3 0AB40616 BD3E0C29 20A29072  7E409710 62E5C30A A5BE6080 9AC72841
        +00353                     BA3E62EE 97249F52 943ECA3A 8A09A7D8  7E40D441 FC9A5052 06001C00 55001200
        +00385                     09002B00 00000000 00000000 7A450000  FA440000 00000000 2B40F19C 2E72EBE9
        +00417                     BA40C925 084A633E 664D0424 00000000  41555832 3A5B5041 554C2E58 522E494E
        +00449                     565D5831 4B524553 462E5041 4B3B3120  41555832 3A5B5041 554C2E53 522E494E
        +00481                     565D5331 4B524553 462E5041 4B3B3120  41555832 3A5B5041 554C2E58 522E504F
        +00513                     4C5D5850 354B2E50 4F4C3B31 20202020  41555832 3A5B5041 554C2E53 522E504F
        +00545                     4C5D5350 354B2E50 4F4C3B31 20202020  113E8CEC 6756F534 053F80C3 89A46044
        +00577                     8B4D883C 00000000 0A4E6448 00000000  00000000 01000000

     2   600   PRINT REQUESTED     A0420000 A0450000 00000000 00000000  00000000 00000000 00000000 00000000
        +00033                     00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000
        +00065                     00000000 00000000 00000000 00000000  F9427EDC 02436AD5 FB42F73F 03431C60
        +00097                     8547274C FDB59F43 00000400 2B001E00  6440DCFB F2000080 AF52C233 CCAF5075
        +00129                     C3521950 89B0C064 2952DE5F E75FA313  B7C76794 9E7449EA 8647A2E7 4C400A07
        +00161                     EA463305 03AEDD39 AF52A732 CB369E51  C3522252 9D5BA08D 2952CC63 36BEEFB6
        +00193                     BAC77802 9B8C496A 85472793 E2F57F17  EA46A60C D7849DD8 3B47121E DDD620F9
```

YR 84
MM 08
DD 03
08/03/84

77-084A-02J,K,L
p3

FATAR DETAIL REPORT D-06387

```
BLOCK  LNGTH/  MESSAGE/               1...5...10...15...20...25...30...35...40...45...50...55...60...65...70...75...80
NUMBER DISPL   BLOCK TYPE                    (COLUMN GRID IS VALID ONLY FOR CHARACTER FORMATTED DATA)

     2     80  PRINT REQUESTED        74C90024 3CBCA0A7 003F0200 73746570  73696D2E 6F757420 20202020 20202020
       +00033                         20202020 20202020 20202020 20202020  20202020 20202020 20202020 20202020
       +00065                         20202020 20202020 FA4DFCD0 00000000

     3     80  PRINT REQUESTED        71C900B3 3CBC5082 003F0400 73746570  73696D2E 6F757420 20202020 20202020
       +00033                         20202020 20202020 20202020 20202020  20202020 20202020 20202020 20202020
       +00065                         20202020 20202020 FA4DFCD0 00000000

   200     80  PRINT REQUESTED        6F490042 00417F30 003F3C13 73746570  73696D2E 6F757420 20202020 20202020
       +00033                         20202020 20202020 20202020 20202020  20202020 20202020 20202020 20202020
       +00065                         20202020 20202020 FA4DFCD0 00000000

   201     80  PRINT REQUESTED        714900B3 00419144 FF3ECF20 73746570  73696D2E 6F757420 20202020 20202020
       +00033                         20202020 20202020 20202020 20202020  20202020 20202020 20202020 20202020
       +00065                         20202020 20202020 FA4DFCD0 00000000

   202     80  PRINT REQUESTED        74490024 0041B650 003FFB14 73746570  73696D2E 6F757420 20202020 20202020
       +00033                         20202020 20202020 20202020 20202020  20202020 20202020 20202020 20202020
       +00065                         20202020 20202020 FA4DFCD0 00000000

* * * * * * *  END OF FILE     3  -- FILE CONTAINED     202 BLOCKS

* * * * * * *  START FILE      4

     1    600  PRINT REQUESTED        564F5941 47455220 31205241 44494F20  4F434355 4C544154 494F4E20 44415441
       +00033                         20544150 45203B20 53435241 2D535441  4E464F52 44000000 00000000 00000000
       +00065                         00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000
       +00097      08/22/91           54000500 16001700 3B000000 00000000  80460000 00460000 00000000 00000000
       +00129                         00000000 00000000 00000000 80410000  80440000 48430000 4C437CBB 868A16A7
       +00161                         7F4025FE CF31D7E7 E2BC3213 4D148A18  44BC178D 34283B89 E23C3213 4D148A18
       +00193                         7F4070FE 2DCBF250 2DB82CA4 134FF73B  443C178D 34283B89 2DB82CA4 134FF73B
       +00225                         7F40B4FF 8C96264D 1FC09B0B A1A926BE  4840BD99 424DB741 BD234703 9F7141D4
       +00257                         47C0883D 8B316F57 1DC088F7 517D8A73  EE3EF216 0AD9C37C BA3EE990 7F7F0FB9
       +00289                         933E0CEB E596F073 7E40A043 E7F763EC  7D401CD5 51D219DC CABE8BFA 4E715C87
       +00321                         ABBEBDD3 0AB40616 BD3E0C29 20A29072  7E409710 62E5C30A A5BE6080 9AC72841
       +00353                         BA3E62EE 97249F52 943ECA3A 8A09A7D8  7E40D441 FC9A5052 06000F00 54000000
       +00385                         36002300 00000000 00000000 9C460040  1C460040 00000000 2B40F19C 2E72EBE9
       +00417                         BA40C925 084A633E 664D0424 00000000  5F445241 333A5B32 53435241 5443482E
       +00449                         5041525D 58354B52 45532E4F 55543B31  5F445241 333A5B32 53435241 5443482E
       +00481                         5041525D 53354B52 45532E4F 55543B31  73637274 63683A34 30393664 30302E70
       +00513                         6F6C2020 20202020 20202020 20202020  73637274 63683A73 31303234 6430302E
       +00545                         706F6C20 20202020 20202020 20202020  113E8CEC 6756F534 053F80C3 89A46044
       +00577                         854DB083 00000000 094E4054 00000000  00000000 01000000

