0. Revision History

0.1. Major Update from V0.01 to V1.00:

- This major update includes generalizations, extensions, and a considerable number of added detailed definitions, descriptions, and examples.

- (A listing/summary will be added after the discussions at the IGS Workshop 2016 in Sydney.)

1. Foreword and Acknowledgment

In 2011, a preliminary bias data format, called \textit{SINEX\_BIAS V0.01}, was proposed by Tim Springer (ESA/ESOC) for handling of GNSS bias estimates as part of the TGVF (Time and Geodetic Validation Facility) and the OVF (Orbit Validation Facility) of Galileo [Springer, 2011]. This format proposal was made on the basis of the \textit{SINEX\_TRO Format for combination of TROpospheric estimates Version 0.01} [Gendt, 1997].

The \textit{SINEX\_BIAS Format Version 1.00} is the result of a substantial update made on the basis of the \textit{SINEX\_BIAS V0.01}. It includes generalizations, extensions, and a
considerable number of added detailed definitions, descriptions, and examples. The SINEX\_BIAS format description document was completely rewritten. The original bias format concept—using the SINEX formalism—as formed by Tim Springer is acknowledged.

2. The Philosophy and General Features

2.1. Bias Data Format

In the face of a steadily growing variety of GNSS signals and observables, an adequate data format for GNSS bias products became indispensable.

The files should have a simple, but flexible structure, so that the IGS Analysis Centers (ACs) can straightforward reformat their internal bias estimates as well as users of IGS products can easily read and handle the bias products.

The proposed format is based on the SINEX Format [SINEX 2.02]. A number of format blocks may be taken directly from [SINEX 2.02], in particular:

- **FILE/REFERENCE**
- **SITE/ID**
- **SITE/RECEIVER**

Some other format blocks are defined within this document:

- **BIAS/DESCRIPTION** (Mandatory)
- **BIAS/RECEIVER_GROUPS** (Optional)
- **BIAS/SOLUTION** (Mandatory)

The IGS ACs should submit daily files containing the estimated GNSS biases from all global sites and satellites. Only information directly connected to the bias estimates should be given.

2.2. Main Features of SINEX\_BIAS

The **BIAS/SOLUTION** format structure of SINEX\_BIAS V1.00 does allow the following main features:

- biases are specified for a given time interval of validity, defined by start and end time;
- biases may be augmented by their slope parameters;
- support of biases responding to: (i) system, (ii) satellite, (iii) receiver, (iv) satellite-receiver, and even (v) biases attributed to (user-defined) receiver groups;
- differential (relative) or observable-specific (pseudo-absolute) bias parameters;

IGS Workshop on GNSS Biases, Bern, Switzerland, 5–6 November 2015 (DRAFT Feb. 7)
• consideration of bias parameters with respect to code and phase observations;
• the possibility to define GNSS observable groups (to be treated with one common bias parameter).

The above listing of features shows a distinct flexibility for handling of any kind of GNSS bias values. It should be obvious that SINEX_BIAS should be well suited for further applications, such as PPP ambiguity resolution (PPP-AR), etc.

3. SINEX_BIAS File Naming

In the following, we provide a file naming convention for both short and long filenames. Filenames may be in uppercase or in lowercase. The filename extension should be: .BIA or .bia (conforming to the SINEX keyword “BIA” internally used).

3.1. Short Filenames

The files are named:  

```
CCCWWWWD.BIA or CCCYYDDD.BIA
```

where

- **CCC**: 3-figure Analysis Center (AC) designator
- **WWW**: GPS week
- **D**: Day of week (0-6) or 7 for a weekly file
- **YY**: 2-digit year
- **DDD**: Day of year

Examples: COD18646.BIA [.gz] or cod15276.bia [.gz]

3.2. Long Filenames

Based on a proposal for a new product naming convention worked out by colleagues from GFZ in analogy with the new RINEX naming scheme, we would propose to name the daily bias files in the following manner:

The full filename specification is given with:

```
```

- **01-03 AAA**: 3-char AC name (e.g.: DLR for “Deutsches Zentrum für Luft- und Raumfahrt”)
- **04-V**: 1-char version/solution identifier (here: nominally 0)
- **06-07 PPP**: 3-char campaign/project specification (e.g.: MGI)
- **08-10 TTT**: 3-char product type specification (e.g.: FIN for “final”)
- **11**: 1-char separator (underscore)
- **12-15 YYYY**: 4-digit year of start epoch
- **16-18 DDD**: 3-digit day-of-year of start epoch
- **19-20 HH**: 2-digit hour of start epoch (here: 00)
Example: DLR0MGXFIN_20150010000_01L_01D_DSB.BIA.gz

4. SINEX_BIAS Version 1.00—Detail Format Description

4.1. Header and Footer Lines (Mandatory)

Description:
The Header line must be the first line in a SINEX_BIAS file.
The Footer line must be the last line in a SINEX_BIAS file.

Contents:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>File Identifier</td>
<td>%=BIA</td>
<td>A5</td>
</tr>
<tr>
<td>Format Version</td>
<td>Four digits indicating the version of SINEX_BIAS format used.</td>
<td>1X,F4.2</td>
</tr>
<tr>
<td>File Agency Code</td>
<td>Identify the agency creating the file.</td>
<td>1X,A3</td>
</tr>
<tr>
<td>Time</td>
<td>Creation time of this SINEX_BIAS file (preferably in UTC).</td>
<td>1X,I2.2, ':', I3.3, ':', I5.5</td>
</tr>
<tr>
<td>Agency Code</td>
<td>Identify the agency providing the data in the SINEX_BIAS file.</td>
<td>1X,A3</td>
</tr>
<tr>
<td>Time</td>
<td>Start time of solution in the this SINEX_BIAS file (see also 'TIME SYSTEM' descriptor).</td>
<td>1X,I2.2, ':', I3.3, ': ', I5.5</td>
</tr>
<tr>
<td>Time</td>
<td>End time of the solution in the this SINEX_BIAS file (see also 'TIME SYSTEM' descriptor).</td>
<td>1X,I2.2, ':', I3.3, ': ', I5.5</td>
</tr>
<tr>
<td>Observation Code</td>
<td>Technique(s) used to generate the SINEX_BIAS solution. 'P' (GNSS) in case of SINEX_BIAS.</td>
<td>1X,A1</td>
</tr>
</tbody>
</table>
4.2. BIAS/DESCRIPTION Block (Mandatory)

Description:
This block gives important parameters from the analysis and defines the fields in the block 'BIAS/SOLUTION'.

Contents:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Type</td>
<td>Describes the type of information present in the next field. May take on the following values:</td>
<td>IX,A39</td>
</tr>
</tbody>
</table>
'OBSERVATION SAMPLING'
- Observation sampling interval [sec] used for data analysis.
  Optional information.

'PARAMETER SPACING'
- Parameter spacing interval [sec] used for parameter representation.
  Optional information.

'DETERMINATION METHOD'
- Determination method used to generate the bias results.
  Recommended entries are:
  o 'DIRECT ESTIMATION' (analysis of observable differences only)
  o 'CLOCK ANALYSIS' (analyzing the ionosphere-free linear combination of the basic observables)
  o 'IONOSPHERE ANALYSIS' (analyzing the geometry-free/ ionospheric linear combination)
  o 'COMBINED ANALYSIS' (results from both clock and ionosphere analysis)
  o 'PPP BIAS ANALYSIS' (determination of biases suited for PPP-AR)
  o 'CALIBRATION' (hardware calibration)
  o 'COMBINATION' (results from a combination of various bias products)
  Mandatory information.

