

# Memorandum

IVS-EOP file format

To: IVS analysis working group

From: Claudia Flohrer (BKG)

Date: June 27, 2022

Subject: Revision of proposal to add header block to IVS-EOP file format

## 1 Background

The IVS is using a dedicated IVS-EOP file format for distributing its EOP time series. The latest format version (2.2) is provided at the IVS AC webpage: [https://ivscc.gsfc.nasa.gov/IVS\\_AC/files\\_IVS-AC/eop\\_transfer\\_format.txt](https://ivscc.gsfc.nasa.gov/IVS_AC/files_IVS-AC/eop_transfer_format.txt). It consists of the data block and optional comment lines. The information on the used nutation model is indicated by the file name extension only. Other relevant information, as e.g. the format version, AC, time window, reference frame, are not provided in a standardized format inside the EOP file. Therefore, we propose to add relevant basic information on the EOP generation in a standardized format directly in the EOP file by using a dedicated header block with keywords.

## 2 Proposal

We propose the following changes to the IVS-EOP file format.

### 2.1 Overall structure

- New format version is version 3.0.
- The ACSCII character set is to be used.
- The format description specifies also the naming convention of the file name, as given at <https://ivscc.gsfc.nasa.gov/products-data/submit-product.html>
- A first line as mandatory data description line (similar to the SINEX format) is added.
- The mandatory data description line contains the used time scale, which has to be specified explicitly. (The old format required the usage of TAI. In case SW packages do not provide TAI there is no need to change the time scale, instead the used time scale needs to be specified.)
- A last line as mandatory footer line (similar to the SINEX format) is added.
- A header block is added after the data description line and before the data block, containing keyword-based information.
- Each header block line provides information via keywords and associated values (to be documented in the format description).
- Keywords can be mandatory or optional.
- The start of the header block is indicated by the line "+HEADER" and its end by the line "-HEADER".
- The start of the data block is indicated by the line "+DATA" and its end by the line "-DATA". Two additional comment lines are added above the actual data lines, describing the data columns (column identifier and units) for better readability.

- The units of the data field entries are no longer fixed but can be chosen. The units are indicated as part of the header keyword EOP\_ESTIMATED. Valid unit values are specified in the format description.
- The format of the data field entry for column 30 (network) has changed. The sequence of 2-character station identifiers is no longer directly attached to each other, but using '-' between each station identifier.
- An additional data field 31 for comments is added.
- The data block comes after the header block.
- All data records have to be ordered in time.
- Lines starting with "#", "\*", "!" are considered as comment lines. Comment lines are allowed everywhere, i.e. also in the header and data block.

## 2.2 Data description line (Mandatory)

The data description line is mandatory and must be the first line in an IVS-EOP file.

```
%=IVS-EOP 3.0 IVS 2021-04-20T10:23:00 BKG 1984-03-08T17:30:00 2021-08-24T18:30:00 TAI R
```

Table 1: Format of the data description line

Field	Description	Format
First character	Single character '%' in column #1. No other character than '%' is allowed.	A1
Second character	Single character '=' in column #2, indicates resultant solution. No other character than '=' is allowed.	A1
Document type	Seven characters 'IVS-EOP' indicating this is an IVS-EOP file.	A7
Format version	Three digits indicating the format version used. '3.0' for this version	1X,F3.1
File agency code	Agency creating the file, e.g., IVS for IVS combination center.	1X,A3
File time	Creation time of this IVS-EOP file (YYYY-MM-DDTHH:MM:SS)	1X,I4,"-",I2,"-",I2,"T",I2,":",I2,":",I2
Agency code	Agency providing the data in the file, e.g. BKG, which runs the IVS combination center	1X,A3
Start time	Start time of the data used in the file (YYYY-MM-DDTHH:MM:SS)	1X,I4,"-",I2,"-",I2,"T",I2,":",I2,":",I2
End time	End time of the data used in the file (YYYY-MM-DDTHH:MM:SS)	1X,I4,"-",I2,"-",I2,"T",I2,":",I2,":",I2
Time scale	Three letters indicating the time scale used.	1X,A3
Observation code	Single character indicating the technique(s) used to generate the EOP solution. It should be consistent with the IERS convention. This character code may be: C - combined techniques used D - DORIS L - SLR M - LLR P - GNSS R - VLBI	1X,A1