     2    600  PRINT REQUESTED        80410000 80440000 00000000 00000000  00000000 00000000 00000000 00000000
       +00033                         00000000 00000000 00000000 00000000  00000000 00000000 00000000 00000000
       +00065                         00000000 00000000 00000000 00000000  FB4287C8 05437359 FD42BE2B 0443C053
       +00097                         684FC53D 84939F52 00000400 2A001900  32408435 7AE50080 AF527D34 E8B3B08A
       +00129                         C352904F F74139C3 2952675F 2E2C713E  B7C7E793 1959927A 864732E8 6B6E4B7D
       +00161                         EA462D06 9B94569B AF526433 70B5E8BF  C3529A51 6446D841 29525563 B186D356
       +00193                         BAC79503 9A097C63 8547AE96 1840181E  EA46A50D 99665EB9 684F763D 46193510
```

77-084A-02J,K,L

CENTER FOR RADAR ASTRONOMY

STANFORD UNIVERSITY
DEPARTMENT OF ELECTRICAL ENGINEERING
STANFORD, CALIFORNIA 94305

March 20, 1986

National Space Science Data Center
NASA/Goddard Space Flight Center
Code 601
Greenbelt, Maryland 20771

Dear Sirs:

The enclosed tape contains newly processed Saturn ring data from the Voyager Radio Science team at the Stanford Center for Radar Astronomy. The data represent the microwave opacity and phase of Saturn's rings as a function of radial location as derived from the Radio Occultation experiment performed by Voyager 1 at Saturn. We view this data set as our standard map of the rings at a nominal resolution of 1 kilometers, and would appreciate its entry into your archives to supplement the data we sent to you in January 1983 and June 1984. The 1984 tape was a lower resolution (5 km) version of these same data.

The tape is 9-track, 1600 bpi, and was generated on March 18, 1986 with the title "X- and S-band Opacity and Phase Profiles of the Rings of Saturn". The enclosed documentation describes the contents of the tape and the data representation. It is also stored as ASCII data in the first file (file 0) of the tape.

Questions regarding the tape and documentation should be addressed to me, Paul Rosen ((415) 497 3597).

Sincerely,

Paul A. Rosen

Paul A. Rosen

STANFORD CENTER FOR RADAR ASTRONOMY

Voyager 1 Radio Occultation Profiles of Saturn's Rings at 3.6 and 13 cm wavelengths

Revision 1.2 November 16, 1985

INTRODUCTION

This tape contains radio occultation data obtained during the Voyager 1 occultation of Saturn's rings.

The files recorded on this tape are:

File 0 - This file contains documentation describing subsequent files. You are presently reading it.
File 1 - Simulated Impulse Response of the occultation experiment and data processing
File 2 - Simulated Step Response of the occultation experiment and data processing
File 3 - Data file containing both data and geometric parameters for processing. Includes error bars for the data.

For a full description of the experiment and the associated data set, see ["Theory of Radio Occultation by Saturn's rings", Marouf E.A. , G.L. Tyler and V.R. Eshleman, Icarus, 49, 161-193 (1982)] and ["The Microwave Opacity of Saturn's Rings at Wavelengths of 3.6 and 13 cm from Voyager 1 Radio Occultation", Tyler G.L. et al., Icarus, 54, 160-188 (1983)]. Briefly, Voyager 1 passed behind Saturn's rings and transmitted 3.6 and 13 cm wavelength coherent signals through the rings toward Earth. Due to interaction with the ring material, a portion of the signal was scattered while the rest propagated through maintaining its coherence but reduced in amplitude. Processing the data to remove the scattered component leaves the coherent signal, which is a profile of microwave opacity and phase at the two wavelengths along the locus of points where the Earth-to-Spacecraft ray intersects the ring plane. Assuming the ring material is constant with azimuth at a given radius, this profile may be interpreted as a radial profile of the ring opacity and phase.

Because of the coherence of the source and the size scales of the variations in the rings themselves, the rings acted as a large diffracting screen through which the signal propagated before observation on Earth. Thus the observed waveform exhibited striking Fresnel diffraction patterns, effectively blurring the true profile of the rings ["Microwave Edge Diffraction by Features in Saturn's Rings: Observations with Voyager 1", Marouf E.A. and G.L. Tyler, Science 217 243-245 (1982)].

To obtain accurate values of the opacity and phase profiles at resolutions finer than the characteristic diffraction scale size (on the order of 15 kilometers), an "inversion" procedure was devised. Processing the coherent data (hereafter referred to as "pre-inversion data") with the inversion filter gives opacity and phase estimates at a resolution dependent on the amount of data used in filtering; more data yields finer resolution.

A measure of the resolution is determined by the "impulse response" of the diffraction-observation-inversion process. One may model a very narrow gap in an otherwise dense portion of the rings as a delta function of radial position (single slit). The observed diffraction pattern for such a diffracting screen is a purely quadratic phase function with constant amplitude. Processing with the inversion filter will give an approximation to the original delta function, i.e. a function with a main spike (or lobe) of finite width, centered at the location of the delta function, and oscillating tails on either side. The functional form varies depending on the nature of the inversion filter, but one may visualize the response as SIN(x) / x where the period of the the sinusoid defines the length of a resolution cell. Digital filtering techniques have been used to suppress the oscillating tails of the impulse response, distorting the shape of the main lobe slightly. A widely used measure of the actual resolution obtained is defined by the ratio of the total power in the main lobe to the peak power at the center. This gives the width of a rectangle with the same integrated power as the impulse response but with constant height equal to the peak power. This is the nominal resolution quoted in the data records. Other researchers may wish to define resolution differently, and for this reason a simulated impulse response is included on this tape in File 1. File 2 contains the step response, i.e. the integrated impulse response. This illustrates how an infinitely sharp transition from an opaque ring to freespace would appear after inversion.

File 3 contains the actual data and support information. We give both pre- and post-inversion data to illustrate the effect of inversion and for completeness. All the necessary information for other researchers to perform the inversion is provided, particularly the Fresnel zones for low resolution inversions (see papers mentioned above). In addition to the data, upper and lower bounds on the error in opacity and phase are given for each inverted data point at both wavelengths. These error bounds represent the limits between which the true opacity or phase lies within some confidence interval. Usually this is a 50% probability confidence interval but another may be given in the header record. The formulae used to derive these quantities are given in ["Fine Resolution Mapping of the Microwave Opacity of Saturn's Rings: Theory, Examples, Limitations", Marouf,E.A., and G.L. Tyler, to be published].

The vectors describing the relative positions of the Sun, Earth, Saturn and Spacecraft from their centers of mass are given in a heliocentric EME-1950.0 system unless otherwise noted. Linear dimensions are in meters and angles are in degrees. Time is in ephemeris seconds from 1950.0 to the event with which the time is associated.

The Saturn system mentioned in what follows uses the pole vector defined by [Simpson R.A., G.L. Tyler, and J.B. Holberg, Astronomical Journal, 88, #10, (1983)]; the x-axis is toward the ascending node of the Saturn mean equator (of date) on the mean 1950.0 Earth equator. A second Saturn system, based on Sturms (1971) pole and equinox, is also used but only to obtain subintercept planetographic longitude.

For more information or clarification contact:

Center for Radar Astronomy
Stanford University
Department of Electrical Engineering/SEL
Stanford CA 94305

The Tape format and Documentation are the work of Paul Rosen,
Durand 211, (415) 497 3597 as of September 1984.

FILE FORMATS

FILE 1 - Impulse Response

Each record is 80 bytes, of which only the first 12 are used. Record 0 contains 12 ASCII characters, something like:

record 0:   Impulse.2500m

"2500m" is the nominal resolution of the inversion which this impulse response simulates, and will vary for different resolutions. Each subsequent record contains 3 single precision words:

