Description of keywords of VTD (VLBI Time Delay) control file language

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Abstract:

This document provides detailed description of syntax of the language used for specification of control file for the package VTD (VLBI Time Delay).

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1 General rules

Control file for VTD consists of lines of variable length. Lines which starts from characters # or * are considered as comments and ignored by parsing software. Each line consists of a keyword and the value. All keywords must be specified, no defaults are allowed. A value should be separated the keyword by one or more delimiters. Valid delimiters: blank (decimal code 32), tabulation (decimal code 9) and binary zero. The first line of the control file should have the label of the format version. The current label version is

```
# VTD Control file.   Format version of 2009.02.21
```

If the file does not have correct format label, VTD library will issue and errors message.

2 Description of keyword

2.1 LEAP_SECOND:

LEAP_SECOND: [leap_second_file_name or NERS]

leap_second_file_name is the name of the file in LEAP_SECOND format which tabulates epochs of discontinuities of the function UT1 - TAI(t) and values of discontinuities.

If NERS is specified, the leap second is downloaded automatically using the Network Earth Rotation Service

2.2 DE403_EPHEMERIDES:

DE403_EPHEMERIDES: planetary_ephemerides_file_name

Planetary_ephemerides_file_name is the name of the DE403 ephemerides file.

2.3 STATION_DESCRIPTION:

STATION_DESCRIPTION: station_description_file_name

Station_description_file_name is the name of the file in STADESC format. That file contains information about all stations which participated in the experiment: IVS station name, antenna mounting type, antenna axis offset, tectonic plate. This file may contain information about other stations which did not participated in the analyzed experiment. All stations which participated in the experiment must be listed in this

file.

2.4 STATION_COORDINATES:

STATION_COORDINATES: station_coordinates_file_name

Station_coordinates_file_name is the name of the file either in
GETPAR_STA format
(http://astrogeo.org/psolve/doc/getpar_02.html#section3.1)
or in SIT-MODFILE format. That file contains information about all stations
which participated in the experiment: IVS station name, station coordinates
and epoch for coordinates of those stations which had episodic motion. This
file may contain information about other stations which did not participated
in the analyzed experiment. All stations which participated in the experiment
must be listed in this file.

2.5 STATION_VELOCITIES:

STATION_VELOCITIES: station_velocities_file_name

Station_velocities_file_name is the name of the file either in
GETPAR_VEL format
(http://astrogeo.org/psolve/doc/getpar_02.html#section3.2)
or in VEL-MODFILE format. That file contains information about all stations
which participated in the experiment: IVS station name, station velocities.
This file may contain information about other stations which did not
participated in the analyzed experiment. All stations which participated
in the experiment must be listed in this file.

2.6 STATION_ECCENTRICITIES:

STATION_ECCENTRICITIES: station_eccentricities_file_name

Station_eccentricities_file_name is the name of the file with
eccentricity vector in ECC-FORMAT. It contains IVS station name, CDP
monument number, starting date of validity of the eccentricity vector,
end date of validity of the eccentricity vector, eccentricity vector for
each station each period of validity defined as the vector from the
monument point for which station coordinates are referred to, to the
reference point on the antenna, defined as a point on the fixed axis which
is located at the closest distance to the moving axis.

2.7 SOURCE_COORDINATES:

SOURCE_COORDINATES: source_coordinates_file_name

The qualifier Source_coordinates_file_name is the name of the file either
in GETPAR_SOU format
(http://astrogeo.org/psolve/doc/getpar_02.html#section3.3)
or in SOU-MODFILE format. That file contains information the sources
which participated in the experiment: IVS source name, source coordinates.
This file may contain information about other source which were not observed
in the analyzed experiment.

2.8 SOURCE_COORDINATES_2ND:

SOURCE_COORDINATES: [source_coordinates_file_name_2 or NONE]

The qualifier source_coordinates_file_name is the name of the file either
in GETPAR_SOU format
(http://astrogeo.org/solve_root/help/getpar_02.html#section3.3)
or in SOU-MODFILE format. This is the secondary catalogue used by VTD.
It might be convenient to keep coordinates of source in more than one file.
That file contains information the sources which participated in the
experiment: IVS source name, source coordinates. This file may contain
information about other source which were not observed in the analyzed
experiment.

2.9 SOURCE_COORDINATES_3RD:

SOURCE_COORDINATES: [source_coordinates_file_name_3 or NONE]

The qualifier source_coordinates_file_name is the name of the file either
in GETPAR_SOU format
(http://astrogeo.org/psolve/doc/getpar_02.html#section3.3)
or in SOU-MODFILE format. This is the ternary catalogue used by VTD.
It might be convenient to keep coordinates of source in more than one file.
That file contains information the sources which participated in the
experiment: IVS source name, source coordinates. This file may contain
information about other source which were not observed in the analyzed
experiment.