## 2.3 HEADER block (Mandatory)

The header block is built of single lines for each keyword, starting with a keyword, followed by a value. Keywords can be mandatory or optional. The keyword values can be specific values from a given list (for machine readability) or free values (for information only). The header block is separated from the rest of the file content by the two lines "+HEADER" and "-HEADER".

```
+HEADER
<MANDATORY_KEY> <VALUE FROM LIST>
<MANDATORY_KEY> <FREE VALUE>
<OPTIONAL_KEY> <VALUE FROM LIST>
<OPTIONAL_KEY> <FREE VALUE>
-HEADER
```

Table 2: Format of the header block

Field	Description	Format
Keyword	Keyword in free format, in capital letters, no blanks are allowed in between words forming one keyword (use '_' instead). Keywords start at the beginning of each line. They are separated from the following values by a single ASCII character space. The list of allowed keywords is provided below.	A,1X
Value	Values may be preceded by extra ASCII spaces or ASCII tabs to aid forming readable columns. Values that contain lists must have the values separated by one or more ASCII spaces or ASCII tabs between each element of the list. Values use either a fixed format, tokens from a defined list or free format. The list of allowed values for each keyword is provided below.	see below

Table 3: List of allowed keywords and values

Keyword		Description	Value (format)
GENERATION_TIME	mandatory	Time of file generation	<i>Fixed format</i> YYYY-MM-DDTHH:MM:SS I4,"-",I2,"-",I2,"T", I2,":",I2,":",I2
DATA_START	mandatory	Start of data	<i>Fixed format as above</i>
DATA_END	mandatory	End of data	<i>Fixed format as above</i>
DESCRIPTION	mandatory	Description of solution	<i>Free format</i>
ANALYSIS_CENTER	mandatory	IVS analysis center code	<i>Free format</i>
CONTACT	mandatory	IVS analysis center point of contact	<i>Free format</i>
SOFTWARE	mandatory	Software and version number used to generate the EOP solution	<i>Free format</i>

TECHNIQUE	mandatory	Observation technique(s) used to generate the EOP solution	<p>Choose from list for single technique solution:</p> <p>V24 (VLBI R1/R4 24h Sessions)  VINT (VLBI Intensive Session)  VGOS (VLBI VGOS Sessions)  VLBI (VLBI, if none of the above)  GNSS  SLR  DORIS</p> <p>Combine individual codes with '+' to generate one value for combined solution, e.g.:</p> <p>VINT+V24  VINT+V24+GNSS  VINT+GNSS  V24+GNSS+SLR  ...</p>
NUTATION_TYPE	mandatory	Representation of nutation	<p>Choose one value from list:</p> <p>EQUINOX-BASED  CIO-BASED</p>
ROTATION_TYPE	mandatory	Representation of rotation	<p>Choose one value from list:</p> <p>UT1-UTC_LOD  UT1-TAI_LOD</p>
TRF_APRIORI	mandatory	A priori terrestrial reference frame	Free format
CRF_APRIORI	mandatory	A priori celestial reference frame	Free format
EOP_SUBDAILY	mandatory	Sub-daily pole model	<p>Choose one value from list:</p> <p>IERS2010  DESAI-SIBOIS  GIPSON  NONE</p>
EOP_APRIORI	mandatory	A priori EOP	Free format
EOP_ESTIMATED	mandatory	<p>One line for each estimated EOP, with values separated by one or more ASCII spaces or ASCII or tabs, following the notation:</p> <p>NAME[_TIMEDEP_DEGREE]  CONSTRAINT UNIT [RHS]</p> <p>with</p> <p>[ ] indicate optional arguments</p> <p>NAME specifies the parameter name. Valid names are:</p> <ul style="list-style-type: none"> <li>- XPOL</li> <li>- YPOL</li> <li>- DUT1,</li> <li>- LOD</li> <li>- DPSI or DX</li> <li>- DEPS or DY</li> </ul>	<p>Examples for offsets:</p> <p>XPOL            0.045 as  YPOL            0.045 as  DUT1            0.003 s  DPSI            NONE mas  DEPS            NONE mas</p> <p>rates:</p> <p>XPOL_DER_1 0.045 as/day  YPOL_DER_1 0.045 as/day  LOD            0.003 s  DPSI_DER_1 NONE mas/day  DEPS_DER_1 NONE mas/day</p> <p>piece-wise linear offsets:</p> <p>XPOL_BSP_1 0.045 as  YPOL_BSP_1 0.045 as  DUT1_BSP_1 0.003 s  DPSI_BSP_1 NONE mas  DEPS_BSP_1 NONE mas</p>