'BIAS MODE'
- The bias mode describes how the included bias values have to be interpreted and applied, respectively.
  Possible modes are:
  o 'DIFFERENTIAL'
  o 'OBSERVABLE-SPECIFIC'
  Obviously, this implies that inclusion of either differential (relative) or observable-specific (pseudo-absolute) bias values is allowed in a SINEX_BIAS file.
  Mandatory information.

'TIME SYSTEM'
- The time tags specified in the BIAS/SOLUTION block have to be given in a common TIME SYSTEM.
  Possible time systems are:
  o RINEX GNSS system flag (e.g. 'G').
  o 'UTC' - Coordinated Universal Time.
  o 'TAI' - International Atomic Time.
  NOTE: The declared 'TIME SYSTEM' should be consistent with the 'TIME SYSTEM ID' declared in an associated Clock-RINEX.
  Compulsory information.

'REFERENCE SYSTEM'
- Reference GNSS used for clock estimation. System code according to RINEX3 standards. E.g.: 'G'
Mandatory in case of clock analysis, else optional.

'OBSERVABLE GROUP'
- GNSS flag, 1X,A1
- number of given observable codes, 2X,I4
- list of observable codes. 6(1X,A4)

NOTE: The first code is used as observable group code (to be used for the assignment of the included bias results).
This implies that by adding a non-existing RINEX3 code an extra observable group code could be defined.
HINT: A leading ‘G’ shall be used to indicate an extra observable group code (e.g.: 'GC1').

Optional information (to be repeated for each desired GNSS observable line).

'REFERENCE OBSERVABLES'
- Each involved GNSS, 1X,A1
- reference code observable, or group of the first frequency, 2X,A4
- reference code observable, or group of the second frequency. 1X,A4

NOTE: Observable codes have to be declared following RINEX3 standards (if it is not a group code).
Already supported GNSS are:
G - GPS
R - GLONASS
E - Galileo
J - QZSS
C - BeiDou
I - IRNSS
S - SBAS payload

NOTE: In particular cases (e.g. the case with GLONASS ISB biases specific to satellite-receiver), the two observable code fields may be ' ', as the selection of observables may be considered for a user of a corresponding GLONASS clock product.

Mandatory data record (to be repeated for multiple GNSS).

'ZERO-MEAN CONDITIONS'
- Each involved GNSS, 1X,A1
- number of effective zero-mean conditions: 2X,I4
  - total number. This number has to be the sum of such conditions with respect to:
    - system (all biases), 6(1X,I4)
    - satellite biases,
    - receiver biases,
    - satellite-receiver biases,
    - frequency channel number dependence (e.g. GLONASS),
    - other.

Optional data record (to be repeated for multiple GNSS).

Any of the above fields may be and in any order.
4.3. BIAS/RECEIVER_GROUPS Block (Optional)

Description:
The satellite bias characteristics may be considerably different among receivers. Therefore, it might make sense to group (for the computation of the satellite biases) the receivers of all involved stations according to a particular assignment scheme. The BIAS/RECEIVER_GROUPS block may be used to provide a corresponding station list, giving the assignment of each involved station (and each constellation) to the appropriate receiver group.

Contents:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station Name</td>
<td>Station codes are encoded using a 9-character field.</td>
<td>1X,A9</td>
</tr>
<tr>
<td>Identifier</td>
<td>NOTE: For backward compatibility, left-aligned 4-character station codes are also permitted. A blank field would be allowed for a general assignment (just on the basis of receiver type and firmware version).</td>
<td></td>
</tr>
<tr>
<td>Constellation</td>
<td>Constellation code:</td>
<td>1X,A1</td>
</tr>
<tr>
<td></td>
<td>G - GPS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R - GLONASS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E - Galileo</td>
<td></td>
</tr>
<tr>
<td></td>
<td>J - QZSS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C - BeiDou</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I - IRNSS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>S - SBAS payload</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A blank field would indicate no constellation dependence.</td>
<td></td>
</tr>
<tr>
<td>Receiver Group</td>
<td>Left-aligned receiver group name with a leading '@' (specific to the given constellation). Mandatory field.</td>
<td>1X,A9</td>
</tr>
<tr>
<td>Identifier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Start time for the assignment of a station to a receiver group.</td>
<td>1X,I2.2, ':',I3.3, ':',I5.5</td>
</tr>
<tr>
<td>Time</td>
<td>End time for the assignment.</td>
<td>1X,I2.2, ':',I3.3, ':',I5.5</td>
</tr>
<tr>
<td>Receiver Type</td>
<td>Receiver type (c.f. the naming conventions for IGS equipment descriptions, rcvr_ant.tab) Mandatory field.</td>
<td>1X,A20</td>
</tr>
<tr>
<td>Receiver Firmware</td>
<td>Receiver firmware version (preferably left-aligned). A blank field might be possible.</td>
<td>1X,A20</td>
</tr>
</tbody>
</table>

Example:

```
8
```
4.4. BIAS/SOLUTION Block (Mandatory)

Description:
This block contains the bias estimates for all time intervals, or epochs.

Contents:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIAS</td>
<td>Bias type identifier.</td>
<td>IX,A4</td>
</tr>
<tr>
<td>Available types are:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>'OSB': Observablespecific</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signal Bias (OSB):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>'DSB': Differential Signal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bias (DSB):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>'ISB': Ionosphere-free (linear combination) Signal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bias (ISB):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mandatory field.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| SVN            | Satellite SVN code "CNNN": | IX,A4  |

An adequate LEGEND has to be included using COMMENT lines. The above example gives an idea how such a LEGEND sequence could be arranged (preferably in a quasi-standardized, human readable format).
"C" - satellite system flag (according to RINEX3); "NNN" - SVN number (or GLONASS number).

Satellite system flag "C" is mandatory in any case.

---

<table>
<thead>
<tr>
<th>PRN</th>
<th>Satellite PRN code &quot;CNN&quot;:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;C&quot; - satellite system flag (according to RINEX3); &quot;NN&quot; - PRN number (or slot number for GLONASS). Satellite system flag &quot;C&quot; is mandatory in any case.</td>
</tr>
</tbody>
</table>

---

| Station Name Identifier | Station codes are encoded using a 9-character field (or a receiver group name). NOTE: For backward compatibility, left-aligned 4-character station codes are also permitted. |

---

| OBS1 and OBS2 Observable Codes | Observables used for estimating the biases. The observable codes have to be given according to RINEX3 format definitions. If 'BIAS MODE' is declared with 'OBSERVABLE-SPECIFIC', only OBS1 is given (and OBS2 field remains blank). IMPORTANT NOTE: Please be aware that distinction between code (or pseudorange) and phase biases is done on the basis of the given GNSS observable codes! |

---

| Time | Start time for the bias estimate. NOTE: The time tags specified here have to be given in a common time system (see also 'TIME SYSTEM' descriptor). |

---

| Time | End time for the bias estimate. |

---

| Unit | Bias estimates are given in the specified unit. Unit has to be 'ns' (nanoseconds). |

---

| Bias Parameter Estimate | Estimated (offset) value of the bias parameter. |

---

| Bias Parameter Standard Deviation | Estimated standard deviation for the bias parameter. NOTE: Bias values taken over from an external source should be indicated with a zero value. |

---

| Slope Estimate | Estimated value of the slope parameter (in ns/n). |
4.4.1. YY:DDD:SSSSS Time Tags

Please note that time tags are commonly given in a YY:DDD:SSSSS formatted representation (see also Appendix B, specifically Sections B.2, B.3.2).

