

## Formats of apriori files for VTD.

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*Abstract:*

*This document provides description of formats for a priori data used for computing VLBI time delay and Doppler frequency shift for observations of objects in the Solar system.*

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## **1 Preliminaries remarks**

### **1.1 Date format:**

Internally dates are kept in VTD in a pair of variables: MJD of INTEGER\*4 type and TAI of REAL\*8 type. TAI keeps time elapsed from the midnight. External dates can be presented in two formats: Solve format compatible with ISO 8601 and VEX format.

### **1.2 Solve date format**

YYYY.MM.DDThh:mm:ss.sssssssss  
where YYYY stands for year  
MM stands for the month number  
DD stands for the day of month

## VTD a priori

hh stands for the hour  
mm stands for the minute  
ss stands for the second. Decimal point  
and the fractional part are optional

Example: 2010.06.20T10:45:51.120391

This format is compatible with ISO 8601.

VTD also accepts date with character "\_" instead of "T"  
in the 11-th position for better readability.

Example: 2010.06.20\_10:46:36

This format is incompatible with ISO 8601.

### 1.3 VEX date format

YYYYyDDDdHHhNNmSS.SSSSSSs

where YYYY stands for year  
DDD stands for the day of year  
HH stands for the hour  
NN stands for the minute  
SS stands for the second. Decimal point  
and the fractional part are optional

Examples:

2010y171d10h49m19.129803s

2010y171d10h50m49s

### 1.4 Angle formats

Angles are presented in the form  
DDD\_MM\_SS.SSSSS or HH\_MM\_SS.SSSSS

where DDD is degree  
MM is arc-minute  
SS is arcsecond. Decimal point  
and the fractional part are optional

or HH is hour

## VTD a priori

MM is minute

SS is second of time. Decimal point  
and the fractional part are optional

Delimiters "\_" or ":" are acceptable

Examples:

-64\_21\_58.19083

+64:21:58

10:52:02.282921

10\_54\_57

## 2 Data formats

### 2.1 LEAP\_SECOND

Label: # LEAP\_SECOND file Version of 2004.01.29

Purpose: Data file in LEAP\_SECOND format contains the dates of  
of the difference TAI-UTC as a function of UTC time tag.

TAI stands for international atomic time

(Temps Atomique International), and UTC is a non-differential  
step-wise function of time.

Type: Ascii

Example: \$(VTD\_ROOT)/share/leapsec.dat

Comment character: #

Data record format:

Field 1:6 A6 Delimiter: Date:

Field 7:27 A21 Date as UTC time tag in Solve format.

Field 28:38 A11 Delimiter: TAI-UTC:

Field 39:43 F5.1 The difference TAI minus UTC

### 2.2 DE\_EPHEMERIDES

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Label: ?

Purpose: Table of Chebyshev coefficients for expansion of positions of the Sun, Moon and 9 major planets.

Type: Ascii

Example: \$(VTD\_ROOT)/share/DE403\_JPL.dat

Comment character: n/a

Data record format: I completely forgot, sorry. It is rather complicated

### 2.3 STATION\_DESCRIPTION

Label: # STATION DESCRIPTION Format version of 2004.01.26

Purpose: Defines name of the tectonic plate, type of the mounting, and the value of axis offset for stations.

Type: Ascii

Example: \$(VTD\_ROOT)/share/station.desc

Comment character: #

Data record format:

Field 1:8 A8 IVS Site name

Field 12:15 A4 Antenna mounting code: AZEL, EQUA, X-YN, X-YE, RICH

Field 18:25 F8.5 Antenna offset (m)

Field 28:31 A4 Tectonic plate according to NUVEL

Field 35:80 A46 Comments

### 2.4 SOURCE\_COORDINATES

Three formats are supported

### 2.5 SOURCE\_COORDINATES: SOU-MODFILES

Label: \$\$ SOU-MODFILE Format pre-2000

Purpose: Defines IVS source name, source right ascension, source declination, and the semi-major axis of the

## VTD a priori

error ellipse.

Type: Ascii

Example: \$(VTD\_ROOT)/share/glo.src

Comment character: \$

Data record format:

```
2357-326 00 00 20.399945 -32 21 01.23327 0.60 !J0000-3221
```

Field 1:4 A4 Delimiter. Must be blank

Field 5:12 A8 IVS name of the source. For 98% sources IVS name coincides with B1950 name. For remaining sources a common name is used.

Field 15:16 I2 Hours of right ascension

Field 18:19 I2 Minutes of right ascension

Field 21:28 F9.6 Seconds of right ascension

Field 35:37 I3 Degrees of declination

Field 39:40 I3 Minutes of declination

Field 42:49 F8.5 Arcseconds of declination

Field 53:58 F6.2 Semi-major axis of the error ellipse.

Units: milli-arcseconds.

Value 999.99 indicates that no estimate of the error ellipse is available. NB: in that case there may be no compact source at that position.

Field 61:128 A58 Comments

## 2.6 SOURCE\_COORDINATES: CAT-FORMAT

Label: \$\$ SOU-MODFILE Format pre-2000

Purpose: Defines IVS source name, IAU J2000 name, source right ascension, source declination, information about errors, and correlated flux densities.

Type: Ascii

Example: <http://astrogeo.org/rfc>

Comment character: #

Data record format:

Field 1:1 A1 Category: C (calibrator), N (non-calibrator), U (unreliable coordinates)

Field 4:11 A8 IVS name (B1950)

Field 13:22 A10 IAU name (J2000.0)

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Field	25:26	I2	Right ascension: hours
Field	28:29	I2	Right ascension: minutes
Field	31:39	F9.6	Right ascension: seconds
Field	41:43	I3	Declination: degrees
Field	45:46	I3	Declination: minutes
Field	48:57	F8.5	Declination: seconds
Field	58:63	F6.2	Inflated error in right ascension in mas
Field	65:70	F6.2	Inflated error in declination in mas
Field	73:78	F6.3	Correlation between right ascension and declination
Field	80:85	I6	Number of observations used
Field	88:88	A1	Blank or < or - for X-band total flux density integrated over entire map
Field	89:92	F4.2	X-band total flux density integrated over entire map, Jy
Field	94:94	A1	Blank or < or - for X-band unresolved flux density at VLBA baselines,
Field	95:98	F4.2	X-band unresolved flux density at long VLBA baselines, Jy
Field	101:101	A1	Blank or < or - for S-band total flux density integrated over entire ma
Field	102:105	F4.2	S-band total flux density integrated over entire map, Jy
Field	107:107	A1	Blank or < or - for S-band unresolved flux density at VLBA baselines
Field	108:111	F4.2	S-band unresolved flux density at long VLBA baselines, Jy
Field	114:116	A3	Used Band: X, S or X/S
Field	119:130	A12	Catalogue name

Missing value: -1.0

minus in columns 88, 94, 101 or 107 means that no data in the following column pres  
< in columns 88, 94, 101 or 107 means that the upper limit of the flux density is pri

## 2.7 SOURCE\_COORDINATES: GETPAR SOU-FORMAT

Label: # GETPAR\_SOU format version 1.0 of 2001.05.25

Purpose: Contains estimates of right ascension and declination of sources, as well as their formal uncertainties and correlations between right ascension and declination of the same source.