2.10 SOURCE_COORDINATES_4TH:

SOURCE_COORDINATES: [source_coordinates_file_name_4 or NONE]
http://astrogeo.org/psolve/doc

The qualifier source_coordinates_file_name is the name of the file either
in GETPAR_SOU format
(http://astrogeo.org/psolve/doc/getpar_02.html#section3.3)
or in SOU-MODFILE format. This is the fourth catalogue used by VTD.
It might be convenient to keep coordinates of source in more than one file.
That file contains information the sources which participated in the
experiment: IVS source name, source coordinates. This file may contain
information about other source which were not observed in the analyzed
experiment.

2.11 SOURCE_PRLX_PRP_MOTION:

SOURCE_PRLX_PRP_MOTION: [source_parallax_and_proper_motion_file or NONE]

The qualifier source_parallax_and_proper_motion_file specifies the name of
the file with a priori source proper motions and parallaxes. Each line of
that file contains IVS source name J2000 source name, proper motion over
right ascension without scaling cos(delta) factor, proper motion over
declination, annual parallax, and comment. See file prlx_prp_format.txt
in the documentation directory for the format description.

2.12 AEM_FILE

AEM_FILE: aem_file_name or NONE

Keyword AEM_FILE specifies the name of the file with the a priori
Earth rotation model. This file is one of the three files that describes
the Earth's rotation in accordance to the empirical Earth rotation model
formalism. The file should conform specifications of the AEM files. The AEM
file defines values of "large" parameters, i.e. those parameters which
squares are not-negligible. These are parameters for precession, several
terms in nutation and several terms in the Earth's axial rotation.

2.13 ERM_FILE

ERM_FILE: erm_file_name or NONE

Keyword ERM_FILE specifies the name of the file with the a priori
Earth rotation model. This file is one of the three files that describes
the Earth's rotation in accordance to the empirical Earth rotation model
formalism. The file should conform specifications of the ERM files. The ERM
file defines coefficients that describe long periodic, "small" variations
in Earth's rotation, i.e. those parameters variations which squares are
negligible. The coefficients of B-spline allows to compute the instantaneous
vector of perturbations to the Earth's rotation. These file describes
the slowly varying component of the Earth rotation.

2.14 HARMONIC_EOP_FILE:

HARMONIC_EOP_FILE: [NONE or NERS or file_name]

Keyword HARMONIC_EOP_FILE specifies the name of the file with the harmonic
Earth Orientation model. This models describes perturbation in the Earth
orientation with respect to the a priori model specified by the a priori EOP
files, a priori nutation, precession and built-in expression for the UT1 angle.
The model is in the form

```
sum (a + b*t)*{sin/cos}( theta/2*t**2 + omega*t + phase)

  The purpose of this model is to correct a priori EOP model specified in
EOP_SERIES, PRECESSION_EXPRESSION, NUTATION_EXPANSION, GEODESIC_NUTATION
keywords.

  NERS      -- the harmonic EOP variations are taken using the Network Earth
               Rotation Service (NERS) automatically. The NERS client
               control file specified by EOP_SERIES keyword is used.

  file_name -- name of the file with the model in HEO format.
```

2.15 EOP_SERIES:

```
    EOP_SERIES: [NONE or NERS or ners_configuration_file or
                 earth_orientation_parameters_file]


   Earth_orientation_parameters_file is the name of the file of the
Earth orientation parameters either in EOP-MOD or NERS EOP series format,
or NERS configuration file or NERS. The file with the Earth Orientation
Parameters contains values of X-coordinate of the pole coordinate,
Y-coordinate of  the pole coordinate, and UT1 angle at the equidistant
grid of time epochs.
   NONE   -- No external file with EOP series.
             (Supported when ERM formalism was chosen)

   NERS   -- The EOP data are taken using NERS. Default NERS client
             control file is used.

   ners_configuration_file -- name of the control file for NERS client

   earth_orientation_parameters_file -- name of the file with Earth
                                        orientation parameters

VTD analyzes the first line of the file in order to determine whether it
is the file with the Earth orientation parameters or the NERS configuration
file.
```

2.16 EOP_TIME_SCALE:

```
    EOP_TIME_SCALE: time_scale_of_eop_table


  Time_scale_of_eop_table defines the time scale used for time tags in the
table of the input Earth orientation series specified in the value of the
keyword EOP_SERIES. Supported values:

   TAI
   TDT
   TDB
   UTC
   UT1
   NERS   -- the same as TAI
   NONE   -- (Supported when ERM formalism was chosen)
```

2.17 UZT_MODEL:

```
    UZT_MODEL: [NONE or NERS or DICKMAN1993 or DICKMAN1993_PRINCIPAL
                or DICKMAN1993_SHORT]


  UT1_zonal_tides_model_name is the name of the model of UT1 variations
induced by zonal tides. Supported  values:

  NONE                  -- no model is used.
  NERS                  -- the same as NONE
  DICKMAN1993           -- model of Dickman, 1993, all terms
  DICKMAN1993_PRINCIPAL -- model of Dickman, 1993, only principal term and
                           14 terms which contributes to UT1 rate greater
                           than 1.0D-14 rad/s
  DICKMAN1993_SHORT     -- model of Dickman, 1993, only terms with periods
                           shorter than 60 days
```

2.18 UZT_USE:

```
    UZT_USE: [NONE or NERS or ADD or INTERPOLATE or SUBTRACT]


  The way how to apply the mode of UT1 variations induced by zonal tides.

  NONE         --  not to apply contribution of UT1 variations induced
```

by zonal tides;

NERS -- the same as NONE

ADD -- add contribution to UT1 caused by zonal tides to apriori EOP;

SUBTRACT -- subtract contribution to UT1 caused by zonal tides from a priori EOP;

INTERPOLATE -- the model is used for subtracting contribution to UT1 due to zonal tides before computation of interpolating coefficients, and then contribution of UT1 are added to final a priori UT1 values after interpolation.