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>YY:DDD:SSSSS. “UTC”</td>
<td>12.2</td>
</tr>
<tr>
<td></td>
<td>YY = last 2 digits of the year,</td>
<td>':' ,</td>
</tr>
<tr>
<td></td>
<td>if YY &lt;= 50 implies 21-st century,</td>
<td>'13.3.'</td>
</tr>
<tr>
<td></td>
<td>if YY &gt; 50 implies 20-th century,</td>
<td>':' ,</td>
</tr>
<tr>
<td></td>
<td>DDD = 3-digit day in year,</td>
<td>'15.5'</td>
</tr>
<tr>
<td></td>
<td>SSSSS = 5-digit seconds in day.</td>
<td></td>
</tr>
</tbody>
</table>

Remark: ‘:’ corresponds to 1H: (as originally used in the SINEX detail format descriptions).

4.4.2. COMMENT Lines and Floating Number Exponent

COMMENT lines starts with “*” in Col. 1 and can be anywhere within or outside a block, though for the clarity sake, beginning and ends of blocks are preferable.

For increased portability, the floating number exponent of “E” should be used rather than “D” or “d” which is not recognized by some compiler/installations.

See also: Appendix B, specifically Sections B.2, B.3.2, B.3.4.

5. General Notes on Bias Handling

5.1. Bias Parameter Representation in the Time Domain

- Biases are specified for a given time interval of validity, defined by start and end time.
- Biases may be augmented by their slope parameters.
- If a slope parameter is specified, the bias is referring to the middle of the given time interval.
• In case of open interval, when end time is indicated as undefined, the bias refers to the start time of the interval.

• In case of open interval, when start time is indicated as undefined, the bias refers to the end time of the interval.

• The unit of the slope has to be ns per s (ns/s).

Figure 1 shows the situation with offsets only (top) and with offsets and slopes (bottom). The bottom subfigure of Figure 1 indicates that, in principle, Bias-SINEX V1.00 would allow to provide bias parameter information without discontinuities (at the time interval boundaries).

Furthermore, it should be obvious that, in the extreme case, provision of epoch bias parameters is possible (by shortening the time intervals accordingly). For an epoch-specific bias product, OBSERVATION SAMPLING and PARAMETER SPACING are assumed to be equal.

5.2. Notes on SVN/PRN and STATION Usage in BIAS/SOLUTION Block

The fields SVN/PRN and STATION may used for coding of biases with four different characteristics:

• **Satellite bias:** If a bias depends only on a satellite, SVN/PRN should be filled, STATION may be left empty.

• **Station bias:** If a bias depends only on a station and a particular GNSS, STATION should be filled and SVN/PRN should have the system code only (e.g. “G”, “R”, “E” for GPS, GLONASS, Galileo).
- **Satellite-station (satellite-receiver) bias**: If a bias depends on both satellite and station, all three fields, SVN/PRN/STATION, should be used.
- **System bias**: If a bias depends only on a particular GNSS, SVN/PRN should have the system code only (e.g. “G”, “R”, “E” for GPS, GLONASS, Galileo).

Examples for the four cases (listed above) may look like:

```
+BIAS/SOLUTION
+BIAS SVN_ PRN STATION__ OBS1 OBS2 BIAS_START__ BIAS_END____ UNIT __ESTIMATED_VALUE____ _STD_DEV___ __ESTIMATED_SL
  DSB G063 G01 C1W C1C 15:276:00000 15:276:86399 ns 0.1480229 37908458E +01 .398201 E -01
  ISB C C ABMF C1I C7I 15:276:00000 15:276:86399 ns 0.24090946 1328850E +02 .835246 E+00
  ISB R730 R01 AUCK C1P C2P 15:276:00000 15:276:86399 ns 0.104 868834341878E +02 .101419 E+01
  ISB G G C1W C2W 15:276:00000 15:276:86399 ns 0.000000000000 000E +00 .000000 E+00
-BIAS/SOLUTION
```

### 5.3. Definition of GNSS Observable Groups

The possibility to define specific **GNSS observable groups** is an additional feature of Bias-SINEX V1.00. RINEX3 observables that showed similar (satellite) bias characteristics may be assigned to a common observable group by defining a corresponding OBSERVABLE GROUP data record in the BIAS/DESCRIPTION block.

**Note and Hint**

The first code is used as observable group code (to be used for the assignment of the included bias results). This implies that by adding a non-existing RINEX3 code an extra observable group code could be defined. A leading “” shall be used to indicate an extra observable group code (e.g.: “C1W”).

### 5.4. Definition of GNSS Receiver Groups

The need for a possibility to define **receiver groups** (or families) came up during the discussions at the IGS Bias Workshop 2015. In order to handle satellite bias information specific to individual receiver (or station) groups, a dedicated (optional) SINEX block, BIAS/RECEIVER GROUPS, was added to Bias-SINEX V1.00.

**Question**: Should it be allowed to leave the STATION field in the BIAS/RECEIVER GROUPS block empty in order to provide any (initial) bias information specific to a list of receiver types (and firmware versions) (e.g. GLONASS DCPB information)?

If receivers are distinguished not for all constellations, then one could introduce either (a) an accumulative group name (e.g. “All”) or (b) no group for such constellations. For better readability, variant (a) should be preferred.
Even though the SINEX_BIAS Format would allow to describe a *residual* satellite bias parameter, \( \delta B_{\text{satellite(receiver-group)}} \), following

\[
B_{\text{total}} = B_{\text{satellite}} + \delta B_{\text{satellite(receiver-group)}} + B_{\text{receiver}},
\]

the above given bias parameter representation should be avoided (as the separation of all components may become rather complicated). Based on receiver-group-specific satellite bias parameters, \( B_{\text{satellite(receiver-group)}} \), the total bias, \( B_{\text{total}} \), should be represented as follows:

\[
B_{\text{total}} = B_{\text{satellite(receiver-group)}} + B_{\text{receiver}}.
\]

5.5. Order of BIAS/SOLUTION Data Records

BIAS/SOLUTION data records may be listed in any arbitrary order. However, we recommend to list the included bias parameters starting with those responding to (i) system, (ii) satellite, (iii) receiver, (iv) satellite-receiver, (v) other. Furthermore, to keep the bias parameters in chronological (and alphabetical) order may be helpful.

6. Basic Definitions and Rules Concerning GNSS Biases

6.1. Sign Convention

The following sign convention is used for bias values:

\[
\text{bias} = \text{observation} - \text{true (or unbiased) observation} \quad (3a)
\]

\[
\text{observation} = \text{true observation} + \text{bias} \quad (3b)
\]

\[
\text{true observation} = \text{observation} - \text{bias} \quad (3c)
\]

Numerical example: ground truth 11, observed 7, bias (or error) −4.

6.2. Bias Arithmetics

In the following, \( B \) is used to address a bias value (or parameter). \( O \) denotes an observation value.

6.2.1. Basic Bias Equation

Using this notation, we may write:

\[
\hat{O}_{\text{true}} = O_{\text{observed}} - B.
\]
6.2.2. Satellite and Receiver Bias Components (and Total Bias)

The total bias (or overall bias), if a separation into a satellite component, $B_{\text{satellite}}$, and into a receiver component, $B_{\text{receiver}}$, is assumed, is defined as follows:

$$B_{\text{total}} = B_{\text{satellite}} + B_{\text{receiver}}$$  \hspace{1cm} (5)

6.2.3. GNSS Signal Bias

We use the following notation to address a GNSS signal bias:

$$B_{(\text{constellation},\text{observable})}.$$  \hspace{1cm} (6)

For example, $B_{(G,C1W)}$ would correspond to a bias for the GPS (G) code (C) first-frequency (1) W-tracking (W) observable.

6.3. Three Types of Signal Biases

We distinguish between three types of signal biases:

- **Observable-specific Signal Bias**, labeled with OSB, or $B_{O(\text{constellation},\text{observable})}$;
- **Differential Signal Bias**, labeled with DSB, or $B_{D(\text{constellation},\text{observable1},\text{observable2})}$;
- **Ionosphere-free linear combination Signal Bias**, or simply **Ionosphere-free Signal Bias**, labeled with ISB, or $B_{I(\text{constellation},\text{observable1},\text{observable2})}$.