Type: Ascii

Example: <http://astrogeo.org/rfc>

Comment character: #

Data record format:

Field	Format	Units	Meaning
Field 1:8	A8	--	record type identifier: SOU_GCO:
Field 11:18	A8	--	IVS source name.
Field 25:26	I2	hours	right ascension. hours part

## VTD a priori

Field 27:27 A1 -- separator "\_ "  
Field 28:29 I2 min. right ascension. minutes part  
Field 30:30 A1 -- separator "\_ "  
Field 31:41 F11.8 sec. right ascension. seconds part  
Field 46:55 F10.4 mas formal error of right ascension  
Field 62:64 I3 deg. declination. degrees part.  
Field 65:65 A1 -- separator "\_ "  
Field 66:67 I2 arcmin declination. arcminutes part.  
Field 68:68 A1 -- separator "\_ "  
Field 69:78 F10.7 arcsec declination. arcseconds part.  
Field 83:92 F10.4 mas formal uncertainty of declination  
Field 99:104 F6.4 d/l correlation between the estimates of  
right ascension and declination.  
Field 116:122 I7 -- the number of observations of this source  
used in solution.  
Field 133:139 I7 -- total number of observations of this source.  
Field 151:155 I5 -- the number of sessions of this source used in  
solution.  
Field 166:170 I5 -- total number of sessions with this source.  
Field 182:191 A10 -- the date of the first session with this source  
used in solution. format: yyyy.mm.dd  
(as integer numbers).  
Field 203:212 A10 -- the date of the last session with this source  
used in solution. format:  
yyyy.mm.dd (as integer numbers).

## 2.8 STATION\_COORDINATES

Label: \$\$ SIT-MODFILE Format 2001.09.26

Purpose: Defines position of stations at the specified epoch.

Type: Ascii

Example: \$(VTD\_ROOT)/share/glo.sit

Comment character: #

Epoch of the station catalogue in date Solve formats defined  
in the 3rd row at fields 11:21.

Data record format:

Field 1:4 A4 Delimiter. Must be blank  
Field 5:12 A8 IVS station name  
Field 13:15 A3 Delimiter. Must be blank



## VTD a priori

Field 16:27 F12.3 Station X-coordinate in meters  
Field 28:31 A4 Delimiter. Must be blank  
Field 32:43 F12.3 Station Y-coordinate in meters  
Field 45:47 A4 Delimiter. Must be blank  
Field 48:59 F12.3 Station Z-coordinate in meters  
Field 60:128 A49 Comments

### 2.9 STATION\_VELOCITIES

Label: \$\$ VEL-MODFILE Format 2001.09.26  
Purpose: Defines secular velocities of stations  
Type: Ascii  
Example: \$(VTD\_ROOT)/share/glo.vel

Comment character: #  
Data record format:

Field 1:4 A4 Delimiter. Must be blank  
Field 5:12 A8 IVS station name  
Field 13:20 A8 Delimiter. Must be blank  
Field 21:28 F8.2 Station velocity along X-axis in mm/year  
Field 29:36 A8 Delimiter. Must be blank  
Field 37:44 F8.2 Station velocity along Y-axis in mm/year  
Field 45:52 A8 Delimiter. Must be blank  
Field 53:60 F8.2 Station velocity along Z-axis in mm/year  
Field 62:128 A47 Comments

### 2.10 STATION\_ECCENTRICITIES

Label: # ECC-FORMAT V 1.0 ECCENTRICITY FILE  
Purpose: Defines a monument number for each VLBI station and an eccentricity vector from the monument to the antenna's reference point (axis intersection)  
Type: Ascii  
Example: \$(VTD\_ROOT)/share/ECCDAT.ecc

Comment character: #

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Data record format:

- Field 3:10 IVS station name
- Field 12:15 Monument number
- Field 18:33 Starting date of validity of the eccentricity vector
- Field 18:21 Year of starting date of validity
- Field 23:24 Month of starting date of validity
- Field 26:27 Day of month of starting date of validity
- Field 29:30 Hour (UTC) of starting date of validity
- Field 32:33 Minute (UTC) of starting date of validity
- Field 36:51 Ending date of validity of validity of the eccentricity vector
- Field 36:39 Year of ending date of validity
- Field 41:42 Month of ending date of validity
- Field 44:45 Day of month of ending date of validity
- Field 47:48 Hour (UTC) of ending date of validity
- Field 50:51 Minute (UTC) of ending date of validity
- Field 54:63 First coordinate of eccentricity (in meters)
- Field 65:74 Second coordinate of eccentricity (in meters)
- Field 76:85 Third coordinate of eccentricity (in meters)
- Field 88:90 Type of eccentricity data. Set meaning of eccentricity coordinates.
  - Two types are supported:
  - NEU -- 1-st coordinate is a north projection;  
2-nd coordinate is an east projection;  
3-rd coordinate is a vertical projection directed up  
(more precisely speaking it is directed along  
a normal to the ellipsoid)
  - XYZ -- 1-st coordinate is a X-coordinate in crust  
fixed system;  
2-nd coordinate is a Y-coordinate in crust  
fixed system;  
3-rd coordinate is a Z-coordinate in crust  
fixed system.

### **2.11 AEM\_FILE**

TBD

### **2.12 ERM\_FILE**

TBD

### 2.13 HARMONIC\_EOP\_FILE:

Label: HEO Format version of 2007.08.23

Purpose: Describes small harmonic variations in the Earth orientation. "Small" means that the squares of the rotation angles can be neglected.

Type: Ascii

Example:  $\$(VTD\_ROOT)/share/heo\_20091201.heo$

A file in HEO format consists of records of variable length in ASCII coding. The records are separated by a character with decimal code 13. The records of the following types are supported:

- 1) Header record;
- 2) N-record: Model name record;
- 3) E-record: Time epoch record;
- 4) H-record: Harmonic definition records;
- 5) A-record: Amplitude definition records;
- 6) V-record: Velocities definition records;
- 7) S-record: Amplitude errors definition records;
- 8) R-record: Velocities errors definition records;
- 9) Trailer record.

Records which start from # character are considered as comments.

The first record of a valid file in HEO format is the header record. It is followed by the model name record, time epoch record and then by one or more harmonic definition records and one or more harmonic definition records. The last record is a trailer record. All harmonic definition records should precede amplitude and velocity definition records. Names of a harmonic in the amplitude or velocity records should be defined in the harmonic definition record. The number of velocity records can be less than the number of amplitude records, and the number of amplitude records can be less than the number of harmonic records. If a harmonic is not defined in an amplitude records, its amplitude is considered to be zero. If a harmonic is not defined in a velocity records, the rate of change of the amplitude of that harmonic is considered to be zero.

Records format:

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- 1) A header record contains the string  
"HEO Format version of 2007.08.23 "

The header record allows to distinguish the valid file in the HEO format from files in other formats and tells to a parsing software that is the version of the format.

- 2) A name record defines the name of the model of the harmonic Earth orientation variations.

Format of an N-record:

-----

Field 1:1 A1 -- Records ID: letter N (decimal code 78).  
field 2:3 a2 -- delimiters: blanks.  
Field 4:80 A77 -- 77-letter long model name. May contain any  
characters in the decimal range [32, 255].

- 3) An epoch record defines the epoch of the expansion.  
An expansion may have mixed terms  $(t-t_0)\sin(at+p)$ ,  $(t-t_0)\cos(at+p)$ , where  $t$  is time. The E-record defines the epoch  $t_0$  in mixed terms.  
If an expansion does not have mixed terms, then the epoch defined in this record is not used. Time scale TDT is used for defining the reference epoch.

Format of a E-record:

-----

Field 1:1 A1 -- Records ID: letter E (decimal code 69).  
field 2:2 a2 -- delimiters: blanks.  
Field 4:7 I4 -- Year  
field 8:8 a1 -- delimiter: letter . (decimal code 46).  
Field 9:10 I2 -- The index of the month in the year in the range [1,12]  
field 11:11 a1 -- delimiter: letter . (decimal code 46).  
Field 12:13 I2 -- The index of the day in the month in the range [1,31]  
field 14:14 a1 -- delimiter: letter - (decimal code 45).  
Field 15:16 I2 -- Hour in the range [0,23]  
field 17:17 a1 -- delimiter: letter : (decimal code 58).  
Field 18:19 I2 -- Minute in the range [0,23]  
field 20:20 a1 -- delimiter: letter : (decimal code 58).  
Field 21:24 F4.1 -- Seconds in the range [0.0, 59.9]

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- 4) A harmonic definition record defines the argument of the harmonic in the form  $\{\text{phase} + \text{freq} \cdot (t - \text{tr}) + 1/2 \cdot \text{accel} \cdot (t - \text{tr})^2\}$  where  $t$  is time in TDT time scale and  $\text{tr}$  is the reference epoch J2000.0, 01 January 2000, 12 hours TDT. The file cannot contain more than one definition of the same harmonic.