2.19 EROT_COMPAT:

EROT_COMPAT: [NONE or NERS or CALC10 or NO_SANG]

If specified, adds corrections to the a priori Earth rotation angles to be compatible with Calc10. It can be used for testing in order to precisely emulate values computed by Calc. These corrections DO NOT improve VLBI path delay prediction. This option is intended for tests only.

NONE (recommended) means that no emulation is performed.

NERS the same as NONE

2.20 PRECESSION_EXPRESSION:

PRECESSION_EXPRESSION: precession_model_name

Keyword PRECESSION_EXPRESSION specifies the name of the precession model.
Supported expansions:

LIESE_1977 -- Values of precession parameters from Lieske 1976.
SIMON_1994 -- Values of precession parameters from Simon 1994.
IERS_1996 -- Values of precession parameters from IERS 1996.
CAPITAINE_2003 -- Values of precession parameters from Capitaine 2003
CAPITAINE_2005 -- Values of precession parameters from Capitaine 2005
NERS -- Precession is computed by the NERS. The NERS client control file specified by EOP_SERIES keyword is used.
NONE -- No precession (Supported when ERM formalism was chosen)

2.21 NUTATION_EXPANSION:

NUTATION_EXPANSION: nutation_expansion_name

Keyword NUTATION_EXPANSION specifies the name of the nutation expansions.
Supported expansions:

WAHR1980 -- Wahr 1980 nutation expansion. Expansion for Doodson arguments referred to at that paper are used.
IERS1996 -- Empirical nutation expansion computed by T. Herring and presented in the IERS 1996 Conventions. Expansion for Doodson arguments referred to at that paper are used.
REN2000 -- Theoretical expansion of the rigid Earth model by J. Souchay
MHB2000 -- MHB2000 expansion according coefficients presented in the program which T. Herring posted on the Web.
MHB2000_TRANSF -- REN2000 expansion with the transfer function from Mathews at al, 2002 paper.
MHB2000_ADDON -- REN2000 expansion with the transfer function from Mathews at al, 2002 paper and all add-on terms listed at that paper.
MHB2000_PETA -- Simplified expansion to nutation with only three non-linear terms.
NERS -- Nutation is computed by the NERS. The NERS client control file specified by EOP_SERIES keyword is used.
NONE -- No nutation (Supported when ERM formalism was chosen)

2.22 GEODESIC_NUTATION:

GEODESIC_NUTATION usage_flag

Keyword NUTATION_EXPANSION specifies whether geodesic nutation should be

modeled.

```
  usage_flag -- one of
                YES -- to model geodesic nutation
                NONE  -- not to model geodesic nutation
```

2.23 SOLID_EARTH_TIDES_ZERO_FREQ:

```
    SOLID_EARTH_TIDES_ZERO_FREQ: Love_model_name
```

```
  Keyword SOLID_EARTH_TIDES_ZERO_FREQ specifies the name of the model of
Love numbers for the zeroth frequency. Unfortunately, several erroneous papers
and thoughtless resolution of scientific societies created a great confusion
about the issues of so-called "permanent tide". VTD allows a user to specify
the model for computation of the zonal tides of the zero-th frequency.

  Love_model_name -- model code. One of

                    MDG97AN -- Mathews, Dehant, Gipson 1997, anelastic
                               variant.
                    NONE    -- consider Love numbers for the tides of
                               the second degree as zero.
```

2.24 SOLID_EARTH_TIDES_2ND_DEGREE:

```
    SOLID_EARTH_TIDES_2ND_DEGREE: Love_model_name
```

```
  Keyword SOLID_EARTH_TIDES_2ND_DEGREE specifies the name of the model of
Love numbers of the second degree as a function of frequency.

  Love_model_name -- model code. One of

                    MDG97EL      -- Mathews, Dehant, Gipson 1997, elastic
                                    variant.
                    MDG97AN      -- Mathews, Dehant, Gipson 1997, anelastic
                                    variant.
                    DDW99EH      -- Dehant, Defraigne, Wahr 1999, elastic,
                                    hydrostatic variant.
                    DDW99IN      -- Dehant, Defraigne, Wahr 1999, inelastic,
                                    non-hydrostatic variant.
                    LOVE         -- Love, 1923 model
                    MATHEWS_2000 -- Mathews, 2000 model
                    MATHEWS_2001 -- Mathews, 2001 model
                    NONE         -- consider Love numbers for the tides of
                                    the second degree as zero.
```

