INTRODUCTION TO DORIS RINEX

(Issue 1.0)

ACRONYMS

DGXX	Third generation DORIS Instrument serial model characterised by internal redundary and 7 measurement channels
DORIS	Doppler Orbitography and Radio Positioning Integrated by satellite
GNSS	Global Navigation Satellite System
IDS	International Doris Service
PANDOR	Pré traitement et ANalyse des mesures DORis
RINEX	Receiver Independent Exchange Format
SIMBAD	French acronym for : DORIS Beacons Database
SSALTO	Multi-Mission Ground Segment for Altimetry precise positionning and Orbitography, (CNES)
STILO	French Acronyme for Altimetry, Precise Orbit Determination, Positionning Instruments Telemtry Processing

CONTENTS

1. PURPOSE

RINEX is the format of files containing the DORIS measurements, for DORIS DGXX instruments.

Those files are delivered regularly, they are available on the IDS website:

ftp://doris.ensg.ign.fr/pub/doris/data/<*mission*>/<*YYYY*>/

ftp://cddis.gsfc.nasa.gov/pub/doris/data/<*mission*>/<*YYYY*>/

with:

mission: name of the Doris mission : cs2, ja2, h2a, srl

YYYY: year of the data

The goal of this document is to give a quick description of this RINEX format.

A detailed description is given in a specific document (RINEX DORIS 3.0).

ftp://ftp.ids-doris.org/pub/ids/data/RINEX_DORIS.pdf

Here we describe some parameters considered as mainly significant and useful for scientific applications.

The principle chosen in this document is to take an example of RINEX content and describe the main parameters.

Note: the RINEX format was designed initially for GNSS measurements. Some adaptations were done, so some parameters may be quite surprising.

The RINEX files are divided into 2 parts:

- The header
- The data

On the following page, an example of RINEX files is given, showing these 2 parts.

Each part is then described in the following paragraphs.