Format of an H-record:

-----

- Field 1:1 A1 -- Records ID: letter H (decimal code 72).  
field 2:3 a2 -- delimiters: blanks.  
Field 4:11 A8 -- 8-letter long harmonic name. May contain any characters with decimal codes 32-255, but blanks are allowed only at the end of the harmonic name. This field should not necessarily have a special meaning. Parsing software should not try to interpret this name.  
field 12:13 a2 -- delimiters: blanks.  
Field 14:25 F11.9 -- Phase of the harmonic in float format.  
Units: rad.  
field 26:27 a2 -- delimiters: blanks.  
Field 28:46 D19.12 -- Frequency of the harmonic in float format.  
Units: rad/sec.  
field 47:48 a2 -- delimiters: blanks.  
Field 49:59 D11.4 -- Acceleration of the harmonic in float format.  
Units: rad/sec\*\*2.  
field 60:60 a1 -- delimiters: blanks.  
field 61:80 A20 -- Comment. Parser ignores contents of this field.

- 5) An amplitude record specifies the harmonic and 4 amplitudes of the variation of the Earth orientation: the in\_phase polar motion (PM\_amp\_cos), the out\_of\_phase polar motion (PM\_amp\_sin), the in\_phase rotation around E3 axis (E3\_amp\_cos), and the out\_of\_phase rotation around E3 axis (E3\_amp\_sin). A file cannot contain more than one amplitude record for the same harmonic. The harmonic referred in an amplitude record must be defined in the preceding harmonic definition record.

These amplitudes allows to define instantaneous small Euler angles of the perturbations in the Earth rotation with respect to an apriori model in this way:

$$E1 = [ \text{PM\_amp\_cos} + \text{PM\_vel\_cos} \cdot (t - t_0) ] \cdot \cos \{ (ut_1 - \text{tdt})^2 \cdot \pi / 86400 + \text{phase} + \text{freq} \cdot (t - \text{tr}) + 1/2 \cdot \text{accel} \cdot (t - \text{tr})^2 \}$$

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$$+ [ PM\_amp\_sin + PM\_vel\_sin*(t-t_0) ] * \\ \sin \{ (ut_1-tdt)*2*\pi/86400 + phase + freq*(t-tr) + 1/2*accel*(t-tr)**2 \}$$

$$E2 = [ PM\_amp\_cos + PM\_vel\_cos*(t-t_0) ] * \\ \sin \{ (ut_1-tdt)*2*\pi/86400 + phase + freq*(t-tr) + 1/2*accel*(t-tr)**2 \} \\ - [ PM\_amp\_sin + PM\_vel\_sin*(t-t_0) ] * \\ \cos \{ (ut_1-tdt)*2*\pi/86400 + phase + freq*(t-tr) + 1/2*accel*(t-tr)**2 \}$$

$$E3 = [ E3\_amp\_cos + E3\_vel\_cos*(t-t_0) ] * \\ \cos \{ (ut_1-tdt)*2*\pi/86400 + phase + freq*(t-tr) + 1/2*accel*(t-tr)**2 \} \\ + [ E3\_amp\_sin + E3\_vel\_sin*(t-t_0) ] * \\ \sin \{ (ut_1-tdt)*2*\pi/86400 + phase + freq*(t-tr) + 1/2*accel*(t-tr)**2 \}$$

Where

E1 -- rotation around axis 1 (+Y angle of the polar motion)

E2 -- rotation around axis 2 (+X angle of the polar motion)

E3 -- rotation around axis 3 (-1.0027\*Ut1 angle of the Earth's rotation)

t-tr -- The interval of time in scale TAU elapsed since

01 January 2000, 12 hours TAI, in seconds

t-t0 -- The interval of time in scale TAI elapsed since the reference

epoch for the expansion defined in the E-record, in seconds.

### Format of a A-record

-----

Field 1:1 A1 -- Record ID: letter A (decimal code 65).

field 2:3 a2 -- Delimiters: blanks.

Field 4:11 A8 -- 8-letter long harmonic name. The harmonic name must be defined in a preceding H-record.

field 12:13 a2 -- Delimiters: blanks.

Field 14:25 F12.0 -- PM\_amp\_cos -- cosine amplitude of the small angle of polar motion. Units: prad.

field 26:26 a1 -- delimiter: blank.

Field 27:38 F12.0 -- PM\_amp\_sin -- sine amplitude of the small angle of polar motion. Units: prad.

field 39:39 a2 -- Delimiters: blanks.

Field 41:52 F12.0 -- E3\_amp\_cos -- cosine amplitude of the small angle of the Earth rotation around axis 3. Units: prad.

field 53:53 a1 -- Delimiter: blank.

Field 54:65 F12.0 -- E3\_amp\_sin -- sine amplitude of the small angle of the Earth rotation around axis 3. Units: prad.

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6) A velocity record specifies rates of changes of the amplitudes of the harmonic of the variation of the Earth orientation: in phase polar motion (PM\_vel\_cos), out\_of\_phase polar motion (PM\_vel\_sin), in\_phase rotation around E3 axis (E3\_vel\_cos), out\_of\_phase rotation around E3 axis (E3\_vel\_sin). A file cannot contain more than one velocity record for the same harmonic. The harmonic referred in an velocity record must be defined in the preceding harmonic definition record.

### Format of a V-record

-----

Field 1:1 A1 -- Record ID: letter A (decimal code 65).  
field 2:3 a2 -- Delimiters: blanks.  
Field 4:11 A8 -- 8-letter long harmonic name. The harmonic name must be defined in a preceding H-record.  
field 12:13 a2 -- Delimiters: blanks.  
Field 14:25 F12.0 -- PM\_vel\_cos -- rate of change of the cosine amplitude of the small angle of polar motion.  
Units:  $10^{-21}$  rad/sec.  
field 26:26 a1 -- delimiter: blank.  
Field 27:38 F12.0 -- PM\_amp\_sin -- rate of change of the sine amplitude of the small angle of polar motion.  
Units:  $10^{-21}$  rad/sec.  
field 39:40 a2 -- Delimiters: blanks.  
Field 41:52 F12.0 -- E3\_amp\_cos -- rate of change of the cosine amplitude of the small angle of the Earth rotation around axis 3.  
Units:  $10^{-21}$  rad/sec.  
field 53:53 a1 -- Delimiter: blank.  
Field 54:65 F12.0 -- E3\_amp\_sin -- rate of change of the sine amplitude of the small angle of the Earth rotation around axis 3. Units:  $10^{-21}$  rad/sec.

7) An amplitude error record specifies the harmonic and 4 formal uncertainties of amplitudes of the variation of the Earth orientation: the error of the in\_phase polar motion (PM\_amp\_cos\_err), the error of the out\_of\_phase polar motion (PM\_amp\_sin\_err), the error of the in\_phase rotation around E3 axis (E3\_amp\_cos\_err), and the error of the out\_of\_phase rotation around E3 axis (E3\_amp\_sin). A file cannot contain more than one amplitude error record for the same harmonic. If information about errors of the amplitude of the harmonic is unavailable, the record can be omitted. The harmonic referred in an amplitude error record must be defined in the preceding harmonic definition record.