2.25 SOLID_EARTH_TIDES_3RD_DEGREE:

```
    SOLID_EARTH_TIDES_3RD_DEGREE: Love_model_name
```

```
  Keyword SOLID_EARTH_TIDES_2ND_DEGREE specifies the name of the model of
Love numbers of the third degree.

  Love_model_name -- model code. One of

                    MDG97EL -- Mathews, Dehant, Gipson 1997.
                    NONE    -- consider Love numbers for the tides of
                               the second degree as zero.
```

2.26 POLE_TIDE_MODEL:

```
    POLE_TIDE_MODEL: Love_model_name
```

```
  Keyword POLE_TIDE_MODEL specifies the name of the model of Love numbers
used for computation of the pole tide.

  Love_model_name -- model code. One of

                    MDG97EL      -- Mathews, Dehant, Gipson 1997, elastic
                                    variant.
                    MDG97AN      -- Mathews, Dehant, Gipson 1997, anelastic
                                    variant.
                    DDW99EH      -- Dehant, Defraigne, Wahr 1999, elastic,
                                    hydrostatic variant.
                    DDW99IN      -- Dehant, Defraigne, Wahr 1999, inelastic,
```

```
                        non-hydrostatic variant.
                LOVE         -- Love, 1923 model
                MATHEWS_2000 -- Mathews, 2000 model
                MATHEWS_2001 -- Mathews, 2001 model
                NONE         -- consider Love numbers for the pole tides
                                as zero.
```

2.27 MPL_FILE:

MEAN_POLE_MODEL: expression_id

```
  Keyword MEAN_POLE_MODEL MPL_FILE specifies the name of the expression
for the mean pole positions.

   expression_id -- one of

   NONE     -- mean pole positions is zero.

   IERS2010 -- expression for pole tide following IERS2010 conventions.
               NB: THIS EXPRESSION IS WRONG!!  It was included only
               for tests.

   IERS2022 -- expression for pole tide following IERS2022 conventions.
```

2.28 POSVAR_FIL:

POSVAR_FIL: model_index model_file_name

```
  Keyword POSVAR_FIL specifies the name of the file with the model of
position variations.

  model_index     -- the index of the model. Should be 1 if only one
                     model of position variations is in use. Of more than
                     one model is in use, then the models are numbered
                     consecutively from 1 to the last model. Maximum
                     8 models can be specified.

  model_file_name -- the name of the file with the model.
```

2.29 POSVAR_MOD:

POSVAR_MOD: model_index model_type

```
  Keyword POSVAR_MOD specifies the model type. Two types are supported:
time series and harmonic site position variations model.

  model_index  -- the index of the model. Should be 1 if only one
                  model of position variations is in use. Of more than
                  one model is in use, then the models are numbered
                  consecutively from 1 to the last model. Maximum
                  8 models can be specified.

  model_type   -- one of
                  HARMONIC_MODE -- the file is in HARPOS format:
                                   http://astrogeo.org/psolve/doc/harpos_format.txt
                  TIME_SERIES   -- the file is in BINDISP format:
                                   http://astrogeo.org/psolve/doc/bindisp_format.txt
                  B_SPLINE      -- ...
```

2.30 POSVAR_INT:

POSVAR_INT: model_index interpolation_type

```
  Keyword POSVAR_MOD specifies the type of interpolation. The values of the
position variations models are first read at several epoch around the time
range of the experiment, then interpolation polynomials are computed. Position
variations at the epoch of the observation are computed on the basis of this
polynomial. Two interpolation types are supported: LINEAR and SPLINE

  model_index        -- the index of the model. Should be 1 if only one
                        model of position variations is in use. Of more than
                        one model is in use, then the models are numbered
                        consecutively from 1 to the last model. Maximum
                        8 models can be specified.
  interpolation_type -- one of
                        LINEAR
                        SPLINE
```

2.31 POSVAR_USE:

POSVAR_USE: model_index usage_flag

Keyword POSVAR_INT specifies the action of position variations model
is not available for the requested station, requested epochs.
An alternative is either issue a warning and continue or print the fatal
error message and stop.

```
model_index        -- the index of the model. Should be 1 if only one
                      model of position variations is in use. Of more than
                      one model is in use, then the models are numbered
                      consecutively from 1 to the last model. Maximum
                      8 models can be specified.
interpolation_type -- one of
                      REQUIRED     -- if position variation model is not
                                      available for a requested station,
                                      requested epoch, then stop.
                      IF_AVAILABLE -- if position variation model is not
                                      available for a requested station,
                                      requested epoch, then print
                                      a warning, set variations to zero
                                      and continue.
```

2.32 AXIS_OFFSET_MODEL:

AXIS_OFFSET_MODEL: usage_flag

```
usage_flag -- the flag. Supported values:
              YES  -- (recommended) means that the contribution to delay
                      due to antenna axis offset is taken into account.
              NONE --  means that the contribution to delay caused
                      by the antenna axis offset is ignored. It is used
                      for tests only.
              CALC9 -- forces VTD to emulated a bug in Calc9. This
                      option is for tests only.
```

2.33 ANTENNA_DEFORMATIONS_FILE:

ANTENNA_DEFORMATIONS_FILE: [NONE or agd_file]

Keyword ANTENNA_DEFORMATIONS_FILE specifies the file name that
keeps parameters of the models of antenna deformation caused by gravity.
The file should conforms AGD specifications. The current model tabulates
the change of the focal length as a function of elevation for each antenna.
Some antenna may me missing from the agd_file file. The contribution to delay
caused by antenna deformations for these antenna will be set to zero.