		<p>TIMEDEP could be either</p> <ul style="list-style-type: none"> <li>- DER (time derivative) or</li> <li>- BSP (B-spline)</li> </ul> <p>DEGREE is the degree of the time derivative/B-spline.</p> <p>CONSTRAINT is the value for the constraint (i.e. the reciprocal weight) applied for the specific EOP. Use 'NONE' if no constraint was used.</p> <p>UNIT specifies the unit of the EOP estimate and of the corresponding constraint (both units have to be the same). Valid units are:</p> <ul style="list-style-type: none"> <li>- s (seconds)</li> <li>- ms (milliseconds)</li> <li>- us (microseconds)</li> <li>- as (arcsecond)</li> <li>- mas (milliarcseconds)</li> <li>- uas (microarcseconds)</li> <li>- /day (each unit above/day)</li> </ul> <p>RHS specifies the right hand side value.</p> <p>EOPs, which are not estimated, should not be specified here. EOPs can appear in random order.</p> <p>Note: LOD is treated here as individual parameter and not as dUT1 derivative. It is maintained with the group of rates for consistency with the other techniques.</p>	
NUMBER_OF_ENTRIES	optional	Total number of entries (data lines) in the data block	<i>Integer number</i>

## 2.4 DATA block (Mandatory)

The data block begins with a line “+DATA” and ends with a line “-DATA”.

The data block is built of single lines per epoch. Two additional comment lines, with the first line describing the data field and the second line describing the units, are placed immediately before the first data line.

For readability the values in the data description lines should be placed centered over the columns. The values of the first description line have to correspond to the identifier given in the 2<sup>nd</sup> column of Table 4, but all values are case insensitive. The units have to be consistent with the units described in the header block (keyword UNIT). They can differ from the example given in Table 4 (3<sup>rd</sup> column). Consult Table 3 for valid units.

All data records have to be ordered in time.

The lines of the data block are free format, allowing for a variable field length. The fields are separated by at least one ASCII space. The lines should be parsed by splitting on whitespaces rather than using hard-coded field widths. There are 31 data fields (columns) per line. Data which is unavailable is replaced by NA. This is the case for example with Intensives, which don't estimate polar motion, nutation, or EOP rates.

Several data entries (i.e. lines) per parameter and session are possible, depending on the EOP parameterization, e.g., high resolution of offsets (every hour) or piece-wise linear offsets.

```
+DATA
#   epoch           xPol           yPol           dUT1           dPsi           ..
#   [MJD]           [as]           [as]           [s]           [mas]           ..
45724.242580      -0.194144373      0.162741232      0.355335524      -0.121292632      ..
45734.253540      -0.217079383      0.195741160      0.343469137      0.747975689      ..
45749.259380      -0.235108852      0.239193653      0.318375799      -1.120167692      ..
:
- DATA
```