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### Format of a S-record

-----

Field 1:1 A1 -- Record ID: letter A (decimal code 83).  
field 2:3 a2 -- Delimiters: blanks.  
Field 4:11 A8 -- 8-letter long harmonic name. The harmonic name  
must be defined in a preceding H-record.  
field 12:13 a2 -- Delimiters: blanks.  
Field 15:26 F12.1 -- PM\_amp\_cos\_err -- cosine amplitude of the small  
angle of polar motion. Units: prad.  
field 27:27 a1 -- delimiter: blank.  
Field 28:39 F12.1 -- PM\_amp\_sin\_err -- sine amplitude of the small  
polar motion. Units: prad.  
field 40:41 a2 -- Delimiters: blanks.  
Field 42:53 F12.1 -- E3\_amp\_cos\_err -- cosine amplitude of the small  
angle of the Earth rotation around axis 3. Units: prad.  
field 54:54 a1 -- Delimiter: blank.  
Field 55:66 F12.1 -- E3\_amp\_sin\_err -- sine amplitude of the small angle  
of the Earth rotation around axis 3. Units: prad.

8) A velocity error record specifies errors of rates of changes of the amplitudes of the harmonic of the variation of the Earth orientation: the in\_phase polar motion (PM\_vel\_cos\_err), the out\_of\_phase polar motion (PM\_vel\_sin\_err), the in\_phase rotation around E3 axis (E3\_vel\_cos\_err), and the out\_of\_phase rotation around E3 axis (E3\_vel\_sin\_err). A file cannot contain more than one velocity record for the same harmonic. If information about errors of the rate of change of amplitude of the harmonic is unavailable, the record can be omitted. The harmonic referred in an velocity record must be defined in the preceding harmonic definition record.

### Format of a R-record

-----

Field 1:1 A1 -- Record ID: letter R (decimal code 82).  
field 2:3 a2 -- Delimiters: blanks.  
Field 4:11 A8 -- 8-letter long harmonic name. The harmonic name  
must be defined in a preceding H-record.  
field 12:13 a2 -- Delimiters: blanks.  
Field 14:25 F12.0 -- PM\_vel\_cos\_err -- error of the rate of change of  
the cosine amplitude of the small angle of polar  
motion. Units:  $10^{-21}$  rad/sec.



## VTD a priori

field 26:26 a1 -- delimiter: blank.

Field 27:38 F12.0 -- PM\_amp\_sin\_err -- error of the rate of change of the sine amplitude of the small angle of polar motion.  
Units:  $10^{-21}$  rad/sec.

field 39:40 a2 -- Delimiters: blanks.

Field 41:52 F12.0 -- E3\_amp\_cos\_err -- error of rate of change of the cosine amplitude of the small angle of the Earth rotation around axis 3.  
Units:  $10^{-21}$  rad/sec.

field 53:53 a1 -- Delimiter: blank.

Field 54:65 F12.0 -- E3\_amp\_sin\_err -- error of rate of change of the sine amplitude of the small angle of the Earth rotation around axis 3. Units:  $10^{-21}$  rad/sec.

9) Trailer record is the same as the header record.

## 2.14 EOP\_SERIES

Label: EOP-MOD Ver 2.0

Purpose: Define the time series of the Earth orientation parameters, such as pole coordinates and UT1-TAI angle.

Type: Ascii, records of fixed length

Example:  $\$(VTD\_ROOT)/share/vlbi\_apr.erp$

NB: 1) All records of this file must have length 76 bytes  
2) non-standard units are used

Comment character: #

Header record format:

Filed 1:15 Label: EOP-MOD Ver 2.0

Field 18:26 F9.1 Julian date (TAI) of the first data record

Field 28:33 F6.2 Time step in days

Field 34:39 I6 The number of records

Field 42:48 A7 Meaning of the 4th column

Field 52:56 A5 Meaning is lost

Field 57:76 A18 Delimiter: blank

Data record format:

Filed 1:9 F9.1 Julian date (TAI)

Filed 11:17 F7.4 X pole coordinate. Units: 0.1 arcsec

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Filed 19:25 F7.4 Y pole coordinate. Units: 0.1 arcsec

Filed 27:35 I9 UT1-TAI. Units: microsecond of time

Filed 36:76 A41 some information not used by VTD.

Its meaning is forgotten

### 2.15 POSVAR\_MOD: (HARMONIC\_MODEL)

Label: HARPOS Format version of 2002.12.12

Purpose: Describes site displacements which can  
be represented by a finite set of harmonic components.

Type: Ascii

Example: \$(VTD\_ROOT)/share/2007b\_oclo.hps

A file in HARPOS format consists of records of variable length in ASCII coding. The records are separated by a character with decimal code 13. The records of the following types are supported:

- 1) Header record;
- 2) Harmonic definition records;
- 3) Site definition records;
- 4) Displacement definition records;
- 5) Trailer record.

Records which start from # character are considered as comments.

Each valid file in HARPOS format has the first header record, one or more harmonic definition records, one or more site definition records and one or more displacement definition records. The last record is a trailer record. All harmonic definition records should precede site definition records. All site definition records should precede displacement definition records.

Records format:

- 1) A header record contains the string  
"HARPOS Format version of 2002.12.12"

The header record allows to distinguish the valid file in the HARPOS format from files in other formats.

- 2) A harmonic definition record defines the argument of the harmonic in the form  $\{\text{phase} + \text{freq} \cdot (t-t_0) + 1/2 \cdot \text{accel} \cdot (t-t_0)^2\}$  where  $t$  is

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time in TDT time scale and t0 is the reference epoch J2000.0, 01 January 2000, 12 hours TDT. The file cannot contain more than one definition of the same harmonic.

### Format of an H-record:

-----

Field 1:1 A1 -- Records ID: letter H (decimal code 72).  
field 2:3 a2 -- delimiters: blanks.  
Field 4:11 A8 -- 8-letter long harmonic name. May contain any characters with decimal codes 32-255, but blanks are allowed only at the end of the harmonic name. This field should not necessarily have a special meaning. Parsing software should not try to interpret this name.  
field 12:13 a2 -- delimiters: blanks.  
Field 14:26 D13.6 -- Phase of the harmonic in float format.  
Units: rad.  
field 27:28 a2 -- delimiters: blanks.  
Field 29:47 D19.12 -- Frequency of the harmonic in float format.  
Units: rad/sec.  
field 48:49 a2 -- delimiters: blanks.  
Field 50:59 D10.3 -- Acceleration of the harmonic in float format.  
Units: rad/sec\*\*2.  
field 60:80 a21 -- delimiters: blanks.

3) A site definition record defines the site identifier and site coordinates in a crust-fixed reference frame. The file cannot contain more than one definition of the same site.

### Format of an S-record:

-----

Field 1:1 A1 -- Record ID. Should be letter S (decimal code 83)  
Field 2:3 A2 -- Delimiters: blanks.  
Field 4:11 A8 -- 8-letter long site identifier. May contain any characters with decimal codes 32-255, but blanks are allowed only at the end of the site identifier. This site identifier should be unique among S-records. This field should not necessarily have a special meaning. Parsing software should not try to interpret it.  
field 12:13 a2 -- delimiters: blanks.  
Field 14:26 F13.4 -- Site X coordinate in a crust fixed reference frame. Units: meters.

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field 27:27 a1 -- delimiters: blanks.  
Field 28:40 F13.4 -- Site Y coordinate in a crust fixed reference frame. Units: meters.  
field 41:41 a1 -- delimiters: blanks.  
Field 42:54 F13.4 -- Site Z coordinate in a crust fixed reference frame. Units: meters.  
field 55:56 a2 -- delimiters: blanks.  
Field 57:64 F8.4 -- Site geocentric latitude, positive to north, in degrees. This field is for information only. Parsing software MUST ignore it.  
field 65:65 a1 -- delimiters: blanks.  
Field 66:73 F8.4 -- Site longitude, positive towards east, in degrees. This field is for information only. Parsing software MUST ignore it.  
field 74:74 a1 -- delimiters: blanks.  
Field 75:80 F6.1 -- Site height above the reference ellipsoid in meters. This field is for information only. Parsing software MUST ignore it.