Header

```
   3.00                O                       D                                  RINEX VERSION / TYPE
Expert           CNES          20120227 071236 UTC                                 PGM / RUN BY / DATE
G = GPS R = GLONASS E = GALILEO S = GEO M = MIXED D = DORIS                        COMMENT
JASON-2                                                                            SATELLITE NAME
2008-032A                                                                          COSPAR NUMBER
STILO_BN1_3.0      CNES                                                            OBSERVER / AGENCY
CHAIN1           DGXX            1.00                                              REC # / TYPE / VERS
DORIS            STAREC                                                            ANT # / TYPE
      1.1940      -0.5980       1.0220                                           APPROX POSITION XYZ
      0.9768       0.0001       0.0011                                           CENTER OF MASS: XYZ
D   10 L1  L2  C1  C2 W1 W2   F   P   T   H                                       SYS / # / OBS TYPES
 2012    02    26    00    00   28.8573904     DOR                                TIME OF FIRST OBS
D  100   2  C1  C2                                                               SYS / SCALE FACTOR
D         1.900                                                                  L2 / L1 DATE OFFSET
   48                                                                            # OF STATIONS
D01  HBMB          HARTEBEESTHOEK          30302S008  3   0                     STATION REFERENCE
D02  MATB          MARION ISLAND           30313S003  3   0                     STATION REFERENCE
D03  LICB          LIBREVILLE              32809S004  3   0                     STATION REFERENCE
D04  REUB          LA REUNION              97401S002  3   0                     STATION REFERENCE
D05  DJIB          DJIBOUTI                39901S003  3   0                     STATION REFERENCE
D06  GAVB          GAVDOS                  12618S001  3  18                     STATION REFERENCE
D07  DIOB          DIONYSOS                12602S012  3   0                     STATION REFERENCE
D08  KIUB          KITAB                   12334S006  3   0                     STATION REFERENCE
D09  GR3B          GRASSE                  10002S018  3 -15                     STATION REFERENCE
D10  METB          METSAHOVI               10503S015  3   0                     STATION REFERENCE
D11  TLSB          TOULOUSE                10003S005  3   0                     STATION REFERENCE
D12  BADB          BADARY                  12338S002  3   0                     STATION REFERENCE
D13  KRBB          KRASNOYARSK             12349S002  3   0                     STATION REFERENCE
D14  SPJB          NY-ALESUND              10317S005  3   0                     STATION REFERENCE
D15  SAKB          YUZHNO-SAKHALINSK       12329S002  3   0                     STATION REFERENCE
D16  COBB          COLD BAY                49804S004  3   0                     STATION REFERENCE
D17  KOLB          KAUAI                   40424S009  3   0                     STATION REFERENCE
D18  BETB          BETIO                    50305S001  3   0                    STATION REFERENCE
D19  PAUB          PAPEETE                 92201S010  3   0                     STATION REFERENCE
D20  NOXB          NOUMEA                  92701S004  3   0                     STATION REFERENCE
D21  CHAB          CHATHAM ISLAND          50207S001  3   0                     STATION REFERENCE
D22  EASB          EASTER ISLAND           41703S009  3   0                     STATION REFERENCE
D23  ROVB          ROTHERA                 66007S004  3   0                     STATION REFERENCE
D24  BEMB          BELGRANO                66018S002  3   0                     STATION REFERENCE
D25  SANB          SANTIAGO                41705S009  3   0                     STATION REFERENCE
D26  ASEB          ASCENSION               30602S005  3   0                     STATION REFERENCE
D27  SALB          SAL                     39601S002  3   0                     STATION REFERENCE
D28  JIUB          JIUFENG                 21602S005  3   0                     STATION REFERENCE
D29  MSPB          MOUNT STROMLO           50119S004  3   0                     STATION REFERENCE
D30  ADGB          TERRE ADELIE            91501S004  3   0                     STATION REFERENCE
D31  RIQB          RIO GRANDE              41507S006  3   0                     STATION REFERENCE
D32  KRWB          KOUROU                  97301S006  3   0                     STATION REFERENCE
D33  PDMB          PONTA DELGADA           31906S002  3   0                     STATION REFERENCE
D34  MANB          MANILLE                 22006S002  3   0                     STATION REFERENCE
D35  YASB          YARAGADEE               50107S011  3   0                     STATION REFERENCE
D36  ARFB          AREQUIPA                42202S007  3   0                     STATION REFERENCE
D37  MIAB          MIAMI                   49914S003  3   0                     STATION REFERENCE
D38  STJB          ST JOHN'S               40101S002  3   0                     STATION REFERENCE
D39  GREB          GREENBELT               40451S176  3   0                     STATION REFERENCE
D40  THUB          THULE                   43001S005  3   0                     STATION REFERENCE
D41  EVEB          EVEREST                 21501S001  3   0                     STATION REFERENCE
D42  MALB          MALE                     22901S002  3   0                    STATION REFERENCE
D43  CIDB          CIBINONG                23101S003  3   0                     STATION REFERENCE
D44  YEMB          YELLOWKNIFE             40127S009  3   0                     STATION REFERENCE
D45  MAHB          MAHE                     39801S005  3   0                    STATION REFERENCE
D46  AMVB          AMSTERDAM               91401S005  3   0                     STATION REFERENCE
D47  KETB          KERGUELEN               91201S005  3   0                     STATION REFERENCE
D48  CRQB          CROZET                  91301S003  3   0                     STATION REFERENCE
   4                                                                             # TIME REF STATIONS
D01                0.270            0.575                                      TIME REF STATION
D11               19.331            5.874                                      TIME REF STATION
D19               0.617            24.802                                      TIME REF STATION
D32               -5.741           -18.762                                     TIME REF STATION
 2012    02    26    00    00    0.0000000                                      TIME REF STAT DATE
                                                                                END OF HEADER
```

Data

```
> 2012 02 26 00 00 27.359947870  0  2       1.497442592 0
D01  -1519613.114    -1952438.990   -44654714.02001 -44654784.45901     -121.150 7
       -112.050 7     4280.724        862.154 1       17.615 1       58.462 1
D02  -1552063.063    -1132345.482   -43858499.60912 -43858764.93512     -122.550 4
       -118.700 4     4280.724        995.000 0       5.800 0        77.000 0
> 2012 02 26 00 00 30.359947870  0  2       1.497442592 0
D01  -1613019.154    -1970844.901   -44656089.20001 -44656159.64601     -121.150 7
       -112.050 7     4280.724        862.154 1       17.615 1       58.462 1
D02  -1530058.107    -1128009.416   -43858175.62512 -43858440.94512     -122.550 4
       -118.700 4     4280.724        995.000 0       5.800 0        77.000 0
```