The terminology introduced here is based on the outcome of a dedicated e-mail discussion carried out after the Bias Workshop 2015. The (previously used) term “Code,” was replaced by “Signal,” as the SINEX BIAS Format now also support biases with respect to GNSS phase observations.

Terms, such as, DCB, DPB, DCPB (introduced at the Bias Workshop 2012), OCB, OPB are (officially) not used in this format document, but they still may be used in an informal context. However, IFB (Inter-Frequency Bias) and ISB (Inter-System Bias) should, as far as possible, no longer be used. Note that ISB now stands for Ionosphere-free (linear combination) Signal Bias. IFB was open misused for (interfrequency) DCB, but, in fact, it had to be interpreted as “GLONASS-dedicated ISB”.

6.3.1. Differential Signal Bias (DSB)

A Differential Signal Bias corresponds to the difference of two Signal Biases (that are commonly inaccessible in the absolute sense). An example for a DSB is:

$$B_{D(G,C1W,C1C)} = B_{(G,C1W)} - B_{(G,C1C)}$$  \hspace{1cm} (7)
Using Equation (7), we may show that direct estimation of $B_{D(G,C1W,C1C)}$ is possible by analyzing the difference of $O_{(G,C1W)}$ and $O_{(G,C1C)}$ observation data:

$$B_{D(G,C1W,C1C)} = (O_{(G,C1W)} - \hat{O}_{(G,C1)}) - (O_{(G,C1C)} - \hat{O}_{(G,C1)}) = O_{(G,C1W)} - O_{(G,C1C)}$$

(8)

where $\hat{O}_{(G,C1)}$ is used to denote the true (or unbiased) observations.

Such a DSB correction may be applied in the following way:

$$O_{(G,C1W)} = O_{(G,C1C)} + B_{D(G,C1W,C1C)}$$

(9)

Differential Signal Biases between different signal frequencies are, of course, also foreseen, e.g.:

$$B_{D(G,C1W,C2W)} = B_{(G,C1W)} - B_{(G,C2W)}.$$  

(10)

There is a common rule that inter-frequency DSBs are declared for the selected reference observables.

6.3.2. Ionosphere-free Signal Bias (ISB)

The Ionosphere-free Signal Bias (ISB) has to be interpreted as

$$B_{I(G,C1W,C2W)} = \kappa_1 B_{O(G,C1W)} + \kappa_2 B_{O(G,C2W)},$$

(11)

where $\kappa_1$ and $\kappa_2$ are the two factors used for the computation of the ionosphere-free linear combination. To be more specific, $\kappa_1 = \nu_1^2 / (\nu_1^2 - \nu_2^2) = 2.546$, $\kappa_2 = -\nu_2^2 / (\nu_1^2 - \nu_2^2) = -1.546$ (for GPS); $\nu_i$ is the frequency of the $i$-th carrier. GPS C1W and C2W observables are assumed in this example.

6.3.3. Observable-specific Signal Bias (OSB)

Using Equations (11) and (10) we may write the following equation system:

$$B_{I(G,C1W,C2W)} = \kappa_1 B_{O(G,C1W)} + \kappa_2 B_{O(G,C2W)}$$

(12a)

$$B_{D(G,C1W,C2W)} = B_{O(G,C1W)} - B_{O(G,C2W)}$$

(12b)

The first equation describes the relationship of the Observable-specific Signal Biases (OSBs), $B_{O(G,C1W)}$ and $B_{O(G,C2W)}$, for the ionosphere-free case (clock analysis), the second equation in accordance with the geometry-free case (ionosphere analysis). The equation system describes the parameter transformation from OSB to ISB/DSB bias representation.
The inverse parameter transformation, from differential (relative) ISB/DSB to observable-specific (pseudo-absolute) OSB, may be derived by inversion of the matrix specified above:

\[
B_{O}(G,C_{1}\text{W}) = B_{I}(G,C_{1}\text{W},C_{2}\text{W}) + \kappa_2 B_{D}(G,C_{1}\text{W},C_{2}\text{W}) \tag{13a}
\]

\[
B_{O}(G,C_{2}\text{W}) = B_{I}(G,C_{1}\text{W},C_{2}\text{W}) - \kappa_1 B_{D}(G,C_{1}\text{W},C_{2}\text{W}). \tag{13b}
\]

Let us give a numerical example. The following OSB values, \(B_{O}(G,C_{1}\text{W}) = +10.73\) ns and \(B_{O}(G,C_{2}\text{W}) = +15.73\) ns, are conform to the following ISB/DSB values, \(B_{I}(G,C_{1}\text{W},C_{2}\text{W}) = +3\) ns and \(B_{D}(G,C_{1}\text{W},C_{2}\text{W}) = -5\) ns.

For a user, consideration of an OSB bias correction would be very convenient, as just the observable type has to be known, e.g.:

\[
O_{(G,C_{1}\text{(ref)})} = O'_{(G,C_{1})} = O_{(G,C_{1}\text{C})} - B_{O}(G,C_{1}\text{C}), \tag{14}
\]

where, assuming GPS C1W/C2W reference observables, \(O'_{(G,C_{1})} = O_{(G,C_{1}\text{W})} - B_{O}(G,C_{1}\text{W})\).

A reader of this document should be aware of the fact that GNSS Signal Biases are commonly inaccessible in the absolute sense. This implies that, taking the example with \(B_{O}(G,C_{1}\text{C})\): \(B_{O}(G,C_{1}\text{C}) \neq B_{(G,C_{1}\text{C})}\), meaning that that any OSB, \(B_{O}\), may be expected to be shifted by an arbitrary offset, \(\Delta B\), with respect to the (commonly unavailable and thus unknown) true bias, \(B\):

\[
B = B_{O} + \Delta B. \tag{15}
\]

Therefore, Observable-specific Signal Biases \(B_{O}\) have to be interpreted as pseudo-absolute bias information.

The same is obviously also valid for: \(O' \neq \tilde{O}\). To be more specific, OSB-corrected observations are not conforming with true observations, meaning that, for the above chosen example, \(O'_{(G,C_{1})} \neq \tilde{O}_{(G,C_{1})}\).

**Important Notes:**

For pseudo-absolute bias values, the selection of the reference observables is absolutely essential.

- **Pro:** A user may just consider bias correction values specific to the given observable types.
- **Con:** OSB-corrected observations are consistent to the original definition of the reference observables—and, consequently, consistent to a GNSS clock product relying on the same definition.
6.4. GPS Group Delay

It is worth mentioning that Equation (13a) actually corresponds to the relationship between the interfrequency “group delays,” \( \tau_{GD} \), broadcast by the GPS system and the interfrequency satellite DSB, \( B_{(G,C1W,C2W)} \):

\[
\tau_{GD} = \kappa_2 B_{(G,C1W,C2W)} + \tau_0.
\] (16)

There may be an arbitrary offset, indicated by \( \tau_0 \). Consequently, the size of \( \tau_{GD} \) corresponds to the single-frequency pseudorange correction according to Equation (13a) (strictly speaking only for \( O_{(G,C1W)} \), not for \( O_{(G,C1C)} \) observations, assuming GPS satellite clock information being consistent to \( B_{1(G,C1W,C2W)} = 0 \).