4) A data record specifies the site, the harmonic and 6 amplitudes of displacements: Up cosine, East cosine, North cosine, Up sine, East sine, North sine. A file cannot contain more than one data record for the same harmonic, the same site. The site and the harmonic referred in a data record must be defined in the preceding site and harmonic definition records.

Notation "Up cosine" and "Up sine" amplitudes of the displacement means that the radial component of the topocentric vector of the displacement, which is parallel to the vector from the geocenter to the site, depends on time in the following way:

$$D_{up} = \text{Ampl\_cos\_up} * \cos \{ \text{phase} + \text{freq} * (t-t_0) + 1/2 * \text{accel} * (t-t_0)^{**2} \} + \text{Ampl\_sin\_up} * \sin \{ \text{phase} + \text{freq} * (t-t_0) + 1/2 * \text{accel} * (t-t_0)^{**2} \}$$

Analogously, "East cosine", "East sine" amplitudes define time dependence of the east component of the displacement vector, and "North cosine", "North sine" define time dependence of the north component.

Format of a D-record:

-----

Field 1:1 A1 -- Record ID: letter D (decimal code 68).  
field 2:3 a2 -- delimiters: blanks.  
Field 4:11 A8 -- 8-letter long harmonic name. The harmonic name

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must be defined in a preceding H-record.

field 12:13 a2 -- delimiters: blanks.

Field 14:21 A8 -- 8-letter long site identifier. The site identifier must be defined in a preceding S-record.

field 22:24 a3 -- delimiters: blanks.

Field 25:32 F8.5 -- Cosine amplitude of the Up component of the displacement vector. Up direction is along the vector from the geocenter to the site.  
Units: meters.

field 33:33 A1 -- delimiter: blank.

Field 34:41 F8.5 -- Cosine amplitude of the East component of the displacement vector. Units: meters.

field 42:42 a1 -- delimiter: blank.

Field 43:50 F8.5 -- Cosine amplitude of the North component of the displacement vector. Units: meters.

field 51:53 a3 -- delimiter: blanks.

Field 54:61 F8.5 -- Sine amplitude of the Up component of the displacement vector. Up direction is along the vector from the geocenter to the site.  
Units: meters.

field 62:62 a1 -- delimiter: blank.

Field 63:70 F8.5 -- Sine amplitude of the East component of the displacement vector. Units: meters.

field 71:71 a1 -- delimiter: blank.

Field 72:79 F8.5 -- Sine amplitude of the North component of the displacement vector. Units: meters.

field 80:80 a1 -- delimiter: blank.

5) Trailer record is the same as the header record.

## 2.16 POSVAR\_MOD: (TIME\_SERIES)

Label: BINDISP

Purpose: describing time series of site position variations. A file in this format contains three components of the displacement vector of a specific site equally sampled within a certain time range.

Type: Binary, little endian

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Example: [http://astrogeo.org/scr/aplo\\_bds](http://astrogeo.org/scr/aplo_bds)

A file consists of records of fixed length. Record length is 8 bytes. A file has 8 header records and at least one data record which follows header records.

Header record 1:

-----

Field 1:8 A8 -- Magic record. Should be "BINDISP " for a valid file.

Header record 2:

-----

Field 1:4 I\*4 -- Integer modified Julian of the format revision date.

Field 5:5 A1 -- Identifier for used binary integer format.  
Supported identifiers:  
B -- big endian format  
L -- little endian format

Field 6:6 A1 -- Identifier for used binary float format.  
Supported identifiers:  
I -- IEEE 754/854 format.  
D -- Dec format.

Field 7:8 I\*2 -- Reserved. filled with binary value 0.

Header record 3:

-----

Field 1:8 A8 -- 8-letter long site identifier. May contain any characters with decimal codes 32-255, but blanks are allowed only at the end of the site identifier. This field should not necessarily have a special meaning. Parsing software should not try to interpret it.

Header record 4:

-----

Field 1:4 I\*4 -- The total number of data records.

Field 5:8 R\*4 -- Sampling interval in seconds: the interval between two consecutive epochs.

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Header record 5:

-----

Field 1:8 R\*8 -- X site coordinate in a crust fixed reference frame. Units: meter.

Header record 6:

-----

Field 1:8 R\*8 -- Y site coordinate in a crust fixed reference frame. Units: meter.

Header record 7:

-----

Field 1:8 R\*8 -- Z site coordinate in a crust fixed reference frame. Units: meter.

Header record 8:

-----

Field 1:4 I\*4 -- Integer modified Julian data at the midnight of the time epoch of the first data record.

Field 5:8 R\*4 -- Time in TDT elapsed from the midnight on the time epoch of the first data record, in seconds.

Data record:

-----

Field 1:2 I\*2 -- X coordinate of site displacement for a given epoch in a crust-fixed reference system. Units: 1.D-5 meter.

Field 3:4 I\*2 -- Y coordinate of site displacement for a given epoch in a crust-fixed reference system. Units: 1.D-5 meter.

Field 5:6 I\*2 -- Z coordinate of site displacement for a given epoch in a crust-fixed reference system. Units: 1.D-5 meter.

Field 7:8 I\*2 -- Reserved. Filled with binary value 0.

Comments:

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1. Data records follow in chronological order. No records can be missed. The epoch of the J+1 th record is the epoch of the J -th record plus the sampling interval. The epoch of the K-th physical record of the file is  $(\text{MJD}, \text{TDT}) + (K-9) * \text{Sample\_interval}$ . Physical records are counted from 1.
2. Maximal displacements in site positions which can be described in this file cannot exceed by modulo 327mm.

### 2.17 POSVAR\_MOD: (B\_SPLINE)

Label: BSPPOS Format version of 2007.10.30"

Purpose: To describe site displacements which can

be represented as the sum of the polynomial of the first degree and an expansion with the B-spline basis. The expansion is defined on a expanded non-descending sequence of knots. The first and the last knot has multiplicity 1-degree, other knots are represented as simple. The sequence may have several consecutive knots with equal epochs, except the first and the last. The number of knots with the same epochs should not exceed the degree of the B-spline basis. The expanded sequence of knots has indexes 1-degree, 1-degree+1, ... 0, 1, 2, ... N, N+1, N+2, ... N+degree, i.e. in the expanded sequence the first and the last knot are split into the set of knots with the number of elements equal to the degree.

BSPPOS file provides the number of knots, the degree of the B-spline basis, apriori site position, time epochs of knots, estimates of B-spline coefficients, global site position, and global site velocity.

A file in BSPPOS format consists of records of variable length in ASCII coding. The records are separated by a character with decimal code 13. The records of the following types are supported:

- 1) Header record
- 2) Solution identifier
- 3) Solution date
- 4) Record that specifies the total number of sites



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- 5) Site definition record
- 6) Record that specifies the B-spline degree
- 7) Record that specifies the number of knots for spline for this site
- 8) Record that specifies the reference epoch for site positions
- 9) Record that specifies position at reference epoch
- 10) Record that specifies site velocity
- 11) Record that specifies epoch of the spline
- 12) Record that specifies B-spline coefficients
- 13) Record that specifies elements of the covariance matrix of B-spline coefficients (optional)
- 14) Trailer record

The records should be placed in this order. Records 5-10 are repeated for each site, records 11-12 are repeated for each spline knot and each site.

Records which start from # character are considered as comments.

### 1. Header record

A header record contains the string  
"BSPPOS Format version of 2007.10.30"

The header record allows to distinguish the valid file in the BSPPOS format from files in other formats.