2. HEADER

Here is an example of a RINEX header with a description of the main parameters

```
   3.00           O                   D                                   RINEX VERSION / TYPE
Expert            CNES                20120227 071236 UTC                 PGM / RUN BY / DATE
G = GPS R = GLONASS E = GALILEO S = GEO M = MIXED D = DORIS COMMENT
JASON-2                                                                   SATELLITE NAME
2008-032A                                                                 COSPAR NUMBER
STILO_BN1_3.0      CNES                                                   OBSERVER / AGENCY
CHAIN1             DGXX            1.00                                  REC # / TYPE / VERS
DORIS              STAREC                                                ANT # / TYPE
      1.1940      -0.5980       1.0220                                   APPROX POSITION XYZ
      0.9768       0.0001       0.0011                                   CENTER OF MASS: XYZ
D   10 L1  L2  C1  C2  W1  W2   F   P   T   H                            SYS / # / OBS TYPES
 2012    02    26    00    00   28.8573904     DOR                       TIME OF FIRST OBS
D  100   2  C1  C2                                                       SYS / SCALE FACTOR

D         1.900                                                           L2 / L1 DATE OFFSET
   48                                                                     # OF STATIONS
D01  HBMB     HARTEBEESTHOEK          30302S008  3   0                  STATION REFERENCE
D02  MATB     MARION ISLAND           30313S003  3   0                  STATION REFERENCE
D03  LICB     LIBREVILLE              32809S004  3   0                  STATION REFERENCE
D04  REUB     LA REUNION              97401S002  3   0                  STATION REFERENCE
D05  DJIB     DJIBOUTI                39901S003  3   0                  STATION REFERENCE
D06  GAVB     GAVDOS                  12618S001  3  18                  STATION REFERENCE
D07  DIOB     DIONYSOS                12602S012  3   0                  STATION REFERENCE
D08  KIUB     KITAB                   12334S006  3   0                  STATION REFERENCE
D09  GR3B     GRASSE                  10002S018  3 -15                  STATION REFERENCE
D10  METB     METSAHOVI               10503S015  3   0                  STATION REFERENCE
D11  TLSB     TOULOUSE                10003S005  3   0                  STATION REFERENCE
D12  BADB     BADARY                  12338S002  3   0                  STATION REFERENCE
D13  KRBB     KRASNOYARSK             12349S002  3   0                  STATION REFERENCE
D14  SPJB     NY-ALESUND              10317S005  3   0                  STATION REFERENCE
D15  SAKB     YUZHNO-SAKHALINSK       12329S002  3   0                  STATION REFERENCE
D16  COBB     COLD BAY                49804S004  3   0                  STATION REFERENCE
D17  KOLB     KAUAI                   40424S009  3   0                  STATION REFERENCE
D18  BETB     BETIO                   50305S001  3   0                  STATION REFERENCE
D19  PAUB     PAPEETE                 92201S010  3   0                  STATION REFERENCE
```

| name of the satellite carrying the DORIS instrument

| DORIS on-board instrument characteristics

| On-board antenna characteristics

| System, observed observation types (cf.detailed description)

| Time of the first measurement of the file, given in TAI scale

| scale factor: 100 to apply to pseudo range C1, C2
(values in the file have to be divided by 100)