6.5. Datum Definition for ISB Bias Parameters in Multi-GNSS Clock Analysis

ISB bias parameters of more than one GNSS considered are directly connected with respect to each other. A clear definition of the ISB bias datum is therefore needed. As a consequence of this, we suggest that those receiver ISB bias parameters which are assumed to be zero must be explicitly included and listed in a SINEX_BIAS file (see, e.g., Example #7). Note that this should concern all ISB bias parameters with respect to the given “REFERENCE SYSTEM” and stations/receivers with the given “REFERENCE OBSERVABLES” (of that reference system). Last but not least, we may argue that the inclusion of “zero-valued”, or “reference” receiver ISB bias parameters is not only a cosmetic issue. To have corresponding “reference” observable codes available (for the respective observation pair used) and to see whether a respective observation pair was actually used, respectively, are strong reasons that legitimize this requirement (of inclusion).

There seems to be no necessity for an inclusion of corresponding “reference” satellite ISB bias parameters. Nevertheless, the provision of corresponding satellite ISB information in SINEX_BIAS is self-evident and, therefore, actually may be strongly recommended—as the datum definition as imposed on the bias solution then becomes crystal-clear to a user of such a bias product.

6.6. GPS Observables From Cross-Correlation Receivers in RINEX2 and CC2NONCC

Cross-correlation receivers (or simply CC-receivers) provide under Antispoofing (AS) a particular code (or pseudorange) observable for the second frequency. Using the RINEX2 notation, the recorded observable, here called \( P2' \), may be written as:

\[
P2' = C1 + (P2 - P1)
\] (17)
However, such observables are labeled in RINEX2 observation files with P2 (in RINEX3 unambiguously with C2D). It is therefore necessary to apply corresponding DSB corrections to C1 and P2' (in order to make them consistent to P1 and P2):

\[ P1 = C1 + B_{P1-C1} \]  
\[ P2 = P2' + B_{P1-C1} \]

where \( B_{P1-C1} \) denotes the satellite P1-C1 DSB information (as provided, e.g., by CODE [Schaer, 2001]).

CC2NONCC, originally developed by Jim Ray, was a RINEX2 observation conversion utility for exactly this (P1–C1) bias correction. This utility program should no longer be used. P1–C1 bias information should be considered directly by the analysis software.

It should be emphasized that IGS ACs processing RINEX2 observation files (e.g., as part of a reprocessing effort) are actually forced to consider the list of concerned CC-receivers from a separate metadata file.

The list of known cross-correlation (CC) receivers (following the IGS naming convention as given in `rcvr_ant.tab`) includes:

```
ADA ICS-4000Z
ROGUE SNR-12
ROGUE SNR-12 AM
ROGUE SNR-8
ROGUE SNR-800
ROGUE SNR-8000
ROGUE SNR-8100
ROGUE SNR-8C
SPP GEOTRACER100
TOPCON GP-DX1
TOPCDR TT4000SSI
TRIMBLE 4000SSI
TRIMBLE 4000SST
```

When using a wildcard character “*”, the CC-receiver list may be reduced to:

```
ADA ICS-4000Z
ROGUE *
SPP GEOTRACER100
TOPCDR GP-DX1
TOPCDR TT4000SSI
TRIMBLE 4000SSI *
```

CC-receivers behave differently if Antispoofing (AS) is turned off. Instead of C1/P2', P1/P2 may be expected. For this reason, a list of AS-free periods might be useful (especially for reprocessings):

\[ \text{Check whether time argument in a AS-free period} \]
\[ \text{-----------------------------------------------} \]
\[ \text{IF ((ajd > 0.0000000000d0 .AND. mjd < 49383.000000d0) .OR. &} \]
\[ \text{(ajd > 49826.87499d0 .AND. mjd < 49847.83334d0) .OR. &} \]
\[ \text{(ajd > 49999.99999d0 .AND. mjd < 50002.00000d0) .OR. &} \]
\[ \text{(ajd > 50480.99999d0 .AND. mjd < 50503.00000d0)) THEN} \]
\[ \text{asmode = 0} \]
```

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7. How to Use a SINEX_BIAS File

(Here, a corresponding flowchart could be added, summarizing the most important steps when using the information from a SINEX_BIAS file.)

8. Additional Remarks

8.1. "X" Observable Issue

RINEX3 includes a clear definition of 3-character observable codes with respect to each supported GNSS system. However, one may have a suspicion that some receiver manufacturer misuse the third character of the corresponding RINEX3 observable code, i.e., they give an “X”, independent of the tracking mode that was effectively used.

It will be one of the tasks for the IGS Bias and Calibration Working Group (BCWG) to identify such cases of misuse.

Additional Notes:

At CODE/AIUB, there is a dedicated analysis method (referred to as “(P1–C1) DCB multiplier” method) available for reliable determination of the (GPS) receiver tracking class [Schaer, 2002]. Corresponding anomalies (in RINEX2 observation data) could be revealed by CODE/AIUB in the past (see, e.g., [Ray, 2002]).

It is obvious that such a method might also be used for verification of all available GNSS observable declarations (made in RINEX3 observation files). It is intended to further develop the current RINEX2-oriented approach to a generalized (“GNSS code bias multiplier”) approach for RINEX3 observation data.

How to handle known GNSS observables with unknown tracking mode? In the extreme case, one could think about treating affected observables in a receiver-group or even in a GLONASS-like mode, where pseudorange biases are treated satellite-receiver-group-specific and satellite-receiver-specific, respectively.

References

Gendt, G. (1997): SINEX_TRO—Solution (Software/technique) INdependent EXchange Format for combination of TROpospheric estimates Version 0.01, March 1, 1997: https://igscb.jpl.nasa.gov/igscb/data/format/sinex_tropo.txt


*RINEX: The Receiver Independent Exchange Format Version 3.03:*

*RINEX Extensions to Handle Clock Information Version 3.00/3.02:*
ftp://igscb.jpl.nasa.gov/igscb/data/format/rinex_clock300.txt
ftp://igscb.jpl.nasa.gov/igscb/data/format/rinex_clock302.txt

*SINEX—Solution (Software/technique) INdependent EXchange Format Version 2.02:*
http://www.iers.org/IERS/EN/Organization/AnalysisCoordinator/analysis.html


Appendix A  Examples for Submissions of Bias Estimates in Bias-SINEX V1.00

A.1 Example #0: Original Bias-SINEX V0.01 example updated to V1.00 standards

%= BIA 1.00 PF2 11:113:86385 PF2 11:114:86385 P 04774 2 SINEX_BIA
* FILE/REFERENCE
REFERENCE FRAME IGS08
DESCRIPTION European Space Operation Center (ESOC)
INPUT ESOC solutions in normal equation format
OUTPUT ESOC solutions in Bias-SINEX format
CONTACT Tim.Springer@esa.int
SOFTWARE Napeos 3.6 TAS 07/06/2011

* FILE/REFERENCE
 KEYWORD __________________________________ VALUE (S) _______________________________
OBSERVATION SAMPLING 300
PARAMETER SPACING 86400
DETERMINATION METHOD CLOCK ANALYSIS
BIAS MODE DIFFERENTIAL
TIME SYSTEM G
REFERENCE SYSTEM G
REFERENCE OBSERVABLES E C1C C7Q
REFERENCE OBSERVABLES G C1W C2W
ZERO-MEAN CONDITIONS G 0 0 0 0 0 0 0
ZERO-MEAN CONDITIONS E 1 0 0 1 0 0 0

*= ENDBIA

A.2 Example #1: GPS C1W–C1C DSB (or classic “P1–C1” DCB) product (extracted from CODE GPS clock analysis)
### A.3 Example #2: GPS/GLONASS C1W–C2W/C1P–C2P DSB product without consideration of GLONASS frequency channel dependence (extracted from CODE final ionosphere analysis)

```plaintext
<table>
<thead>
<tr>
<th>BIAS SOLUTION</th>
<th>SYM_PRN</th>
<th>OBS1 OBS2</th>
<th>BIAS_START</th>
<th>BIAS_END</th>
<th>UNIT</th>
<th>ESTIMATED_VALUE</th>
<th>STD_DEV</th>
<th>ESTIMATED_SLE</th>
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<td>C1C</td>
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<td>C1C</td>
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<td>C1C</td>
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---