2.34 ANTENNA_THERMAL_EXPANSION

ANTENNA_THERMAL_EXPANSION NONE or [MODEL antenna_information_file
INSITU [NONE or insitu_file]
TEMPERATURE [METEO or SPD]
LAG time_in_seconds]

Keyword ANTENNA_THERMAL_EXPANSION defines the mode for computing
the contribution to time delay caused by antenna structures thermal
expansion. The 1st qualifier may be NONE or MODEL. If the 1st qualifier
is MODEL, then VTD expects to read 8 qualifiers. The second qualifier
is the name of the antenna information file in the ANTI format. The
antenna information file defines the type of each antenna, dimensions
of the antenna structure and their coefficient of thermal expansion,
reference temperature. Some antennas may be missing from this file.
Contribution to path delay caused by antenna deformations of these antennas
will be set to zero. The 3rd qualifier is INSITU. The 4th qualifier is
the name of the file with information about antennas that have available
data of their thermal height variation measurements with the invar rod.
These stations will be excluded from computation of contribution due to antenna
thermal deformation according to the model of thermal expansion. Position
variations of the reference point for these antennas should be included to
the model specified by POSVAR_MOD, POSVAR_FIL, POSVAR_INT, POSVAR_USE.

The antenna deformations caused by thermal expansion depend on the
effective temperature of elements of antenna structure. The 5th
qualifier is TEMPERATURE. It defines the source of temperature data
defined in the 6th qualifier METEO or SPD. If METEO, then temperature is
supplied with VTD_METEO_IN subroutine. These are usually data collected
by local meteorological sensor. If SPD, then air temperature is supplied
in SPD (slant path delay) data files. It is computed from the output of
the global numerical weather model. The 7th qualifier is LAG. The 8th

qualifier defines the lag of antenna temperature with respect to air
temperature. Antenna temperature at time t is computed as air temperature
at time t - lag.

  Restrictions: TEMPERATURE SPD requires EXTERNAL_DELAY_DIR directory
names be defined that supplied the source of information about
expansion coefficients via 3D B-splines.

2.35 METEO_DEF

METEO_DEF model

Qualifier METEO_DEF defines the model that is used for computing
missing meteorological parameters. If the atmospheric pressure and/or
air temperature are negative, they are interpreted as missing.

  default_model:
    IMA -- the model of the International Meteorological Association
            ISO Standard atmosphere 1976.
    CALC -- Undocumented model that Calc uses. This model is for
            test only.
    NONE -- not to change meteorological parameters. Keep in mind,
            that if NONE specified, subsequent computation of zenith
            path delay using SAASTAMOINEN model will be
            __completely wrong__.

2.36 HYDROSTATIC_ZENITH_DELAY:

HYDROSTATIC_ZENITH_DELAY: [NONE or zenith_delay_path_model_name or
MMF mmd_model_file]

Keyword HYDROSTATIC_ZENITH_DELAY specifies the name of the a priori model
for the hydrostatic component zenith path delay.

   zenith_delay_path_model_name -- the name of the model. One of
          NONE   -- do not model hydrostatic path delay
          SAASTAMOINEN -- Saastamoinen model
          MMF   -- the Mean Mapping Function mode (Petrov (2009), in
                           preparation). Requires the name of the file with
                           the MMF model in the following qualifier.

2.37 WET_ZENITH_DELAY:

WET_ZENITH_DELAY: [NONE or zenith_delay_path_model_name]

Keyword WET_ZENITH_DELAY specifies the name of the a priori model
for the non-hydrostatic component of the zenith path delay.

   zenith_delay_path_model_name -- the name of the model. One of
          NONE   -- do not model non-hydrostatic path delay
          MMF   -- the Mean Mapping Function mode (Petrov (2009), in
                           preparation). Requires the name of the file with
                           the MMF model in the following qualifier.

2.38 HYDROSTATIC_MAPPING_FUNCTION:

HYDROSTATIC_MAPPING_FUNCTION: [NONE or mapping_function_name
or [MMF mmf_mode file]]

Keyword HYDROSTATIC_MAPPING_FUNCTION defines the model for the mapping
function for the hydrostatic component of the path delay -- dependence of
the hydrostatic component of the atmospheric path delay with elevation.
NB: the argument of the mapping function is so-called vacuum elevation: the
elevation which the source would have in the absence of refractive
atmosphere.

  mapping_function_name -- the name of the mapping function. One of
          NMFH -- Niell 1996 mapping function.
          MMF -- the Mean Mapping Function mode (Petrov (2009), in
                  preparation). Requires the name of the file with
                  the MMF model in the following qualifier.