### 2. Solution identifier

Field 1:7 A7 Field ID: SOL\_ID:  
Field 8:10 a3 Delimiter (blank)  
Field 11:43 A32 Text identifying the solution

### 3. Solution date

Field 1:9 A9 Field ID: SOL\_DATE:  
Field 10:10 a1 Delimiter (blank)  
Field 11:29 A19 Date of the solution in ISO format

### 4. Record that specifies the total number of sites

Field 1:6 A6 Field ID: N\_STA:  
Field 7:7 a1 Delimiter (blank)  
Field 8:11 I4 The total number of sites

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### 5. Site definition record

Field 1:2 A2 Field ID: S:  
Field 3:3 a3 Site ID: an arbitrary sequence of letters.  
NB: parsing software SHOULD NOT ATTEMPT to interpret  
Field 8:11 I4 The total number of sites  
Field 12:13 a2 Delimiter (blanks)  
Field 14:26 F13.5 X-coordinate of the site in the crust fixed coordinate system  
Field 27:27 a1 Delimiter (blank)  
Field 28:40 F13.5 Y-coordinate of the site in the crust fixed coordinate system  
Field 41:41 a1 Delimiter (blank)  
Field 42:54 F13.5 Z-coordinate of the site in the crust fixed coordinate system  
Field 12:13 a2 Delimiter (blanks)  
Field 57:64 F8.4 Site geocentric latitude.  
Field 65:65 a1 Delimiter (blank)  
Field 66:73 F8.4 Site geocentric longitude positive to East in [0,360]  
Field 74:74 a1 Delimiter (blank)  
Field 75:80 F5.1 Site height above the reference ellipsoid

### 6. Record that specifies the B-spline degree

Field 1:6 A6 Field ID: L\_DEG:  
Field 7:7 a1 Delimiter (blank)  
Field 8:11 I4 Spline degree  
Field 12:18 a7 Delimiter STA:  
Field 19:22 I4 Site index. The index of the site definition  
record for this site, counted from 1  
Field 23:24 a2 Delimiter (blanks)  
Field 25:32 A8 Site name specified in the preceding site definition  
record

### 7. Record that specifies the number of knots for spline for this site

Field 1:6 A6 Field ID: N\_NOD:  
Field 7:7 a1 Delimiter (blank)  
Field 8:11 I4 The number of knots for this site  
Field 12:18 a7 Delimiter STA:  
Field 19:22 I4 Site index. The index of the site definition  
record for this site, counted from 1  
Field 23:24 a2 Delimiter (blanks)  
Field 25:32 A8 Site name specified in the preceding site definition  
record

### 8. Record that specifies the reference epoch for site positions

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Field 1:6 A6 Field ID: R\_EPC:  
Field 7:18 a12 Delimiter STA:  
Field 19:22 I4 Site index. The index of the site definition  
record for this site, counted from 1  
Field 23:24 a2 Delimiter (blanks)  
Field 25:32 A8 Site name specified in the preceding site definition  
record  
Field 33:34 a2 Delimiter (blanks)  
Field 35:57 A23 Reference epoch for site positions in TAI in ISO format.

### 9. Record that specifies position at reference epoch

Field 1:6 A6 Field ID: P\_EST:  
Field 7:18 a12 Delimiter STA:  
Field 19:22 I4 Site index. The index of the site definition  
record for this site, counted from 1  
Field 23:24 a2 Delimiter (blanks)  
Field 25:32 A8 Site name specified in the preceding site definition  
record  
Field 33:34 a2 Delimiter (blanks)  
Field 35:48 F14.6 X component of site position at the reference epoch in meters  
Field 49:49 a1 Delimiter (blanks)  
Field 50:63 F14.6 Y component of site position at the reference epoch in meters  
Field 64:64 a1 Delimiter (blanks)  
Field 65:78 F14.6 Z component of site position at the reference epoch in meters

### 10. Record that specifies site velocity

Field 1:6 A6 Field ID: P\_EST:  
Field 7:18 a12 Delimiter STA:  
Field 19:22 I4 Site index. The index of the site definition  
record for this site, counted from 1  
Field 23:24 a2 Delimiter (blanks)  
Field 25:32 A8 Site name specified in the preceding site definition  
record  
Field 33:34 a2 Delimiter (blanks)  
Field 35:48 F14.6 X component of site velocity in m/s  
Field 49:49 a1 Delimiter (blanks)  
Field 50:63 F14.6 Y component of site velocity in m/s  
Field 64:64 a1 Delimiter (blanks)  
Field 65:78 F14.6 Z component of site velocity in m/s

### 11. Record that specifies epoch of the spline

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Field 1:6 A6 Field ID: EPOCH:  
Field 7:7 a1 Delimiter (blank)  
Field 8:11 I4 The knot index starting from 1-L\_DEG  
Field 12:18 a7 Delimiter STA:  
Field 19:22 I4 Site index. The index of the site definition  
record for this site, counted from 1  
Field 23:24 a2 Delimiter (blanks)  
Field 25:32 A8 Site name specified in the preceding site definition  
record  
Field 35:57 A23 Epoch of the knot in TAI in ISO fort mat.

### 12. Record that specifies B-spline coefficients

Field 1:6 A6 Field ID: EPOCH:  
Field 7:7 a1 Delimiter (blank)  
Field 8:11 I4 The knot index starting from 1-L\_DEG  
Field 12:18 a7 Delimiter STA:  
Field 19:22 I4 Site index. The index of the site definition  
record for this site, counted from 1  
Field 23:24 a2 Delimiter (blanks)  
Field 25:32 A8 Site name specified in the preceding site definition  
record  
Field 33:35 a3 Delimiter (blanks)  
Field 36:48 F13.6 B-spline coefficient for X component of position of this site, this kno  
Field 49:49 a1 Delimiter (blanks)  
Field 50:62 F13.6 B-spline coefficient for Y component of position of this site, this kno  
Field 63:63 a1 Delimiter (blanks)  
Field 64:76 F13.6 B-spline coefficient for Z component of position of this site, this kno

### 13. Record that specifies elements of the covariance matrix of B-spline coefficients (optional). Covariance matrix is a 4-dimensional array in the crust-fixed terrestrial coordinate system. The first two dimensions run through the knot indexes + global position + global velocity. The second two dimensions, the 3rd and the 4th, run through components of the coordinate vectors: X, Y, Z.

Field 1:6 A6 Field ID: EPOCH:  
Field 7:18 a12 Delimiter (blank)  
Field 12:18 a7 Delimiter STA:  
Field 19:22 I4 Site index. The index of the site definition  
record for this site, counted from 1  
Field 23:24 a2 Delimiter (blanks)  
Field 25:32 A8 Site name specified in the preceding site definition  
record  
Field 33:41 a9 Delimiters

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- Field 43:43 I1 The first component of the displacement vector in the terrestrial coordinate system. Components runs as X, Y, and Z.
- Field 49:49 a1 Delimiter (blanks)
- Field 50:52 a3 Delimiters
- Field 53:56 I4 The first covariance element index. Index starts from 1-L\_DEG and runs through N\_NOD+L\_DEG-1. The element with index N\_NOD+L\_DEG+1 corresponds to the global position, the element with index N\_NOD+L\_DEG corresponds to the global velocity, other indexes correspond to knot index.
- Field 57:65 a9 Delimiters
- Field 66:66 I1 The second component of the displacement vector in the terrestrial coordinate system. Components runs as X, Y, and Z.
- Field 67:75 a9 Delimiters
- Field 76:79 I4 The second covariance element index. Index starts from 1-L\_DEG and runs through N\_NOD+L\_DEG-1. The element with index N\_NOD+L\_DEG+1 corresponds to the global position, the element with index N\_NOD+L\_DEG corresponds to the global velocity, other indexes correspond to knot index.
- Field 80:86 a7 Delimiters
- Field 87:99 D13.6 The element of the covariance matrix

### 14. Trailer record

The same as the header record, string:  
"BSPPOS Format version of 2007.10.30"

## 2.18 ANTENNA\_DEFORMATIONS\_FILE

Label: \$ Antenna Gravity Deformation File Format Version of 2008.04.25

Purpose: Contains the table of the antenna focus line as a function of elevation angle.