| time delay between L1 measurement and L2 measurement

| Number of DORIS stations received in the file

| List of the DORIS stations received with their
| characteristics
|
| D01: DORIS station number in the current RINEX file
| HBMB: DORIS antenna point mnemonic
| HARTEBEESTHOEK :DORIS site name
| 30302S008: Domes number
| 3: Beacon generation
| 0: K factor (frequency shift factor)
|
| **Note:** the correspondence
| station number / mnemonic-name changes for every
| RINEX

```
D20  NOXB     NOUMEA                    92701S004  3   0     STATION REFERENCE
D21  CHAB     CHATHAM ISLAND            50207S001  3   0     STATION REFERENCE
D22  EASB     EASTER ISLAND             41703S009  3   0     STATION REFERENCE
D23  ROVB     ROTHERA                   66007S004  3   0     STATION REFERENCE
D24  BEMB     BELGRANO                  66018S002  3   0     STATION REFERENCE
D25  SANB     SANTIAGO                  41705S009  3   0     STATION REFERENCE
D26  ASEB     ASCENSION                 30602S005  3   0     STATION REFERENCE
D27  SALB     SAL                       39601S002  3   0     STATION REFERENCE
D28  JIUB     JIUFENG                   21602S005  3   0     STATION REFERENCE
D29  MSPB     MOUNT STROMLO             50119S004  3   0     STATION REFERENCE
D30  ADGB     TERRE ADELIE              91501S004  3   0     STATION REFERENCE
D31  RIQB     RIO GRANDE                41507S006  3   0     STATION REFERENCE
D32  KRWB     KOUROU                    97301S006  3   0     STATION REFERENCE
D33  PDMB     PONTA DELGADA             31906S002  3   0     STATION REFERENCE
D34  MANB     MANILLE                   22006S002  3   0     STATION REFERENCE
D35  YASB     YARAGADEE                 50107S011  3   0     STATION REFERENCE
D36  ARFB     AREQUIPA                  42202S007  3   0     STATION REFERENCE
D37  MIAB     MIAMI                     49914S003  3   0     STATION REFERENCE
D38  STJB     ST JOHN'S                 40101S002  3   0     STATION REFERENCE
D39  GREB     GREENBELT                 40451S176  3   0     STATION REFERENCE
D40  THUB     THULE                     43001S005  3   0     STATION REFERENCE
D41  EVEB     EVEREST                   21501S001  3   0     STATION REFERENCE
D42  MALB     MALE                      22901S002  3   0     STATION REFERENCE
D43  CIDB     CIBINONG                  23101S003  3   0     STATION REFERENCE
D44  YEMB     YELLOWKNIFE               40127S009  3   0     STATION REFERENCE
D45  MAHB     MAHE                      39801S005  3   0     STATION REFERENCE
D46  AMVB     AMSTERDAM                 91401S005  3   0     STATION REFERENCE
D47  KETB     KERGUELEN                 91201S005  3   0     STATION REFERENCE
D48  CRQB     CROZET                    91301S003  3   0     STATION REFERENCE
   4                                                          # TIME REF STATIONS     | Time reference stations information, for specific
D01              0.270          0.575                       TIME REF STATION        | processing (time tagging re processing)
D11             19.331          5.874                       TIME REF STATION
D19              0.617         24.802                       TIME REF STATION
D32             -5.741        -18.762                       TIME REF STATION
 2012   02   26   00   00   0.0000000                       TIME REF STAT DATE
                                                            END OF HEADER
```

3. DATA

```
> 2012 02 26 00 00 27.359947870  0  2       1.497442592 0
D01  -1519613.114    -1952438.990   -44654714.02001 -44654784.45901     -121.150 7
       -112.050 7      4280.724        862.154 1       17.615 1        58.462 1
D02  -1552063.063    -1132345.482   -43858499.60912 -43858764.93512     -122.550 4
       -118.700 4      4280.724        995.000 0       5.800 0         77.000 0
```

Record block 1

```
> 2012 02 26 00 00 30.359947870  0  2       1.497442592 0
D01  -1613019.154    -1970844.901   -44656089.20001 -44656159.64601     -121.150 7
       -112.050 7      4280.724        862.154 1       17.615 1        58.462 1
D02  -1530058.107    -1128009.416   -43858175.62512 -43858440.94512     -122.550 4
       -118.700 4      4280.724        995.000 0       5.800 0         77.000 0
```