% BIA 1.00 COD 15:276:86399 IGS 15:276:0000 15:276:86399 P 00032 2 SINEK_BIA

---

% FILE/REFERENCE

**INFO_TYPE** INFO

**DESCRIPTION** CODE, Astronomical Institute, University of Bern

**OUTPUT** CODE GPS clock analysis

**CONTACT** code@aiub.unibe.ch

**SOFTWARE** Bernese GNSS Software Version 5.3

**HARDWARE** UBELEX: Linux, x86_64

**INPUT** IGS GPS/GLONASS tracking data

---

% BIAS DESCRIPTION

**KEYWORD**

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<th>VALUE(S)</th>
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**OBSERVATION SAMPLING** 300

**PARAMETER SPACING** 86400

**DETERMINATION METHOD** CLOCK ANALYSIS

**BIAS MODE** DIFFERENTIAL

**TIME SYSTEM** G

**REFERENCE SYSTEM** G

**REFERENCE OBSERVABLES** G C1W C1P

**ZERO-MEAN CONDITIONS** G 0 0 1 0 0 0 0

---

% BIAS SOLUTION

---

A.3 Example #2: GPS/GLONASS C1W–C2W/C1P–C2P DSB product without consideration of GLONASS frequency channel dependence (extracted from CODE final ionosphere analysis)
FILE/REFERENCE

*BIA/SOLUTION
+BIAS/DESCRIPTION
+KEYWORD

OBSERVATION SAMPLING

300

PARAMETER SPACING

86400

DETERMINATION METHOD

IONOSPHERIC ANALYSIS

BIAS MODE

DIFFERENTIAL

TIME SYSTEM

G

REFERENCE SYSTEM

G

OBSERVABLE GROUP

G 4 C2W C2W C2L C2S

REFERENCE OBSERVABLES

G C1W C2W

REFERENCE OBSERVABLES

R C1P C2P

ZERO-MEAN CONDITIONS

G 1 0 1 0 0 0 0

ZERO-MEAN CONDITIONS

R 1 0 1 0 0 0 0

BIAS/DESCRIPTION

PRE-SVD PRN STATION OBS1 OBS2 BIAS_START BIAS_END UNIT ESTIMATED_VALUE STD_DEV ESTIMATED_S L

- FOR THE ACQUISITION OF DATA FOR DETERMINATION OF THE PRELIMINARY BIAS USING THE

SOFTWARE BERNES. GNSS SOFTWARE VERSION 5.3

THE BIAS SOLUTION IS BASED ON A SINGLE CASE OF THE SOFTWARE BERNES. GNSS SOFTWARE VERSION 5.3.

THE FOLLOWING TABLES SHOW THE BIAS SOLUTIONS FOR THE DIFFERENT OBSERVABLES.

THE BIAS SOLUTIONS ARE PROVIDED IN AN ALPHABETICAL ORDER.

THE STANDARD DEVIATIONS AND THE ESTIMATED STANDARD DEVIATIONS ARE GIVEN.

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A.4 Example #3: GPS/GLONASS DSB product (obtained from both clock and ionosphere analysis)

A.5 Example #4: GPS OSB product (obtained from both clock and ionosphere analysis)

A.6 Example #5: GPS/GLONASS OSB product (obtained from both clock and ionosphere analysis)

A.7 Example #6: GPS/GLONASS ISB/DSB product with GLONASS ISB biases assumed to be frequency-channel-dependent parameters (extracted from CODE rapid clock analysis)
<table>
<thead>
<tr>
<th>ISB</th>
<th>R</th>
<th>ALBH</th>
<th>C1W</th>
<th>C2W</th>
<th>15:276:00000 15:276:86399 ns</th>
<th>0.00000000 0000000E +00</th>
<th>0.000000 E+00</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISB</td>
<td>R</td>
<td>ALBH</td>
<td>C1P</td>
<td>C2P</td>
<td>15:276:00000 15:276:86399 ns</td>
<td>0.00000000 0000000E +00</td>
<td>0.000000 E+00</td>
</tr>
</tbody>
</table>
A.8 Example #7: Five-GNSS (MGEX) ISB/DSB product (extracted from CODE MGEX clock analysis)