2.39 WET_MAPPING_FUNCTION:

WET_MAPPING_FUNCTION: [NONE or mapping_function_name

```
                              or [MMF mmf_mode file]
                              or external_delay_dir ]
```

```
  Keyword WET_MAPPING_FUNCTION defines the model for the mapping function
for the non-hydrostatic component of the path delay -- dependence of the
non-hydrostatic component of the atmospheric path delay with elevation.
NB: the argument of the mapping function is the so-called vacuum elevation:
the elevation which the source would have in the absence of refractive
atmosphere.

  mapping_function_name -- the name of the mapping function. One of
          NMFW -- Niell 1996 mapping function.
          MMF  -- the Mean Mapping Function mode (Petrov (2009), in
                  preparation). Requires the name of the file with
                  the MMF model in the following qualifier.
```

2.40 ATMOSPHERE_TILT_PARTIALS:

```
    ATMOSPHERE_TILT_PARTIALS: tilt_partials
```

```
  Keyword ATMOSPHERE_TILT_PARTIALS defines the model for partial
derivatives of the atmospheric tilt, or using another words,
atmospheric gradients.

  tilt_partials  -- the name of tilt_partials model.
                    Currently, only one value is supported:
                    MACMILLAN_1995
```

2.41 SLANT_PATH_DELAY

```
    SLANT_PATH_DELAY [SPD_3D or NONE]
```

```
  Keyword  SLANT_PATH_DELAY  defines that the path delay through
the neutral atmosphere for a given elevation, azimuth, time for a given
station should be computed by three-dimensional B-spline interpolation
of the time series of slant path delays. These time series of path delays
are supposed to have been computed at an elevation/azimuth grid for
each station using a standalone program SPD_3D by solving numerically a system
of non-linear differential equations of wave propagation through the 4D,
heterogeneous atmosphere (L. Petrov, 2009, in preparation) represented by
the 4D field of atmospheric parameters that are the output of a numerical
weather model. NB: the contribution of the neutral atmosphere can be computed
either by using mapping function approach (keywords HYDROSTATIC_ZENITH_DELAY,
HYDROSTATIC_MAPPING_FUNCTION, WET_MAPPING_FUNCTION, WET_ZENITH_DELAY)
or by SLANT_PATH_DELAY.

   SPD_3D -- slant path delay will be computed by interpolation of time
             series of B-spline coefficients stored in files that are
             kept directory EXTERNAL_DELAY_DIR (or EXTERNAL_DELAY_DIR_2,
             EXTERNAL_DELAY_DIR_3, EXTERNAL_DELAY_DIR_4 if defined )

   NONE   -- algorithm for computing slant path delay by interpolation of time
             series of B-spline coefficients will be disabled.
```

2.42 ATMOSPHERE_PATH_DELAY_PARTIAL

```
   ATMOSPHERE_PATH_DELAY_PARTIAL [NONE or NMW or NMF or IONO_350 or IONO_400 or
                                  IONO_450 or IONO_500 or TOTAL_SCALE or
                                  TOTAL_WATER or
                                  (GAUSSIAN_LAYER [layer_height layer_fwhm])]
```

```
   Keyword ATMOSPHERE_PATH_DELAY_PARTIAL defines partial derivative of
slant path delay with respect to the path delay in zenith direction.
This partial derivatives is not used for computing a priori path delay,
but is supposed to be used for parameter estimation. The partial derivatives
are placed in arrays DER_DEL, DER_RAT, in slots VTD__DER_AT1 (partial
derivatives for station #1) and VTD__DER_AT2 (partial derivatives for
station #2).

            NONE -- no partial is computed

            NMFH -- Niell (1996) hydrostatic mapping function

            NMFW -- Niell (1996) wet mapping function

         IONO_350 -- mapping function for the case when residual
                     atmosphere is described as a thin shell
                     at height 350 km. Such a model is suitable
                     for characterizing residual ionosphere.
```

```
        IONO_400 -- mapping function for the case when residual
                    atmosphere is described as a thin shell
                    at height 400 km. Such a model is suitable
                    for characterizing residual ionosphere.

        IONO_450 -- mapping function for the case when residual
                    atmosphere is described as a thin shell
                    at height 450 km. Such a model is suitable
                    for characterizing residual ionosphere.

        IONO_500 -- mapping function for the case when residual
                    atmosphere is described as a thin shell
                    at height 500 km. Such a model is suitable
                    for characterizing residual ionosphere.

     TOTAL_SCALE -- mapping function for the case when residual
                    atmosphere is considered proportional to
                    the total atmosphere. The partial derivative
                    is defined as a ratio of the total slant path
                    delay to the total path delay in the zenith
                    direction. NB: this partial derivative requires
                    computation of a priori slant path delay
                    (SLANT_PATH SPD_3D).

     WATER_SCALE -- mapping function for the case when residual
                    atmosphere is considered proportional to
                    the water vapor contribution to the atmosphere.
                    The partial derivative is defined as a ratio of
                    the water vapor contribution of slant path
                    delay to the water vapor contribution to path
                    delay in the zenith direction. NB: this partial
                    derivative requires computation of a priori slant
                    path delay (SLANT_PATH SPD_3D).

  GAUSSIAN_LAYER -- layer_height  layer_fwhm  -- mapping function for
                    the case when the dependence of concentration
                    of the residual atmosphere is described with
                    the Gaussian model with the specified height
                    and the specified full width half maximum
                    (FWHM). The height of the layer in meters
                    is specified in the 3rd qualifier and the FWHM
                    in meter is specified in the 4th qualifier.
```