Table 4: Format of data block

Field	identifier (1st line)	unit (2nd line)	description	
1	epoch	[MJD]	Decimal MJD of the measurement (with at least 5 decimal digits)	
2	xPol	[as]	Earth orientation	x component of the pole (with at least 7 decimal digits)
3	yPol	[as]		y component of the pole (with at least 7 decimal digits)
4	dUT1	[s]		UT1-UTC or UT1R-UTC or UT1-TAI or UT1R-TAI (with at least 8 decimal digits)
5	dPsi or dX	[mas]	Nutation	dPsi or dX (with at least 4 decimal digits)
6	dEps or dY	[mas]		dEps or dY (with at least 4 decimal digits)
7	sig_xP	[as]	Uncertainty of Earth orientation and nutation	uncertainty in x pole (with at least 7 decimal digits)
8	sig_yP	[as]		uncertainty in y pole (with at least 7 decimal digits)
9	sig_UT	[s]		uncertainty in UT1-UTC or UT1-TAI (with at least 8 decimal digits)
10	sig_dPsi or sig_dX	[mas]		uncertainty in dPsi or dX (with at least 4 decimal digits)
11	sig_dEps or sig_dY	[mas]		uncertainty in dEps or dY (with at least 4 decimal digits)
12	wRMS	[ps]	wrms residual delay of the session in ps (with at least 1 decimal digit)	
13	cor_xPyP	[-]	Correlations	correlation coefficient: x, y
14	cor_xPUT	[-]		correlation coefficient: x, dUT1
15	cor_yPUT	[-]		correlation coefficient: y, dUT1

16	cor_dPdE or cor_dXdY	[-]		correlation coefficient: dPsi,dEps or dX/dY
17	nObs	[-]		number of observables used for deriving reported EOP or '0' for a global solution
18	sessID	[-]	Indicators	6-character session code according to the 2 <sup>nd</sup> column of IVS master schedules Use the key 'COMBINED' for combined sessions or techniques. Use the key 'GLOBAL' for a global solution. Note: The current 6-character session code might, in the future, change to at least 32 characters.
19	span	[h]		span of the observation used for deriving reported EOP or '0' for a global solution
20	xPolR	[as/day]		x rate of the pole (with at least 8 decimal digits)
21	yPolR	[as/day]		y rate of the pole (with at least 8 decimal digits)
22	LOD	[s]	Rates of Earth orientation and nututation	excess length of day (LOD) (seconds), see comment below (with at least 9 decimal digits)
23	dPsiR or dXR	[mas/day]		dPsi or dX rate (with at least 5 decimal digits)
24	dEpsR or dYR	[mas/day]		dEps rate (with at least 5 decimal digits)
25	sig_xPR	[as/day]		uncertainty in x rate (with at least 8 decimal digits)
26	sig_yPR	[as/day]		uncertainty in y rate (with at least 8 decimal digits)
27	sig_LOD	[s]	Uncertainty of rates of Earth orientation and nututation	uncertainty in LOD (with at least 9 decimal digits)
28	sig_dPR or sig_dXR	[mas/day]		uncertainty in dPsi or dX rate (with at least 5 decimal digits)
29	sig_dER or sig_dYR	[mas/day]		uncertainty in dEps or dY rate (with at least 5 decimal digits)
30	network	[-]		Configuration of network employed for these results: sequence of two-character IVS station identifiers as maintained in IVS master control file ns-codes.txt (no blanks between stations) e.g. Ts-Wz-Wf-Tc-Gc-Ft-45-Oh, Ts-Wz-Ny or Ny-Ts Use the key 'COMBINED' for combined sessions or techniques. Use the key 'GLOBAL' for a global solution.
31	comments	[-]		Comment field, could be used for any additional information, e.g., session specific constraints, details on combined sessions.  Entry has to start with a leading "!".

## 2.5 Footer line (Mandatory)

The footer line is mandatory and must be the last line in an IVS-EOP file.

```
%IVS-EOP 3.0 END
```

## 2.6 File name convention

The IVS-EOP file name follows the file name convention as given at:

<https://ivsc.gsfc.nasa.gov/products-data/submit-product.html>

There are three file types with different extensions: .eopi and .eops and .eoxy.