- Bias Solution Independent EXchange Format (Bias-SIXE)

```
# Example #7: Five-GNSS (MGEX) ISB/DSB product (extracted from CODE MGEX clock analysis)

%bias 1.00 con 15:280:36620 con 15:276:00000 15:276:86399 p 01020 2 sinex_bia

 biases

+file/reference
+info_type
reference frame igb08
description astronomical institute, university of bern

% bias solution independent exchange format (bias-sixe)

# Example #7: Five-GNSS (MGEX) ISB/DSB product (extracted from CODE MGEX clock analysis)

%bias 1.00 con 15:280:36620 con 15:276:00000 15:276:86399 p 01020 2 sinex_bia

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description astronomical institute, university of bern

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+file/reference
+info_type
reference frame igb08
description astronomical institute, university of bern

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 biases

+file/reference
+info_type
reference frame igb08
description astronomical institute, university of bern

% bias solution independent exchange format (bias-sixe)
<table>
<thead>
<tr>
<th>SITE/ID</th>
<th>CODE</th>
<th>DOMES</th>
<th>DESCRIPTION</th>
<th>APPROX_LON</th>
<th>APPROX_LAT</th>
<th>APP_H</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABMF</td>
<td>A</td>
<td>97103</td>
<td>Les Abymes, FR</td>
<td>28.85</td>
<td>15.44</td>
<td>-25.6</td>
</tr>
<tr>
<td>ADIS</td>
<td>A</td>
<td>31502</td>
<td>Addis Ababa, ET</td>
<td>9.38</td>
<td>6.52</td>
<td>2439.2</td>
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<tr>
<td>AIRA</td>
<td>A</td>
<td>21742</td>
<td>Aira, JP</td>
<td>31.35</td>
<td>26.31</td>
<td>314.7</td>
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<tr>
<td>ZIMJ</td>
<td>A</td>
<td>14001</td>
<td>Zimmervald, CH</td>
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<td>46.52</td>
<td>954.3</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>SITE/ RECEIVER</th>
<th>CODE</th>
<th>DOMES</th>
<th>DESCRIPTION</th>
<th>APPROX_LON</th>
<th>APPROX_LAT</th>
<th>APP_H</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABMF</td>
<td>A</td>
<td>1</td>
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<td>--------</td>
<td>--------</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>VALUE(S)</th>
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<tr>
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<td>300</td>
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<tr>
<td>PARAMETER SPACING</td>
<td>86400</td>
</tr>
<tr>
<td>DETERMINATION METHOD</td>
<td>CLOCK ANALYSIS</td>
</tr>
<tr>
<td>BIAS MODE</td>
<td>DIFFERENTIAL</td>
</tr>
<tr>
<td>TIME SYSTEM</td>
<td>G</td>
</tr>
<tr>
<td>REFERENCE SYSTEM</td>
<td>G</td>
</tr>
<tr>
<td>REFERENCE OBSERVABLES</td>
<td>C11 C1T</td>
</tr>
<tr>
<td>REFERENCE OBSERVABLES</td>
<td>C1X C5X</td>
</tr>
<tr>
<td>REFERENCE OBSERVABLES</td>
<td>C1W C2W</td>
</tr>
<tr>
<td>REFERENCE OBSERVABLES</td>
<td>J C1C C2X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BIAS SOLUTION</th>
<th>CODE</th>
<th>DOMES</th>
<th>OBS1</th>
<th>OBS2</th>
<th>BIAS_START/END</th>
<th>UNIT</th>
<th>ESTIMATED_VALUE</th>
<th>STD_DEV</th>
<th>ESTIMATED_SL</th>
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</thead>
<tbody>
<tr>
<td>DSB G063 G01</td>
<td>CIW</td>
<td>C1C</td>
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<td>ns</td>
<td>0.1480229</td>
<td>37908458E+01</td>
<td>0.398201E-01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSB G061 G02</td>
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<td>C1C</td>
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<td>87124460E+01</td>
<td>0.463167E-01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSB G067 G05</td>
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<td>C1C</td>
<td>15:276:00000 15:276:86399</td>
<td>ns</td>
<td>0.1809495</td>
<td>40435891E+01</td>
<td>0.393379E-01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSB G069 G05</td>
<td>CIW</td>
<td>C1C</td>
<td>15:276:00000 15:276:86399</td>
<td>ns</td>
<td>0.5171948</td>
<td>75813799E+00</td>
<td>0.396322E-01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

28
A.9 Example #8: Five-GNSS (MGEX) OSB product (obtained from both clock and ionosphere analysis)
Appendix B contains an excerpt from the SINEX (2.02) format descriptions in order to complete this document for a reader who is not familiar with SINEX.

B.1 INTRODUCTION

The SINEX acronym was suggested by Blewitt et al. (1994) and the first versions, 0.04, 0.05, 1.00 evolved from the work and contributions of the SINEX Working Group of the IGS. The IGS Analysis Centres and Associated Analysis Centres use the SINEX format for their weekly solutions since mid 1995. Although the SINEX format was developed by the IGS, the ILRS and IVS decided to use it for their pilot projects as well because SINEX was designed to be modular and general enough to handle GPS as well as other techniques. To meet all the requirements for SLR and VLBI solutions some new elements and more detailed specifications were added by the ILRS Analysis Working Group and by the IVS. These extensions were merged with the previous SINEX version 1.00 to get a unique format definition for all space geodetic techniques, and after an intensive discussion the new version called SINEX 2.00 could be finalized. We have to thank the IGS Reference Frame Working Group chaired by R. Ferland, the ILRS Analysis Coordinator R. Noomen and the ILRS Analysis Working Group, the IVS Analysis Coordinator A. Rothnagel and Z. Altamimi from the ITRF section of IGN for their contributions and advice concerning a new SINEX format definition. The changes from version 1.00 to 2.00 are given in the next section of this document. The complete and detailed format definition can be seen in APPENDIX I, and the relevant least squares adjustment formulas with their relations to the SINEX format are summarized in APPENDIX II.

B.2 SINEX SYNTAX

SINEX is an ASCII file with lines of 80 chars or less. It consists of a number of blocks which are mutually referenced (related) through station codes/names, epochs and/or index counters. Some blocks consist of descriptive lines (starting in Col.2) and/or fixed format fields with numerous headers and descriptive annotations.

The first line is MANDATORY and must start with "%" in col 1, and contains information about the agency, file identification, solution spans, techniques, type of solution, etc. (for more details see the Appendix I or II). The last line ends with "%ENDNX".

The SINEX format consists of a number BLOCKS which start with "+" in the first col. followed by a standardized block labels, and each block ends with "-" and the block label. Each block data starts in the column 2 or higher. Blocks can be in any order, provided that they start with (+) and end with (-) block labels. The first header line and most blocks are related through epochs or time stamps in the following format: YY:DOY:SECOD YY - year; DOY - day of year; SECOD - sec of day; E.g. the epoch 95:120:86399 denotes April 30, 1995 (23:59:59UT). The epochs 00:00:00000 are allowed in all blocks, except the first header line if the SINEX file is an output of a data analysis (in case of a SINEX template the epoch 00:00:00000 is allowed in the header line as well) and default into the start or end epochs of the first header line which must always be coded. This is particularly useful for some blocks, such as the ones related to hardware, occupancy, which should be centrally archived by IGSCB with 00:00:00000 as the end (current) epochs, and which should be readily usable by ACs for SINEX and other analysis/processing as official (authoritative) IGS information.

COMMENT lines starts with "*" in Col. 1 and can be anywhere within or outside a block, though for the clarity sake, beginning and ends of blocks are preferable. For increased portability, the floating number exponent of "E" should be used rather than "D" or "d" which is not recognized by some compiler/installations. Fields not coded should be filled with "-" characters to allow efficient row and column format readings.
B.3 SINEX VERSION 2.00—DETAIL FORMAT DESCRIPTION

1. INTRODUCTION
2. DATA STRUCTURE
3. HEADER LINE
4. FILE/REFERENCE BLOCK
5. FILE/COMMENT BLOCK
6. INPUT/HISTORY BLOCK
7. INPUT/FILES BLOCK
8. INPUT/ACKNOWLEDGMENTS BLOCK
9. NUTATION/DATA BLOCK
10. PRECESSION/DATA BLOCK
11. SOURCE/ID BLOCK
12. SITE/ID BLOCK
13. SITE/DATA BLOCK
14. SITE/RECEIVER BLOCK
15. SITE/ANTENNA BLOCK
16. SITE/GPS_PHASE_CENTER BLOCK
17. SITE/ECCENTRICITY BLOCK
18. SOLUTION/EPOCHS BLOCK
19. BIAS/EPOCHS BLOCK
20. SOLUTION/STATISTICS BLOCK
21. SOLUTION/ESTIMATE BLOCK
22. SOLUTION/APRIORI BLOCK
23. SOLUTION/MATRIX_ESTIMATE BLOCK
24. SOLUTION/MATRIX_APRIORI BLOCK
25. SOLUTION/NORMAL_EQUATION_VECTOR BLOCK
26. SOLUTION/NORMAL_EQUATION_MATRIX BLOCK
27. FOOTER LINE

B.3.1 1. Introduction

This document describes the Software Independent Exchange (SINEX) format. It started in early 1995 with an effort by a number of IGS participants and it was designed to be easily extended. For the new IERS structure, operational since January 1, 2001, and due to the use of SINEX by the ILRS (pilot project ‘positioning and earth orientation’) and the IVS as well, some extensions were made with the purpose to have a unique format description for all techniques.

B.3.2 2. Data Structure

Each SINEX line has at most 80 ASCII characters.