2.43 EXTERNAL_DELAY_DIR

EXTERNAL_DELAY_DIR [NONE or directory_name]

Keyword EXTERNAL_DELAY_DIR specifies the directory name of files with external path delays. The format of these files is defined by SLANT_PATH_DELAY keyword. If SLANT_PATH_DELAY is SPD_3D, then the files in the EXTERNAL_DELAY_DIR directory should satisfy spd_3d_bin specification. Each file contains the time series of the B-spline coefficients for a specific station.

2.44 EXTERNAL_DELAY_DIR_2ND

EXTERNAL_DELAY_DIR_2ND [NONE or directory_name]

Keyword EXTERNAL_PATH_DELAY_FILE specifies the secondary directory name of files with external path delays. Each file contains the time series of B-spline coefficients for a specific station. If a file for a given station is not found in directory EXTERNAL_DELAY_DIR, it is sought in directory EXTERNAL_DELAY_DIR_2ND.

2.45 EXTERNAL_DELAY_DIR_3RD

EXTERNAL_DELAY_DIR_3RD [NONE or directory_name]

Keyword EXTERNAL_PATH_DELAY_FILE specifies the name of third directory of files with external path delays. Each file contains the time series of B-spline coefficients for a specific station. If a file for a given station is not found in directories EXTERNAL_DELAY_DIR, EXTERNAL_DELAY_DIR_2ND, it is sought in directory EXTERNAL_DELAY_DIR_3RD.

2.46 EXTERNAL_DELAY_DIR_4TH

EXTERNAL_DELAY_DIR_4TG [NONE or directory_name]

Keyword EXTERNAL_PATH_DELAY_FILE specifies the name of fourth directory of files with external path delays. Each file contains the time series of B-spline coefficients for a specific station. If a file for a given station is not found in directories EXTERNAL_DELAY_DIR, EXTERNAL_DELAY_DIR_2ND, and EXTERNAL_DELAY_DIR_3RD, it is sought in directory EXTERNAL_DELAY_DIR_4TH.

2.47 IONOSPHERE_MODEL:

IONOSPHERE_MODEL: [NONE or GNSS_TEC_MAP]

Keyword IONOSPHERE_MODEL specifies the ionospheric model for computation of path delay. Accepted values:

NONE -- no ionosphere path delay is applied.

GNSS_TEC_MAP -- apply ionospheric path delay computed using GNSS TEC maps.

2.48 IONOSPHERE_SCALE:

IONOSPHERE_SCALE: value

Keyword IONOSPHERE_SCALE specifies the scale factor. The ionospheric contribution computed from TEC maps is multiplied by that parameter.

2.49 SOU_DEBIAS_MODEL:

SOU_DEBIAS_MODEL: [None value]

Keyword SOU_DEBIAS_MODEL specifies the name of the source position de-bias model. It is for compensation of the source position bias caused by the the deficiency of an ionospheric model or other models. The contribution of the de-bias model to path delay is computed on the basis of an empirical model that describes the position bias in declination as a function of declination. Supported models: NONE, MAP_850N, MAP_750R, MAP_780S.

2.50 IONOSPHERE_DATA_FILE:

IONOSPHERE_DATA_FILE: [NONE or file name]

Keyword IONOSPHERE_DATA_FILE specifies a binary file ion viono format that keeps GNSS TEC maps for some period of time.

2.51 IONOSPHERE_DATA_FILE_2ND:

IONOSPHERE_DATA_FILE_2ND: [NONE or file_name]

Keyword IONOSPHERE_DATA_FILE_2ND specifies a binary file ion viono format that keeps GNSS TEC maps for some period of time.

2.52 IONOSPHERE_DATA_FILE_3RD:

IONOSPHERE_DATA_FILE_3RD: [NONE or file_name]

Keyword IONOSPHERE_DATA_FILE_3RD specifies a binary file ion viono format that keeps GNSS TEC maps for some period of time.

2.53 IONOSPHERE_DATA_FILE_4TH:

IONOSPHERE_DATA_FILE_4TH: [NONE or file_name]

Keyword IONOSPHERE_DATA_FILE_4TH specifies a binary file ion viono format that keeps GNSS TEC maps for some period of time.

2.54 IONOSPHERE_DATA_FILE_5TH:

IONOSPHERE_DATA_FILE_5TH: [NONE or file_name]

Keyword IONOSPHERE_DATA_FILE_5TH specifies a binary file ion viono format that keeps GNSS TEC maps for some period of time.