Table 5: IVS-EOP file types

File type	Naming convention	Comment
EOP-I results	aaaccccc.eopi	Intensive EOP series (without nutation offsets)
EOP-S results (IAU1980)	aaaccccc.eops	Session EOP series with nutation offsets referring to the IAU1980 model
EOP-S results (IAU2000)	aaaccccc.eoxy	Session EOP series with nutation offsets referring to the IAU2000 model

The following keys are used:

- aaa Analysis Center 3-letter code
- ccccc solution 5-character code

## 2.7 Example file

Below is an example file shown. All lines in black are content of this proposal. It still allows the current usage of comment lines (in gray).

```
%=IVS-EOP 3.0 IVS 2021-04-20T10:23:00 BKG 1984-03-08T17:30:00 2020-08-24T18:30:00 TAI R
+HEADER
# This block contains mandatory and optional keywords.
GENERATION_TIME      2021-04-20T10:23:00
DATA_START           1984-03-08T17:30:00
DATA_END             2020-08-24T18:30:00
DESCRIPTION           IVS quarterly combined solution
ANALYSIS_CENTER      IVS
CONTACT              IVS Combination Center @BKG (ccivs@bkg.bund.de)
SOFTWARE              DOGS-CS V5.1 (DGFI/TUM)
# Within the header block we can add comment lines.
TECHNIQUE             V24
NUTATION_TYPE         EQUINOX-BASED
ROTATION_TYPE         UT1-UTC_LOD
TRF_APRIORI           VTRF2014
CRF_APRIORI           ICRF3
EOP_SUB-DAILY_MODEL   DESAI-SIBOIS
EOP_APRIORI           BULLETIN_A
EOP_ESTIMATED         XPOL          0.045 as
EOP_ESTIMATED         YPOL          0.045 as
EOP_ESTIMATED         DUT1          0.003 s
EOP_ESTIMATED         DPSI          NONE mas
EOP_ESTIMATED         DEPS          NONE mas
EOP_ESTIMATED         XPOL_DER_1    0.045 as/day
EOP_ESTIMATED         YPOL_DER_1    0.045 as/day
EOP_ESTIMATED         LOD           0.003 s
EOP_ESTIMATED         DPSI_DER_1    NONE mas/day
EOP_ESTIMATED         DEPS_DER_1    NONE mas/day
NUMBER_OF_ENTRIES     4266
```



```

-HEADER
# Now we defined the data block.
+DATA
# Within the data block we can have comment lines too.
# All fields are in free format separated by blanks.
# If a parameter was not estimated a filler NA is placed.
#   epoch           xPol           yPol           dUT1           dPsi           ..
#   [MJD]           [as]           [as]           [s]           [mas]           ..
45724.242580      -0.194144373      0.162741232      0.355335524      -0.121292632
45734.253540      -0.217079383      0.195741160      0.343469137      0.747975689
45749.259380      -0.235108852      0.239193653      0.318375799      -1.120167692
:
-Data
%IVS-EOP 3.0 END

```

### 3 Next steps

Based on the IVS AWG feedback we will provide a new IVS-EOP format description V3.0 in a txt file format. This will contain also a reference to the current format. All format versions should be made available on the IVS analysis center coordinator webpage: [https://ivscc.gsfc.nasa.gov/IVS\\_AC/IVS-AC\\_data\\_information.htm](https://ivscc.gsfc.nasa.gov/IVS_AC/IVS-AC_data_information.htm). Also the main IVS AC page [https://ivscc.gsfc.nasa.gov/IVS\\_AC](https://ivscc.gsfc.nasa.gov/IVS_AC) needs proper linking from the IVS homepage <https://ivscc.gsfc.nasa.gov/>.

### 4 Timeline

- 2021/05/17: Distribution of proposal and beginning of comment period
- 2021/05/17 to 2021/06/15: Comment period
- 2021/07/07: Presented to the IVS governing board
- 2021/09/10: During IVS AWG meeting: decision on bigger format change, i.e. using explicit start and end lines for header and data block start and not using any comment line characters for lines not being comment lines
- 2021/10/27: Revision (3) of updated proposal
- 2021/10/28: Announcement of proposal idea to IERS DB (before DB meeting)
- 2021/11/18: Revision (4) of updated proposal
- 2021/11/30: Preparation of final IVS-EOP format description document based on revised proposal
- 2021/11/30: Revision (5) of updated proposal and format description document
- 2021/12/16: Revision (6) of updated proposal and format description document
- 2022/01/15: Distribution of format description to IVS ACs and IERS DB
- 2022/07/01: [Hard deadline for transition to new format](#)