The SINEX file is subdivided in groups of data called blocks. Each block is enclosed by a header and trailer line. Each block has a fixed format. The blocks contain information on the file, its input, the sites and the solution. All elements within a line are defined. A character field without information will have "-"s within its field and a missing numerical element will have a value of 0 within its field. Therefore the SINEX file is accessible "column-wise" as well as "line-wise". Character fields should be left hand justified whenever applicable.

The first character of each line identifies the type of information that the line contains. Five characters are reserved. They have the following meaning when they are at the beginning of a line, they identify:
Character Definition
"%" Header and trailer line,
"*" Comment line within the header and trailer line,
"+" Title at the start of a block
"-" Title at the end of a block
" " Data line within a block

No other character is allowed at the beginning of a line!

A SINEX file must start with a header line and ends with a footer line.

The following blocks are defined:
FILE/REFERENCE
FILE/COMMENT
INPUT/HISTORY
INPUT/FILES
INPUT/ACKNOWLEDGMENTS
NUTATION/DATA
PRECESSION/DATA
SOURCE/ID
SITE/ID
SITE/DATA
SITE/RECEIVER
SITE/ANTENNA
SITE/GPS_PHASE_CENTER
SITE/GAL_PHASE_CENTER
SITE/ECCENTRICITY
SATELLITE/ID
SATELLITE/PHASE_CENTER
BIAS/EPOCHS
SOLUTION/EPOCHS
SOLUTION/STATISTICS
SOLUTION/ESTIMATE
SOLUTION/APRIORI
SOLUTION/MATRIX_ESTIMATE {p} {type}
SOLUTION/MATRIX_APRIORI {p} {type}
SOLUTION/NORMAL_EQUATION_VECTOR
SOLUTION/NORMAL_EQUATION_MATRIX {p}

Where: {p} L or U
{type} CORR or COVA or INFO

These block titles are immediately preceded by a "+" or a "-" as they mark the beginning or the end of a block. The block titles must be in capital letters. After a block has started (+) it must be ended (-) before another block can begin. The general structure is as follows:

% = SNX ........... (Header line)--------|
+ (BLOCK TITLE)----------| |
------------- | |
------------- | |
------------- | |
+ (BLOCK TITLE)----------| |
------------- | |
------------- | |
------------- | |
+ (BLOCK TITLE)----------| |
------------- | |
------------- | |
------------- | |
+- (BLOCK TITLE)----------| |
------------- | |
------------- | |
------------- | |
------------- | |
------------- | |
% ENDSNX (Trailer line)--------|

Most fields within a SINEX line are separated by a single space. In the following sections, each SINEX line is defined by its field name, a general description and the (FORTRAN) format.

A comment line (not to be confused with the FILE/COMMENT Block) can be written anywhere within the header and the footer line. All comment lines must start with a "*" in the first column. With the use of this character information can be hidden from the software reading the file without deleting it from the file. A comment line is defined as follows:

| Field _______ | Description __________________________ | Format ______ |
|_______________|________________________________________|______________|
| Comment _____ | Any general comment relevant to _______ | 1H*,A79 |
|_______ | the SINEX file. | |
|_______________|________________________________________|______________|
|_______________|________________________________________|______________|
|____________________ | 80 | |

Some fields are found in several blocks. To keep the description short, they are described in detail here, and will be referred to in the sections with additional information added when necessary. The fields defined below will be referenced to by putting them within square brackets [] when encountered in the
following sections.

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>YY:DDD:SSSSS. “UTC”</td>
<td>12.2</td>
</tr>
<tr>
<td></td>
<td>YY = last 2 digits of the year.</td>
<td>1H:.13.3.</td>
</tr>
<tr>
<td></td>
<td>if YY &lt;= 50 implies 21-st century.</td>
<td>1H:.15.5</td>
</tr>
<tr>
<td></td>
<td>if YY &gt; 50 implies 20-th century.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DDD = 3-digit day in year,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SSSSS = 5-digit seconds in day.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constraint Code</th>
<th>Single digit indicating the constraints:</th>
<th>A1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>fixed / tight constraints,</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>significant constraints,</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>unconstrained.</td>
<td></td>
</tr>
</tbody>
</table>

B.3.3 4. FILE/REFERENCE Block (Mandatory)

Description:
This block provides information on the Organization, point of contact, the software and hardware involved in the creation of the file.

Contents:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Type</td>
<td>Describes the type of information present in the next field. May take on the following values:</td>
<td>1X, A18</td>
</tr>
<tr>
<td></td>
<td>‘DESCRIPTION’ - Organization(s) gathering/altering the file contents.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>‘OUTPUT’ - Description of the file contents.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>‘CONTACT’ - Address of the relevant contact.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>e-mail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>‘SOFTWARE’ - Software used to generate the file.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>‘HARDWARE’ - Computer hardware on which the software was run.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>‘INPUT’ - Brief description of the input used to generate this solution.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Any of the above fields may be and in any order.</td>
<td></td>
</tr>
</tbody>
</table>

| Information | Relevant information for the type indicated by the previous field. | 1X, A60 |

B.3.4 5. FILE/COMMENT Block (Optional)

Description:
This block can be used to provide general comments about the SINEX data file.

Contents:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comment</td>
<td>Any general comment providing relevant information about the SINEX file.</td>
<td>1X,A79</td>
</tr>
</tbody>
</table>

B.3.5 12. SITE/ID Block (Mandatory)

Description:

This block provides general information for each site containing estimated parameters.

Contents:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Site Code]</td>
<td>Call sign for a site.</td>
<td>1X,A4</td>
</tr>
<tr>
<td>[Point Code]</td>
<td>Physical monument used at a site</td>
<td>1X,A2</td>
</tr>
<tr>
<td>Unique Monument Identification</td>
<td>Unique alpha-numeric monument identification. For ITRF purposes, it is a nine character DOMES/DDMEX number (five/six digits, followed by the single letter 'M' or 'S', followed by four/three digits)</td>
<td>1X,A9</td>
</tr>
<tr>
<td>[Observation Code]</td>
<td>Observation technique(s) used.</td>
<td>1X,A1</td>
</tr>
<tr>
<td>Station Description</td>
<td>Free-format description of the site, typically the town and/or country.</td>
<td>1X,A22</td>
</tr>
<tr>
<td>Approximate Longitude</td>
<td>Approximate longitude of the site in degrees(E/+) and minutes and seconds.</td>
<td>1X,A12, 1X,F4.1</td>
</tr>
<tr>
<td>Approximate Latitude</td>
<td>Approximate latitude of the site in degrees(NS/+) and minutes and seconds.</td>
<td>1X,A12, 1X,F4.1</td>
</tr>
<tr>
<td>Approximate Height</td>
<td>Approximate height of the site in metres.</td>
<td>1X,F7.1</td>
</tr>
</tbody>
</table>

Comments:

For DOMES numbers and station description as well as for Site Codes please
refer to ftp://large.ensg.ign.fr/pub/itrf/iers_dir.sta

If a DOMES number is not available (e.g. for a new station), please ask Zuheir Altamimi for a DOMES number (altamimi@ensg.ign.fr).

Use the minus sign for negative approximate longitude or latitude only in the "degrees" component and don’t repeat it in the "minutes" and "seconds" component.

Following the ISO6709 specification, the range of longitude should be [-180 +180].

B.3.6 14. SITE/RECEIVER Block (Mandatory for GPS)

Description:

List the receiver used at each site during the observation period of interest.

Contents:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Site Code]</td>
<td>Site code for which some parameters are estimated.</td>
<td>1X,A4</td>
</tr>
<tr>
<td>[Point Code]</td>
<td>Point Code at a site for which some parameters are estimated.</td>
<td>1X,A2</td>
</tr>
<tr>
<td>[Solution ID]</td>
<td>Solution Number at a Site/Point code for which some parameters are estimated.</td>
<td>1X,A4</td>
</tr>
<tr>
<td>[Observation Code]</td>
<td>Identification of the observation technique used.</td>
<td>1X,A1</td>
</tr>
<tr>
<td>[Time]</td>
<td>Time since the receiver has been operating at the Site/Point. Value 00:000:00000 indicates that the receiver has been operating at least since the &quot;File Epoch Start Time&quot;.</td>
<td>1X,I2.2, I8,I3.3, I8,I5.5</td>
</tr>
<tr>
<td>[Time]</td>
<td>Time until the receiver is operated at a Site/Point. Value 00:000:00000 indicates that the receiver has been operating at least until the &quot;File Epoch End Time&quot;.</td>
<td>1X,I2.2, I8,I3.3, I8,I5.5</td>
</tr>
<tr>
<td>Receiver Type</td>
<td>Receiver Name &amp; model.</td>
<td>1X,A20</td>
</tr>
<tr>
<td>Receiver Serial Number</td>
<td>Serial number of the receiver.</td>
<td>1X,A5</td>
</tr>
<tr>
<td>Receiver Firmware</td>
<td>Firmware used by this receiver during the epoch specified above. Takes on value '--------' if unknown.</td>
<td>1X,A11</td>
</tr>
</tbody>
</table>

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Comments:

- For IGS standard receiver names please refer to
  ftp://igscb.jpl.nasa.gov/igscb/station/general/rcvr_ant.tab