```
                         +----------+----------+----------+
record i, i > 0 :        ! SpWord1  ! SpWord2  ! SpWord3  !
                         +----------+----------+----------+
```

where

SpWord1 is the relative location in meters from the center of the impulse
SpWord2 is the opacity at the location in SpWord1
SpWord3 is the phase at the location in SpWord1

No error bounds apply to the simulation context.

The file is of indefinite length so end-of-file conditions must be handled appropriately.

File 2 - Step Response

This file has exactly the same format as File 1 with obvious modifications of the word "step" for "impulse". The location of the edge of the step coincides with the impulse response center.

File 3 - Data File

This file contains 3 types of records:

1) Header Record - a single 600 byte record at the beginning of the file which contains information about the rest of the file. Most important, it states how many bytes are contained in each data record.

2) Data Header Record - Every so many data points, geometry and processing parameter information are stored. This record is 600 bytes.

3) Data Record - Contains the pre- and post- inversion data as well as error bounds. The length of this record depends on the resolution. All this information is contained in the header record.

Each data record has an associated header record. For n = 0, 1, 2, ...

```
                 +------------------------------------+
record 0         ! Header     600 bytes               !
                 +------------------------------------+
                 +------------------------------------+
record 1         ! DataHeader    600 bytes            !
                 +------------------------------------+
                 +---------------------------------------...
record 2         ! Data       variable number of bytes
                 +---------------------------------------...
    .
    .
    .
                 +------------------------------------+
record 2n+1      ! DataHeader    600 bytes            !
                 +------------------------------------+
                 +---------------------------------------...
record 2n+2      ! Data       variable number of bytes
                 +---------------------------------------...
```

RECORD FORMATS

HEADER RECORD

The word number serves as an index into a record. Numbering of words starts from 1. Then following labels are assigned to word numbers:

- D - indicates a Double precision word
- R - indicates a Single precision word
- I - indicates an integer word
- H - indicates an half integer word
- B - indicates a byte or ascii character

For example, a single precision value stored at word number R10 in the record is located at the byte address 37. Similarly, a double precision value stored at D10 is located at byte address 73. The following word numbers all have the same record byte address:

D6 , R11 , I11 , H21 , B41

Item descriptions preceded by (P) are quantities which were included for completeness and troubleshooting. It is unlikely that researchers will use them.

WORD NUMBER	MNEMONIC	DESCRIPTION
B1 - B80	COMNT	Comment line from tape-generating program
B81 - B96	-	Unused
H49	INYR	Time of Data Inversion (year)
H50	INMO	(month)
H51	INDA	(day)
H52	INHR	(hour)
H53	INMI	(minute)
H54	INSC	(second)
H55 - H56	-	Unused
R29	DCRTOX	(P) Data decimation value of X-band pre-inversion data
R30	DCRTOS	(P) Data decimation value for S-band
R31 - R35	-	Unused
R36	DTPTS	Number of data samples per data record
R37	DRECL	Number of bytes in data record
R38	CONF	Confidence parameter for error bounds calculation.
D20	DELTAT	Difference in seconds between UTC and Ephemeris time.
D21 - D29	EME50	EME-1950.0 to EME-date transform matrix.
D30 - D38	EMESAT	EME-1950.0 to Saturn-equator system transformation matrix
D39 - D47	EMESTURMS	(P) EME-1950.0 to Saturn-date (Sturms) tr
H189	YY	(P) Time of generation of this tape (Year)
H190	MO	(P) (Month)

H191	DD	(P)	(Day)
H192	HH	(P)	(Hour)
H193	MM	(P)	(Minute)
H194	SS	(P)	(Second)
R100	INRES	Nominal Inversion resolution	
D51	PTSPA	Data sample spacing (meters)	
D52	ALPHA	Right ascension of Saturn's Pole	
D53	DELTA	Declination of Saturn's Pole	
D54	RSUBS	Radius of Saturn (meters)	
B433 - B464	INVX	(P) File name of X band inverted data	
B465 - B496	INVS	(P) File name of S band inverted data	