Type: ascii

Example: \$(VTD\_ROOT)/share/agd.dat

Comment character: #

Data record format:

## VTD a priori

1:5 A3 Delimiter: "AGD "  
6:13 A8 IVS station name  
14:15 A2 Delimiter: blank  
16:22 A7 Focus type  
23:24 A2 Delimiter: blank  
25:28 F4.1 Elevation (in deg)  
29:30 A2 Delimiter: blank  
31:37 F7.3 Focus length change (in mm)

### 2.19 SLANTED\_PATH\_DELAY\_BIAS\_FILE

Label: SPD\_3D\_BIAS Format version of 2010.05.18  
Purpose: Determine empirical bias and scale factor for the  
slanted path delay model. The non-hydrostatic  
component of the Slanted path delay is to  
be multiplied by the scale and added the bias.  
Example: n/a  
Comment character: #  
Data record format:

A file in the SPD\_ASCII format consists of records of variable  
length in ASCII coding. The records are separated by a character with  
decimal code 13. The records are grouped into sections. Sections follow  
in this order:

- 1) N-record -- defines the number of records in further other  
sections.
- 2) S-record -- defines name and coordinates of stations for which path  
delay have been computed.
- 3) B-record -- defines bias and scaling factor

Format of an N-record:

-----

Field 1:1 A1 -- Record ID: letter "N".  
field 2:3 a2 delimiter: blank.  
Field 4:7 I4 -- Number of M-records in the file. i.e. brief algorithm

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description and options used during computations.

field 8:9 a2 delimiter: blank.

field 10:13 I4 -- Number of I-records in the file, i.e. the number of lines with a brief description of the numeric model of the atmosphere used during computation.

field 14:15 a2 delimiter: blank.

field 16:21 I6 -- Number of S-records in the file, i.e. the number of stations.

field 22:23 a2 delimiter: blank.

field 24:27 I4 -- Number of E-records in the file, i.e. the number elevations in the grid.

field 28:29 a2 delimiter: blank.

field 30:33 I4 -- Number of A-records in the file, i.e. the number azimuths in the grid.

### Format of an S-record:

-----

Field 1:1 A1 -- Record ID: letter "S".

field 2:3 a2 delimiter: blanks.

field 4:9 I6 -- station index

field 10:11 a2 delimiter: blanks.

Field 12:19 A8 -- 8-letter long site identifier. May contain any characters with decimal codes 32-255, but blanks are allowed only at the end of the site identifier. This site identifier should be unique among S-records. This field should not necessarily have a special meaning. Parsing software SHOULD NOT TRY TO INTERPRET it.

field 20:21 a2 delimiter: blanks.

Field 22:33 F12.3 -- X site coordinate in a crust fixed reference frame. Units: meters.

field 34:34 a1 delimiter: blank.

Field 35:46 F13.4 -- Y site coordinate in a crust fixed reference frame. Units: meters.

field 47:47 a1 delimiter: blank.

Field 48:59 F13.4 -- Z site coordinate in a crust fixed reference frame. Units: meters.

field 60:61 a2 delimiter: blanks.

Field 62:69 F8.4 -- Site geocentric latitude, positive to north, in degrees. This field is for information only. Parsing software MUST ignore it.

field 70:70 a1 delimiter: blank.

Field 71:78 F8.4 -- Site longitude, positive towards east,

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in degrees. This field is for information only.

Parsing software MUST ignore it.

field 79:80 a2 delimiter: blank.

Field 81:86 F6.1 -- Site height above the reference ellipsoid in meters. This field is for information only.

Parsing software MUST ignore it.

field 87:87 a1 delimiter: blank.

Field 88:93 F6.1 -- Site height above the geoid in meters. This field is for information only.

Parsing software MUST ignore it.

Format of an B-record:

-----

Field 1:1 A1 -- Record ID: letter "B".

field 2:11 a10 -- delimiter: blank

Field 12:19 A8 -- 8-letter long site identifier.

field 20:24 a5 -- delimiter: blank

Field 25:34 D10.3 -- Slanted path delay offset. Units: seconds

field 35:37 a3 -- delimiter: blank

Field 38:44 F7.4 -- Slanted path delay scale factor

## 2.20 EXTERNAL\_DELAY\_DIR

Label: spd\_3d\_bin 1.0 version of 2009.01.07 LE

Purpose: Contains results of computing slanted path delay of radio wave propagation through the 3D, continuous, heterogeneous atmosphere. The path delay is defined as a difference in the propagation time between the emitter and the receiver through the atmosphere and the propagation between these two points along the geodetic line in vacuum. The path delay is computed for a set of stations for a certain epoch at a regular grid of azimuths and elevations. The grid is equidistant at azimuths and non-equidistant at elevation angles. The values of path delays computed on a grid can be used for computing coefficients of the interpolating functions that enable us to compute the path delay in an arbitrary direction.

Example: [http://astrogeo.org/spd\\_data/spd\\_6h\\_bin](http://astrogeo.org/spd_data/spd_6h_bin)

Type: Binary, little endian.

File in spd\_3d\_bin format consists of records of 7 types.



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The type of each record is determined by the first 8-characters long field prefix. The records follow in this order:

LAB\_REC -- Defines offsets, sizes and the number of other records  
TIM\_REC -- Defines the start time, stop time of DEL records  
          and the time step  
STA\_REC -- Defines station coordinates  
MOD\_REC -- Defines the slanted path model type and the model description  
MET\_REC -- Defines description of the numerical weather model used  
          for computation  
ELV\_REC -- Defines the elevation axis for the 2D grid of  
          path delays through the neutral atmosphere  
AZM\_REC -- Defines the azimuth axis for the 2D grid of  
          path delays through the neutral atmosphere  
DEL\_REC -- Defines the surface pressure surface temperature  
          and the 2D grid of path delay through the neutral atmosphere.

The file contains only one record of the first seven types and usually more than one record of DEL\_REC. Each DEL\_REC corresponds to one time epoch. The time epochs follow each other in chronological order with the same time step, without gaps. The time epoch of a specific DEL\_REC is determined by its index in the file, time of the first epoch, and the time step.

Description of individual records:

### LAB\_REC

```
CHARACTER  PREF*8    ! prefix: LAB_REC
INTEGER*8  LEN      ! length of the LAB_REC record
CHARACTER  FMT_LAB*40 ! Format label
INTEGER*8  OFF_TIM  ! Offset of the TIM record in bytes wrt the file beginning
INTEGER*8  OFF_STA  ! Offset of the STA record in bytes wrt the file beginning
INTEGER*8  OFF_MOD  ! Offset of the MOD record in bytes wrt the file beginning
INTEGER*8  OFF_MET  ! Offset of the MET record in bytes wrt the file beginning
INTEGER*8  OFF_ELV  ! Offset of the ELV record in bytes wrt the file beginning
INTEGER*8  OFF_AZM  ! Offset of the AZM record in bytes wrt the file beginning
INTEGER*8  OFF_DEL  ! Offset of the first TIM record in bytes wrt the file beginning
INTEGER*8  LEN_TIM  ! Length of the TIM record in bytes
INTEGER*8  LEN_STA  ! Length of the STA record in bytes
INTEGER*8  LEN_MOD  ! Length of the MOD record in bytes
INTEGER*8  LEN_MET  ! Length of the MET record in bytes
INTEGER*8  LEN_ELV  ! Length of the ELV record in bytes
INTEGER*8  LEN_AZM  ! Length of the AZM record in bytes
INTEGER*8  LEN_DEL  ! Length of the DEL record in bytes
INTEGER*4  TOT_NUM_DEL ! The number of DEL records
```

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### TIM\_REC

CHARACTER PREF\*8 ! prefix: TIM\_REC  
INTEGER\*8 NREC ! The number of time epochs the file contains  
INTEGER\*4 MJD\_BEG ! Modified Julian date at TAI ! Modified Julian date at TAI for  
INTEGER\*4 MJD\_END ! Modified Julian date at TAI for the last epoch  
REAL\*8 TAI\_BEG ! TAI for the first epoch. Units: seconds  
REAL\*8 TAI\_END ! TAI for the last epoch. Units: seconds  
REAL\*8 TIM\_STEP ! Time step. Units: seconds