2.55 IONOSPHERE_DATA_FILE_6TH:

IONOSPHERE_DATA_FILE_6TH: [NONE or file_name]

Keyword IONOSPHERE_DATA_FILE_7TH specifies a binary file ion viono format that keeps GNSS TEC maps for some period of time.

2.56 IONOSPHERE_DATA_FILE_8TH:

IONOSPHERE_DATA_FILE_8TH: [NONE or file_name]

Keyword IONOSPHERE_DATA_FILE_8TH specifies a binary file ion viono format that keeps GNSS TEC maps for some period of time.

2.57 GRS_METRIC:

GRS_METRIC: metric_identifier

Keyword GRS_METRIC specifies the name of the metric tensor for the geocentric reference system.

metric_identifier -- Identifier of the metric tensor. Supported values:
- IAU2000 -- the metric tensor proposed by Kopeikin and Brumberg. recommended by IAU2000 resolution.
- ITRF2000 -- the metric tensor which was implicitly used in data analysis in the 20-th century, which was used for constructing the ITRF2000 catalogue of station positions and velocities.

Comment: recommendation of IERS2003 is contradictory: in one place the authors of Conventions claimed that they compliant with the IAU2000 recommendation, at another place they propose formulae based on ITRF2000 metric.

2.58 TROP_AXOF_COUPLING:

TROP_AXOF_COUPLING: usage_flag

The keyword TROP_AXOF_COUPLING specifies whether to compute contribution to delay due to coupling of the troposphere path delay and antenna axis offsets. By another words TROP_AXOF_COUPLING takes into account additional troposphere path delay due to motion of the reference point.

usage_flag -- the flag. Supported values:
- YES -- to compute contribution due to coupling of the troposphere path delay and antenna axis offsets.
- NO -- not to compute contribution due to this coupling.

2.59 TROP_GEOMETRIC_COUPLING:

TROP_GEOMETRIC_COUPLING: usage_flag

The keyword TROP_GEOMETRIC_COUPLING specifies whether to compute the contribution to delay due to coupling of the troposphere path delay and geometric delay.

```
usage_flag -- the flag. Supported values:
              YES -- to compute contribution due to coupling of the
                     troposphere path delay and geometric delay.
               NO -- not to compute contribution due to this coupling.
```

2.60 PARALLACTIC_ANGLE:

PARALLACTIC_ANGLE: usage_flag

The keyword PARALLACTIC_ANGLE specifies whether to compute the contribution to phase delay and phase delay rate due to the parallactic angle. NB: the contribution of the parallactic angle to group delay is zero.

```
usage_flag -- the flag. Supported values:
              YES -- to compute contribution to phase delay due
                     parallactic angle
               NO -- not to compute contribution due to parallactic angle.
```

2.61 GALACTIC_ABERRATION:

GALACTIC_ABERRATION: usage_flag

The keyword GALACTIC_ABERRATION specifies whether to compute the contribution to delay caused by the galactic aberration.

```
usage_flag -- the flag. Supported values:
              YES -- to compute contribution to phase delay due
                     parallactic angle
               NO -- not to compute contribution due to parallactic angle.
```

2.62 GEOM_EXPR_FAR_ZONE:

GEOM_EXPR_FAR_ZONE: model_name

The keyword GEOM_EXPR_FAR_ZONE specifies the name of the expression for geometric delay in far zone (larger than 10 pc) in vacuum based on general relativity.

```
model_name -- the name of the expression. Supported values:
              KS_1999 -- expression Kopeikin and Schaefer, 1999
              PK_2001 -- expression Petrov and Kopeikin, 2001 (recommended)
```

2.63 GEOM_EXPR_NEAR_ZONE:

GEOM_EXPR_NEAR_ZONE: model_name

The keyword GEOM_EXPR_NEAR_ZONE specifies the name of the expression for geometric delay in the near zone (from Earth's satellite to 10 pc) in vacuum based on general relativity.

```
model_name -- the name of the expression. Supported values:
              LIGHT_TIME -- iterative solution of the light equation
```

2.64 SOURCE_STRUCTURE:

SOURCE_STRUCTURE: control_file_name

The keyword SOURCE_STRUCTURE specifies the control file for modeling contribution to delay due to source structure.

```
control_file_name -- the name of the control file or
                     NO -- contribution to delay due to source structure
                           will not be computed.
                     This option is currently being tested.
```

2.65 DOPPLER_EXPR:

```
DOPPLER_EXPR: model_name
```

The keyword DOPPLER_EXPR specifies the name of the expression for computation of the Doppler frequency shift for an object within the Solar system based on general relativity.

2.66 DELAY_RATE:

```
DELAY_RATE: YES or NONE
```

The keyword DELAY_RATE specifies whether to compute delay rate. If DELAY_RATE is NONE computation runs faster.

YES -- to compute delay rate using analytical expressions.

NO -- not to compute delay rate.

Questions and comments about this guide should be directed to:

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