B497 - B528	POLX	(P) First file of X band pre-inversion data	
B529 - B560	POLS	(P) First file of S band pre-inversion data	
D71	LAMBX	X band wavelength	
D72	LAMBS	S band wavelength	
D73	RSTRT	Start Radial location of data	
D74	REND	End Radial location of data	
H297 , H298	-	Unused	
H299	VOLNO	Tape number for this data set	
H300	OUTREC	Record number (0 for header)	

DATA HEADER RECORD

All quantities in this record are computed for the first point of data in the subsequent data record. To obtain values for the other data samples, one must interpolate.

WORD NUMBER	MNEMONIC	DESCRIPTION
R1	DTPTS2	Same as DTPTS in header
R2	DRECL2	Same as DRECL in header
R3 - R20	-	Unused
R21	TSR	System temperature (K) right circular polarization S band
R22	TSL	(P) System temperature (K) left circular polarization S band
R23	TXR	System temperature (K) right circular polarization X band
R24	TXL	(P) System temperature (K) left circular polarization X band
D13	TR	Receive Time, E.T. Seconds from 1950.0
H53	DOYR	Receive Time (UTC), day of year
H54	HHR	hour
H55	MIR	minute
H56	SSR	second
D15	DPDSR	fractional seconds
D16 - D18	RE	Earth Position
D19 - D21	VE	Earth Velocity
D22 - D24	RD	DSS Position
D25 - D27	VD	DSS Velocity
D28	TT	Transmit Time, E.T. Seconds from 1950.0
H113	DOYT	Transmit Time (UTC), day of year
H114	HHT	hour
H115	MIT	minute
H116	SST	second
D30	DPDST	fractional seconds
D31 - D33	RS	Saturn Position
D34 - D36	VS	Saturn Velocity
D37 - D39	RV	Voyager Position
D40 - D42	VV	Voyager Velocity
D43 - D45	UE	High Gain Antenna Boresight unit vector
D46	TP	Intersection Time, E.T. Seconds from 1950.0
H185	DOYP	Intersection Time (UTC), day of year
H186	HHP	hour
H187	MIP	minute
H188	SSP	second
D48	DPDSP	fractional seconds
D49 - D51	RP	Intersection point Position
D52 - D54	RPP	Intersection point Position in Saturn Centered, Saturn equator system
D55	RPPMM	Radial distance to intercept point (meters)
D56	RPPMK	Radial distance to intercept point

		(kilometers)
D57	RPPMR	Radial distance to intercept point (Saturn Radii)
D58	ALPP1	Azimuthal position of intersection point, in the Saturn equator from the ascending node of the EME50 equator
D59	ALPP2	Azimuthal position from the Saturn-Earth line
D60	ALPP3	Azimuthal position from the Saturn-Sun line
D61	LONG	Longitude on Saturn of sub-intersection point, using Sturms frame
D62	MEWO	SIN of the angle of incidence of the beam
D63	PHIO	Angle between radial direction and Spacecraft-Earth direction (radians)
D64	DMAG	Distance from the spacecraft to the intersection point
D65	FZX	X band Fresnel zone size (radial)
D66	FZS	S band Fresnel zone size (radial)
H265 - H298	-	Unused
H299	VOLNO	Same as VOLNO in header
H300	OUTREC	Record number

DATA RECORD

The following format pertains to one sample point in the data record. The format repeats itself for however many data points are in the record. That value is stored in DTPTS in the Header and DTPTS2 in the Data Header. The total byte length of the record is stored in DRECL in the Header and DRECL2 in the Data Header. For example TX for sample point n is stored in R[(n-1)*16+1]. Phases are given in cycles (radians/2*3.15159...)

WORD NUMBER	MNEMONIC	DESCRIPTION
R1	TX	Pre-inversion X-band opacity
R2	PX	Pre-inversion X-band phase
R3	TS	Pre-inversion S-band opacity
R4	PS	Pre-inversion S-band phase
R5	TTWX	Post-inversion X-band opacity
R6	PTWX	Post-inversion X-band phase
R7	TTWS	Post-inversion S-band opacity
R8	PTWS	Post-inversion S-band phase
R9	TUBX	X-band opacity upper bound
R10	TLBX	X-band opacity lower bound
R11	PUBX	X-band phase upper bound
R12	PLBX	X-band phase lower bound
R13	TUBS	S-band opacity upper bound
R14	TLBS	S-band opacity lower bound
R15	PUBS	S-band phase upper bound
R16	PLBS	S-band phase lower bound

NUMBER CONVENTIONS

A byte is 8 bits. A word is defined as 4 bytes, which applies to integer numbers and single precision floating point numbers. Double precision numbers are 8 bytes and most integers are stored in two bytes (halfwords). The number representations are in VAX-11 FORTRAN format. They are as follows:

Integer HalfWord

Two byte integers are stored in two's complement representation and lie in the range -2**15 < halfword < 2**15 - 1, where ** denotes "raised to the power". The chart below illustrates the physical storage of the two bytes. The Least Significant Bit (LSB) is bit 0 and the Most Significant Bit (MSB) is bit 15.

