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.ssssssssss
```

```
where YYYY stands for year
        MM stands for the month number
        DD stands for the day of month
        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
      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
```

<h3 style="text-align:center">2.2 DE_EPHEMERIDES</h3>

```
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
```

<h3 style="text-align:center">2.3 STATION_DESCRIPTION</h3>

```
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
```

<h3 style="text-align:center">2.4 SOURCE_COORDINATES</h3>

```
Three formats are supported
```

<h3 style="text-align:center">2.5 SOURCE_COORDINATES: SOU-MODFILES</h3>

```
Label:   $$  SOU-MODFILE Format pre-2000
Purpose: Defines IVS source name, source right ascension,
         source declination, and the semi-major axis of the
         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)
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, Jy
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 map
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 present
         <    in columns 88, 94, 101 or 107 means that the upper limit of the flux density is presented in the following c
```

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
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
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:  #
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:

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-t0)*sin(at+p), (t-t0)*cos(at+p),
   where t is time. The E-record defines the epoch t0 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]

4) A harmonic definition record defines the argument of the harmonic in
   the form {phase + freq*(t-tr) + 1/2*accel*(t-tr)**2} where t is
   time in TDT time scale and 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 = [PM_amp_cos + PM_vel_cos*(t-t0)] *
        cos { (ut1-tdt)*2*pi/86400 + phase + freq*(t-tr) + 1/2*accel*(t-tr)**2 }
      + [PM_amp_sin + PM_vel_sin*(t-t0)] *
        sin { (ut1-tdt)*2*pi/86400 + phase + freq*(t-tr) + 1/2*accel*(t-tr)**2 }

   E2 = [PM_amp_cos + PM_vel_cos*(t-t0)] *
        sin { (ut1-tdt)*2*pi/86400 + phase + freq*(t-tr) + 1/2*accel*(t-tr)**2 }
      - [PM_amp_sin + PM_vel_sin*(t-t0)] *
        cos { (ut1-tdt)*2*pi/86400 + phase + freq*(t-tr) + 1/2*accel*(t-tr)**2 }

   E3 = [E3_amp_cos + E3_vel_cos*(t-t0)] *
        cos { (ut1-tdt)*2*pi/86400 + phase + freq*(t-tr) + 1/2*accel*(t-tr)**2 }
      + [E3_amp_sin + E3_vel_sin*(t-t0)] *
        sin { (ut1-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.

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.


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.
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.
```

<div align="center">2.14 EOP_SERIES</div>

```
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
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
```

<div align="center">2.15 POSVAR_MOD: (HARMONIC_MODEL)</div>

```
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 {phase + freq*(t-t0) + 1/2*accel*(t-t0)**2} where t is
   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.
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= Ampl_cos_up * cos {phase + freq*(t-t0) + 1/2*accel*(t-t0)**2} +

```
              Ampl_sin_up * sin {phase + freq*(t-t0) + 1/2*accel*(t-t0)**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
                           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.
```

```
     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


   A file consists of records of fixed length. Record length is
8 bytes. A file has 44 header records and at least one data record
which follows header records.

Header record 1:
----------------

Field  1:8  A8   -- Unix 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.

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 of
                     the time epoch of the first data record,
                     in seconds.

Header record 9:
----------------

Field 1:8   C*8  -- Model type

Header record 10:
-----------------

Field 1:8   C*8  -- Model name

Header record 10:
-----------------

Field 1:8   C*8  -- Model version


Header records 11 to 44:
------------------------

Field 1:8   C*8  -- Comment


Data record:
============

Displacement is endcoded as a sum of the base displacement and
extension. Total extension is computed as
total = 1.0D-5 * base + 0.32D0 * sign(base)*extension
```

The total displacement can be in a range [-5.44, 5.44] meters.

```
Field 1:2  I*2 -- 1.0D-5 singed base 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 -- base Y coordinate of site displacement without extension
                 for a given epoch in a crust-fixed reference system.
                 Units: 1.D-5 meter.

Field 5:6  I*2 -- base Z coordinate of site displacement without extension
                 for a given epoch in a crust-fixed reference system.
                 Units: 1.D-5 meter.

Field 7:8  I*2 -- Bit fields of extension. The word is split into four
                 bit fields of 4 bits each.
                 bits  0:3  -- reserved
                 bits  4:7  -- unsigned extension for X coordinate
                 bits  8:11 -- unsigned extension for Y coordinate
                 bits 12:15 -- unsigned extension for Z coordinate
```

  Comments:

  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 (MJD,TDT) + (K-9)*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 5.4 meters.

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
    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

 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
```

```
        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

        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 knot
        Field 49:49  a1    Delimiter (blanks)
        Field 50:62  F13.6 B-spline coefficient for Y component of position of this site, this knot
        Field 63:63  a1    Delimiter (blanks)
        Field 64:76  F13.6 B-spline coefficient for Z component of position of this site, this knot

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
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:

 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
                      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,
                      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
```

<h3 align="center">2.20 EXTERNAL_DELAY_DIR</h3>

```
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
Type:    Binary, little endian.

File in spd_3d_bin format consists of records of 7 types.
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

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 the first epoch for the first epoc
        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 necessarily
                             ! 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 components.
                             ! Supported values:
                             !   total    -- Total path delay through the neutral atmosphere
                             !   hydro    -- Path delay through the hydrostatic component of the atmosphere
                             !   non-hydr -- Path delay through the non-hydrostatic component of the atmosphere
                             !   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 that contains \n characters
                             ! 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 weather model description in bytes
        CHARACTER*1, POINTER :: TEXT(:) ! Text with the numerical weather model description as
                             ! a string that contains \n characters of length
                             ! LEN_TEXT + 1 (the last character is \0)
ELV_REC
        CHARACTER  PREF*8     ! Prefix: ELV_REC
        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


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
        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. Units: TECU
        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 by 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.

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.
                            Parsing software MUST ignore it.
```

Questions and comments about this guide should be directed to:

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