### STA\_REC

CHARACTER PREF\*8 ! prefix: STA\_REC  
CHARACTER NAME\*8 ! Station name. NB: the station name does NOT necessa  
! conforms any convention. It may be an arbitrary combination  
! of characters. Parser software should NOT assign any meaning  
! to this field  
REAL\*8 COO\_CFS(3) ! Station coordinates in the crust-fixed coordinate system.  
! Units: meters  
REAL\*8 PHI\_GCN ! Station geocentric latitude. Units: radians  
REAL\*8 PHI\_GDT ! Station geodetic latitude. Units: radians  
REAL\*8 HEI\_ELL ! Station height above the reference ellipsoid. Units: meters  
REAL\*8 HEI\_GEOID ! Station height above the geoid. Units: meters

### MOD\_REC

CHARACTER PREF\*8 ! prefix: MOD\_REC  
INTEGER\*4 N\_RFR ! Number of components of the model  
CHARACTER SPD\_TYPE(3)\*8 ! Array of names of the slanted path delay model compo  
! Supported values:  
! total -- Total path delay through the neutral atmosphere  
! hydro -- Path delay through the hydrostatic component of the at  
! non-hydr -- Path delay through the non-hydrostatic component of  
! undef -- Undefined, not used  
INTEGER\*8 N\_LINES ! Number of lines with model description  
INTEGER\*8 LEN\_TEXT ! Length of the text with model description in bytes  
CHARACTER\*1, POINTER :: TEXT(:) ! Text with the model description as a string th  
! of length LEN\_TEXT + 1 (the last character is \0)

### MET\_REC

CHARACTER PREF\*8 ! Prefix: STA\_REC  
INTEGER\*8 N\_LINES ! Number of lines with numerical weather model description  
INTEGER\*8 LEN\_TEXT ! Length of the text with the numerical model description in  
CHARACTER\*1, POINTER :: TEXT(:) ! Text with the numerical weather model desc  
! a string that contains \n characters of length  
! LEN\_TEXT + 1 (the last character is \0)

### ELV\_REC

CHARACTER PREF\*8 ! Prefix: ELV\_REC

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```
INTEGER*8 N_EL ! The number of elements along the elevation angle axis
REAL*4, POINTER :: ELEV(:) ! Array of elevation angles. Dimension: N_EL,
! Units: radians. Array is sorted in decreasing order.
```

AZM\_REC

```
CHARACTER PREF*8
INTEGER*8 N_AZ ! The number of elements along the azimuth axis
REAL*4, POINTER :: AZIM(:) ! Array of azimuth angles. Dimension: N_AZ,
! Units: radians. Array is sorted in increasing order.
```

DEL\_REC

```
CHARACTER PREF*8
REAL*4 SURF_PRES ! Surface pressure. Units: Pascal
REAL*4 SURF_TEMP ! Surface air temperature. Units: Kelvin
REAL*4, POINTER :: DEL(;;;:;) ! 3D array of slanted path delay components.
! The first axis runs over elevation angles.
! Dimension: N_EL defined in ELV_REC
! The second axis runs over azimuth angles
! Dimension: N_AZ defined in AZM_REC
! The third runs over components.
! Dimension: N_RFR defined in MOD_REC
! Units: seconds
```

## 2.21 IONOSPHERE\_DATA\_FILE

Label: VIONO Little-Endian Format of 2010.05.08

Purpose: Contains the total electron contents of the ionosphere presented at the regular 3D grid with axes: longitude, latitude, and time.

Type: Binary, little endian

Example: [http://astrogeo.org/viono/codg\\_01.vio](http://astrogeo.org/viono/codg_01.vio)

Format description:

The file in VIONO format consists of the header record and one or more data records.

HEADER:

```
CHARACTER LABEL*48 ! File label
CHARACTER MODEL*16 ! Model name
CHARACTER AUTHOR*16 ! Name of the model author
INTEGER*4 NLON ! The number of grid steps along longitude axis
```

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INTEGER\*4 NLAT ! The number of grid steps along latitude axis  
INTEGER\*4 NEPC ! The number of grid steps along time axis  
INTEGER\*4 MJD\_BEG ! MJD at TAI of the first epoch  
INTEGER\*2 MISSING ! Missing value  
INTEGER\*2 FILLER(3) ! fillers  
REAL\*8 UTC\_BEG ! UTC Time tag of the first epoch. Units: seconds  
REAL\*8 TIM\_STEP ! Time step along the time axis. Units: seconds  
REAL\*8 SCALE ! The scaling factor which should be applied to raw TEC values. U  
REAL\*8 LON\_MIN ! Longitude at the beginning of the longitude axis. Units: radians  
REAL\*8 LAT\_MIN ! Latitude at the beginning of the latitude axis. Units: radians  
REAL\*8 LON\_STEP ! Longitude step along the longitude axis. Units: radians  
REAL\*8 LAT\_STEP ! Latitude step along the latitude axis. Units: radians  
REAL\*8 HEIGHT ! Height of the ionosphere. Units: meters

### DATA RECORD:

INTEGER\*2, POINTER :: TEC\_VAL(:, :) ! TEC values on a 2D longitude/latitude grid  
! Dimensions: NLON,NLAT. Units: dimensionless

TEC\_VAL array must be multiplied by SCALE. Units of the results: TECU.

## 2.22 HYDROSTATIC\_MAPPING\_FUNCTION/WET\_MAPPING\_FUNCTION: (MMF)

Label: # MMF\_MOD Format of 2008.09.21

Purpose: contains coefficients of polynomials that expand the mean mapping function in the neutral atmosphere for the set observing stations.

Example: \$(VTD\_ROOT)/share/mmf.mod

A file in MMF\_EPO format consists of records of variable length in ASCII coding. The records are separated by a character with decimal code 13. The records are grouped into sections. Sections follow in this order:

1) Header record -- the first record should have a signature:

TROPO\_PATH\_DELAY Format version of 2007.10.04

The header record allows to distinguish a valid file in the TROPO\_PATH\_DELAY format from files in other formats.

## VTD a priori

### 2) M-record section

M-record has letter M in the first field. The M record keeps the model identifier.

### 3) N-record section

### 4) S-record section

### 5) D-record section

### 6) Trailer record -- the last record is the same as the header record.

#### Format of an S-record:

-----

Field 1:1 A1 -- Record ID. Should be letter S (decimal code 83).

field 2:2 a1 delimiter: blanks.

Field 4:11 A8 -- 8-letter long site identifier. May contain any characters with decimal codes 32-255, but blanks are allowed only at the end of the site identifier. This site identifier should be unique among S-records. This field should not necessarily have a special meaning. Parsing software should not try to interpret it.

field 12:13 a2 delimiter: blanks.

Field 14:26 F13.4 -- X site coordinate in a crust fixed reference frame. Units: meters.

field 27:27 a1 delimiter: blank.

Field 28:40 F13.4 -- Y site coordinate in a crust fixed reference frame. Units: meters.

field 27:27 a1 delimiter: blank.

Field 42:54 F13.4 -- Z site coordinate in a crust fixed reference frame. Units: meters.

field 55:56 a2 delimiter: blanks.

Field 57:64 F8.4 -- Site geocentric latitude, positive to north, in degrees. This field is for information only. Parsing software MUST ignore it.

field 65:65 a1 delimiter: blank.

Field 66:73 F8.4 -- Site longitude, positive towards east, in degrees. This field is for information only. Parsing software MUST ignore it.

field 74:74 a1 delimiter: blank.

Field 75:80 F6.1 -- Site height above the reference ellipsoid in meters. This field is for information only.

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Parsing software MUST ignore it.

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Questions and comments about this guide should be directed to:

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