```
               Byte 0       Byte 1
             +----------+-----------+
             !          !           !
             +----------+-----------+
bit#          7        0 15         8
```

To obtain a bit-sequential representation of the integer, the bytes must be switched. Then the bits are in order from MSB on the left to LSB on the right:

```
               Byte 1       Byte 0
             +----------+-----------+
             !          !           !
             +----------+-----------+
bit#          15       8 7          0
```

Integer Word

4 byte integers are stored in two's complement representation and lie in the range -2**31 < Word < 2**31 - 1. The same definitions apply here as for HalfWords. The physical storage is:

```
               Byte 0       Byte 1      Byte 2       Byte 3
             +----------+-----------+----------+-----------+
             !          !           !          !           !
             +----------+-----------+----------+-----------+
bit#          7        0 15        8 23      16 31         24
```

Bit sequential representation requires the following:

```
               Byte 3       Byte 2      Byte 1       Byte 0
             +----------+-----------+----------+-----------+
             !          !           !          !           !
             +----------+-----------+----------+-----------+
bit#          31      24 23      16 15       8 7           0
```

Floating Point Numbers

Both Single and Double precision numbers use the same storage representation. The exponent is stored in excess 128 notation. Thus the exponent ranges from 1 to 256 to represent exponents of -127 to 128. The format of the number is sign magnitude with bit 15 the sign bit, and bits 14:7 the exponent. The fraction stored with the redundant most significant bit not represented. The number is normalized in such a way that this bit is assumed to be set (1) unless the exponent is stored as a value of 0.

Single Precision

The Physical representation is

```
              Byte 0      Byte 1      Byte 2      Byte 3
           +----------+-----------+----------+-----------+
           !E!  F     !S !  E     !    F     !    F      !
           +----------+-----------+----------+-----------+
bit#        7 6      0 15 14     8 23      16 31        24
```

Here E means exponent, S means sign bit, and F means fraction. Note that bits 14:7 represent the exponent, and 6:0 concatenated with 31:16 represent the fraction (24 bits including redundant bit). Bit sequential order gives:

```
              Byte 1      Byte 0      Byte 3      Byte 2
           +----------+-----------+----------+-----------+
           !S !  E    !E!  F      !    F     !    F      !
           +----------+-----------+----------+-----------+
bit#        15 14    8 7 6       0 31      24 23       16
```

When unpacking the bits remember that the most significant fraction bit is not represented. Thus the straightforward conversion is

```
fraction = .5 + bit 6 * 2**-2 + bit5 * 2**-3 + ... + bit16 *2**-24
```

The only exception is when the exponent is stored as the value 0. In this case, the single precision value is 0.

Double Precision

Double precision numbers are the same as single precision but with an extended fraction.

```
              Byte 0      Byte 1      Byte 2      Byte 3      Byte 4
           +----------+-----------+----------+-----------+----------+
           !E!  F     !S !  E     !    F     !    F      !    F     !
           +----------+-----------+----------+-----------+----------+
bit#        7 6      0 15 14     8 23      16 31        24 39      32
```

```
        Byte 5      Byte 6       Byte 7
       +-----------+-----------+-----------+
       !     F     !     F     !     F     !
       +-----------+-----------+-----------+
        47       40 55       48 63       56
```

Bit Sequential order is obtained by reversing the bytes pairwise, as with single precision.

```
          Byte 1      Byte 0      Byte 3       Byte 2      Byte 5
         +----------+-----------+-----------+-----------+-----------+
         !S !  E    !E!   F     !     F     !     F     !     F     !
         +----------+-----------+-----------+-----------+-----------+
bit#      15 14     8 7 6      0 31       24 23       16 47       40

          Byte 4      Byte 7      Byte 6
         +-----------+-----------+-----------+
         !     F     !     F     !     F     !
         +-----------+-----------+-----------+
          39       32 63       56 55       48
```

SAMPLE PROGRAM TO READ DATA FILE

```
      Program read inversion tape

c* This program will read a tape with occultation data on it.

c*                **** Documentation ****
c*
c* Author: Paul Rosen SCRA
c* Date:   June 13 1984
c*
c* Matrices:
c*
c*      Eme         Converts Eme-Date Vectors To Eme50
c*      Eme2sat     Converts Eme50 To Saturn-Me-Date Frame
c*      Eme2sturms  Converts Eme50 To Saturn-Me-Date Frame With Sturms'
c*                  Parameters

c* Scalars:
c*
c*      Rsaturn     Saturn Radius (60330 Km)

c*                    **** Declarations ****
c*
      Implicit Real*8 (A-H,O-Z)

c* Tape-specific lengths and offsets and command defs. Parameter statements
c* speeds computation.  Also modification is easier.  NOTE: The PARAMETER
c* statements used here without parentheses are VAX specific and the symbolic
c* names take on the data type of the constant assigned to them.  E.g.
c* PARAMETER INUM = 544.43  assigns the REAL value 544.43 to INUM
c*
      Integer      Ret_count       , Drec_len       , Data_len
      Parameter    MaxD_len = 100  , Data_wid = 16
      Parameter    Byte_len = 6400 , I2_len = 3200  , I4_len = 1600
      Parameter    Sp_len   = 1600 , Dp_len = 800   , Header_len = 600
      Parameter    Max_len  = MaxD_len + 10

c* Function codes for tape routine.
c*
      Parameter    Tp_read  = 1    , Tp_write = 2
      Parameter    Tp_rewnd = 3    , Tp_weof  = 4


c* Header record offsets.  Each offset is in terms of the number of words in
c* that particular data type. For example, iINYR is 49 integer*2 words into the
c* array while iDELTAT is 20 real*8 words into the array.
c*
      Parameter    iCOMNT  =   1
      Parameter    iINYR   =   49 ,    iINMO   =   50 ,    iINDA  = 51
      Parameter    iINHR   =   52 ,    iINMI   =   53 ,    iINSC  = 54
      Parameter    iDCRTOX =   29 ,    iDCRTOS =   30
      Parameter    iDTPTS  =   36 ,    iDRECL = 37
      Parameter    iCONF   =   38 ,    iDELTAT =   20 ,    iEME50 = 21
      Parameter    iEMESAT =   30 ,    iEMESTR =   39
      Parameter    iYY     =  189 ,    iMO     =  190 ,    iDD    = 191
      Parameter    iHH     =  192 ,    iMM     =  193 ,    iSS    = 194
      Parameter    iOUTTAP =  389 ,    iINRES  =  100 ,    iPTSPA = 51
      Parameter    iALPHA  =   52 ,    iDELTA  =   53 ,    iRSUBS = 54
      Parameter    iINVX   =  433 ,    iINVS   =  465 ,    iPOLX  = 497
```

```
        Parameter   iPOLS   =  529 ,   iLAMBX  =  71  ,   iLAMBS = 72
        Parameter   iRSTRT  =  73  ,   iREND   =  74  ,   iVOLNO = 299
        Parameter   iOUTREC =  300

c* Data Header record offsets.
c*
        Parameter   iDTPTS2 =  1   ,   iDRECL2  =  2
        Parameter   iTSR    =  21  ,   iTSL    =  22  ,   iTXR    = 23
        Parameter   iTXL    =  24  ,   iTR     =  13  ,   iDOYR   = 53
        Parameter   iHHR    =  54  ,   iMIR    =  55  ,   iSSR    = 56
        Parameter   iDPDSR  =  15  ,   iRE     =  16  ,   iVE     = 19
        Parameter   iRD     =  22  ,   iVD     =  25  ,   iTT     = 28
        Parameter   iDOYT   =  113 ,   iHHT    =  114 ,   iMIT   = 115
        Parameter   iSST    =  116 ,   iDPDST  =  30  ,   iRS    = 31
        Parameter   iVS     =  34  ,   iRV     =  37  ,   iVV    = 40
        Parameter   iUA     =  43  ,   iTP     =  46  ,   iDOYP  = 185
        Parameter   iHHP    =  186 ,   iMIP    =  187 ,   iSSP   = 188
        Parameter   iDPDSP  =  48  ,   iRP     =  49  ,   iRPP   = 52
        Parameter   iRPPMM  =  55  ,   iRPPMK  =  56  ,   iRPPMR = 57
        Parameter   iALPP1  =  58  ,   iALPP2  =  59  ,   iALPP3 = 60
        Parameter   iLONG   =  61  ,   iMEWO   =  62  ,   iPHIO  = 63
        Parameter   iDMAG   =  64  ,   iFZX    =  65  ,   iFZS   = 66

c* Data record offsets.
c*
        Parameter   iTX     =  1
        Parameter   iPX     =  2    , iTS      = 3  , iPS   = 4
        Parameter   iTTWX   =  5    , iPTWX    = 6  , iTTWS = 7
        Parameter   iPTWS   =  8    , iTUBX    = 9  , iTLBX = 10
        Parameter   iPUBX   =  11   , iPLBX    = 12 , iTUBS = 13
        Parameter   iTLBS   =  14   , iPUBS    = 15 , iPLBS = 16


        Byte        Byte_data(Byte_len) ,    nam_byts(64)
        Integer*2   I2_data(I2_len)
        Integer*4   I4_data(I4_len)
        Real*8      Dp_data(Dp_len)
        Real*4      Sp_data(Sp_len)     ,    Tape_data(Data_wid,MaxD_len)
        Integer     Rec_num ,   Ret_len ,    Logu ,Tp_file
        Real*8      Location,   Loc_incr
        Dimension   Eme(3,3),  Eme2sat(3,3) ,  Eme2sturms(3,3)

        Character   Nam*64

        Equivalence (Dp_data(1),Sp_data(1),I2_data(1),I4_data(1),
     1                                 Tape_data(1,1),Byte_data(1))
        Equivalence (Nam,Nam_byts(1))

        Data Logu/14/

        Tp_file = 3
        Open(logu,file='readtape.log',form='formatted',status='new')

        Write(Logu,800)
 800    Format(/,' -------  Log file for READTAPE program  ------- ',//)

c* Read the zero record (header record) into byte data array
c*
        Rec_num = 0
        Call Tape_handl(Tp_read,Byte_data,Tp_file,Rec_num,
     1                            Header_len,Ret_count,istat)

        Drec_len = Sp_data(iDRECL)
        Data_len = Sp_data(iDTPTS)
```

```
      Write(logu,7322) Data_len,Drec_len
7322  Format(' Number of Data rows per record ',i6,
    1        '    Number pf Bytes ',i6,/)
      Do i = 0 , 52
          Nam_byts(i+1)   =  Byte_data(iCOMNT + i)
      End do
      Write(logu,*) Nam
      Write(logu,799) (I2_data(iYY+i),i=0,5)
799   Format(' Time of tape generation: ',6i6)

      Write(logu,807) Sp_data(iDCRTOX),Sp_data(iDCRTOS),
    1       Dp_data(iLAMBX),Dp_data(iLAMBS),Dp_data(iRSUBS)
    2                                   ,Dp_data(iDELTAT),
    3                    Dp_data(iALPHA),Dp_data(iDELTA)
807    Format(' Constants etc. for calculations...',/,
    1  ' Decratx'    ,t10, 1p1d23.14 ,t40, 'Decrats'     ,t50, 1p1d23.14
    2                               ,t80, 'Lambdax'    ,t90, 1p1d23.14,/,
    3  ' Lambdas'  ,t10, 1p1d23.14 ,t40, 'Rsaturn'    ,t50, 1p1d23.14
    4                               ,t80, 'Etmutc'    ,t90, 1p1d23.14,/,
    5  ' Right asc'  ,t10, 1p1d23.14 ,t40, 'Decl'    ,t50, 1p1d23.14,/)


      k = 0
      do i = 1 , 3
          do j = 1 , 3
               Eme(i,j)          =  Dp_data(iEME50 + k)
               Eme2sat(i,j)      =  Dp_data(iEMESAT + k)
               Eme2sturms(i,j)   =  Dp_data(iEMESTR + k)
             k = k + 1
          end do
      end do

      Write(logu,813) Eme,Eme2sat,Eme2sturms
813   Format(3(' Eme:         ', 1p3d23.14,/),/,
    1         3(' Eme2sat:     ', 1p3d23.14,/),/,
    2         3(' Eme2sturms: ', 1p3d23.14,/),/)

      do i = 0 , 31
          Nam_byts(i+1)   =  Byte_data(iINVX + i)
      end do
      Write(logu,806) nam
806   Format(' X-band inversion file used by Maketape: ',t44,a31)

      do i = 0 , 31
           Nam_byts(i+1) = Byte_data(iINVS + i)
      end do
      Write(logu,808) nam
808   Format(' S-band inversion file: ',t44,a31)

      do i = 0 , 31
           Nam_byts(i+1) = Byte_data(iPOLX + i)
      end do
      Write(logu,810) nam
810   Format(' First X-band POL-file: ',t30,a31)

      do i = 0 , 31
           Nam_byts(i+1) = Byte_data(iPOLS + i)
      end do
      Write(logu,812) nam
812   Format(' First S-band POL-file: ',t30,a31)

      Write(logu,809) Dp_data(iRSTRT),Dp_data(iREND),Sp_data(iINRES),
    1                 Dp_data(iPTSPA),
    2                 Sp_data(iCONF),I2_data(iINYR),I2_data(iINMO),
```

```
     3                   I2_data(iINDA),I2_data(iINHR),I2_data(iINMI),
     4                   I2_data(iINSC),I2_data(iVOLNO),I2_data(iOUTREC)

 809    Format(' Input parameters...',/,
     1   ' Start(km)',t10, 1p1d23.14 ,t40, 'End'         ,t50, 1p1d23.14
     2                               ,t80, 'Resolut '    ,t90, 1p1d23.14,/,
     3   ' Spacing'  ,t10, 1p1d23.14 ,t40, 'Confidenc'   ,t50, 1p1d23.14
     4                               ,t80, 'Inver Year'  ,t90, i6,/,
     5   ' Month'    ,t10, i6        ,t40, 'Day'         ,t50, i6
     6                               ,t80, 'Hour'        ,t90, i6,/,
     7   ' Minute'   ,t10, i6        ,t40, 'Second'      ,t50, i6
     8                               ,t80, 'Vol no'      ,t90, i6,/,
     9   ' Record'   ,t10, i6)

c***   Main Program Loop    ***

        istat = 1
        Do while(istat .eq.1)

c* Read a Data header record.
c*
          Rec_num = Rec_num + 1
          Call Tape_handl(Tp_read,Byte_data,Tp_file,Rec_num,
     1                           Header_len,Ret_count,istat)

          Write(logu,*) 'Dreclen,Datalen ',Sp_data(iDRECL2),
     1                                     Sp_data(iDTPTS2)

          Write(logu,830)  (Sp_data(iTSR+i),i=0,3)
830       format(' Systemps: ',1p4f15.7)
          Write(logu,831) Dp_data(iTR),(I2_data(iDOYR+i),i=0,3),
     1                 Dp_data(iDPDSR)
831       Format(' Receive time:   ',1pd23.14,
     1           '   Integer fields: ',4i6,
     2           '   Fractional sec: ',1pd23.14)

          Write(logu,832)  (Dp_data(iRE+i),i=0,2),
     1                     (Dp_data(iVE+j),j=0,2),
     2                     (Dp_data(iRD+k),k=0,2),
     3                     (Dp_data(iVD+l),l=0,2)
832       Format(' Re: ', 1p3d23.14,/,
     4           ' Ve: ', 1p3d23.14,/,
     5           ' Rd: ', 1p3d23.14,/,
     6           ' Vd: ', 1p3d23.14)

          Write(logu,833) Dp_data(iTT),(I2_data(iDOYT+i),i=0,3),
     1                 Dp_data(iDPDST)
833       Format(' Transmit time:   ',1pd23.14,
     1           '   Integer fields: ',4i6,
     2           '   Fractional sec: ',1pd23.14)

          Write(logu,834)  (Dp_data(iRS+i),i=0,2),
     1                     (Dp_data(iVS+j),j=0,2),
     2                     (Dp_data(iRV+k),k=0,2),
     3                     (Dp_data(iVV+l),l=0,2),
     4                     (Dp_data(iUA+ll),ll=0,2)

834       Format(' Rs: ', 1p3d23.14,/,
     1           ' Vs: ', 1p3d23.14,/,
     2           ' Rv: ', 1p3d23.14,/,
     3           ' Vv: ', 1p3d23.14,/,
     4           ' Ua: ', 1p3d23.14)

          Write(logu,835) Dp_data(iTP),(I2_data(iDOYP+i),i=0,3),
```

```
     1                        Dp_data(iDPDSP)
835         Format(' Intercept time:    ',1pd23.14,
     1             '   Integer fields: ',4i6,
     2             '   Fractional sec: ',1pd23.14)

            Write(logu,836)  (Dp_data(iRP+i),i=0,2),
     1                       (Dp_data(iRPP+j),j=0,2)
836         Format(' Rp:   ', 1p3d23.14,/,
     1             ' Rpp: ', 1p3d23.14)

            Write(logu,837) Dp_data(iRPPMM),Dp_data(iRPPMK),
     1          Dp_data(iRPPMR),Dp_data(iALPP1),Dp_data(iALPP2),
     2          Dp_data(iALPP3),Dp_data(iLONG),Dp_data(iMEWO),
     3          Dp_data(iPHIO),Dp_data(iDMAG),Dp_data(iFZX),
     4          Dp_data(iFZS),I2_data(iOUTREC)
837         Format(' Intercept pt: ',1p3d23.14,/,
     1             ' Azimuths:      ',1p3d23.14,/,
     2            ' Long,mew,phi: ',1p3d23.14,/,
     3             ' Dmag,Fzx,Fzs: ',1p3d23.14,
     4             ' Recnum:        ',i6)

c* Read a data record.
c*
            Rec_num = Rec_num + 1
            Call Tape_handl(Tp_read,Byte_data,Tp_file,Rec_num,
     1                          Drec_len,Ret_count,istat)

            Write(logu,862) data_wid/2,((Tape_data(i,j),
     1                               i=1,data_wid/2),j=1,data_len)
862         Format(' First ',i4,' columns of data...',/,
     1      <data_len>(<data_wid/2>f15.7,/))
            Write(logu,863) data_wid/2,((Tape_data(i,j),
     1                      i=data_wid/2+1,data_wid),j=1,data_len)
863         Format(' Last ',i4,' columns of data...',/,
     1      <data_len>(<data_wid/2>f15.7,/))
        End do

999     Stop 'Readtape:  Tape read! '
        end
```