Record block 2

3.1. RECORD BLOCK

```
> 2012 02 26 00 00 27.359947870  0  2       1.497442592 0
```

Sequence characteristics

```
D01  -1519613.114    -1952438.990   -44654714.02001 -44654784.45901     -121.150 7
       -112.050 7      4280.724        862.154 1       17.615 1        58.462 1
```

First measurement of the sequence

```
D02  -1552063.063    -1132345.482   -43858499.60912 -43858764.93512     -122.550 4
       -118.700 4      4280.724        995.000 0       5.800 0         77.000 0
```

Second measurement of the sequence

3.2. RECORD DESCRIPTION:

3.2.1. SEQUENCE CHARACTERISTICS:

> 2012 02 26 00 00 27.359947870 0 2 1.497442592 0

2012 02 26 00 00 27.359947870	0	2	1.497442592	0
Epoch: L1 measurement time tagging of the sequence measurements, given in the receiver time scale	Epoch flag 0 => OK 1 => measurement not exploitable	Number of measurement during the sequence	receiver clock offset	receiver clock offset flag

Nota : The TAI time tag of L1 of the sequence is determined by the expression: date TAI = epoch + receiver clock offset (cf ANN 1)

3.2.2. FIRST MEASUREMENT OF THE SEQUENCE

Num (D01)	: DORIS station number. In the example, if we look at the header, D01 corresponds to the mnemonic HBMB and the site HARTEBEESTHOEK
L1 (-1519613.114)	: 2GHz phase measurement, given in full cycles (F14.3) (optionally followed by 2 flags on 2 characters)
L2 (-1952438.990)	: 400MHz phase measurement, given in full cycles (F14.3) (optionally followed by 2 flags on 2 characters) Note: these phases are equal to the phases measured by the DORIS instrument with the opposite sign.
C1 (-44654714.020)	: 2GHz pseudo-range, given in km (F14.3) 01: indicator flags (see DR1)
C2 -44654784.459	: 400MHz pseudo-range, given in km (F14.3) 01: indicator flags (see DR1)
-121.150	:W1 (F14.3): 2GHz power received (dBm) (optionally followed by 2 flags on 2 characters, see DR1): here flag = 7
-112.050	:W2 (F14.3): 400MHz power received (dBm) (optionally followed by 2 flags on 2 characters, see DR1): here flag = 7
4280.724	:F (F14.3): relative frequency offset (10^{-11}) (optionally followed by 2 flags on 2 characters, see DR1)
862.154	:P (F14.3): atmospheric pressure (100 Pa) (optionally followed by 2 flags on 2 characters, see DR1): here flag = 1
17.615	:P (F14.3): atmospheric pressure (100 Pa) (optionally followed by 2 flags on 2 characters, see DR1): here flag = 1
58.842	:H (F14.3): humidity (%) (optionally followed by 2 flags on 2 characters, see DR1): here flag = 1

4. ADDITIONAL INFORMATION:

Intended for all users of RINEX files

4.1. DATA SEQUENCING:

As already mentioned, there can be two sets of measurements in sequences of 10 seconds, the first at T0, the second at T0 + 3s. The dates introduced by the ">" sign therefore indicate alternately the date of the first series of a sequence and then the date of the second series of the same sequence. In the file given as an example, it must therefore be read:

=> Record block 1: first measurements set of the first sequence

=> Record block 2: second measurement set of the first sequence

etc.

It should be noted that both series are not always present. In particular at the start of a pass or following a stall due to Doppler collision, the first series (phase measurements at T0) is absent because of the time the receiver takes to lock on (or reconnect to) the signal. In this case, the first step in the sequence will be at T0 + 3s.

4.2. DATA ACCURACY:

- Accuracy of the measurements:

In DORIS RINEX, two dual-frequency phase measurements are delivered every 10 seconds: the first at T0, the second at T0 + ~3s.

This may be of interest to those who want faster temporal sampling than 1 every 10 seconds.

In RINEX, the measurements are dated to a few microseconds in the TAI scale. This avoids the need for users to repeat a BT/UT match.

Pseudo Range:

The DORIS measurement of pseudo-range is not very accurate ~ 1km at 400MHz and ~ 5km at 2GHz.
The phase measurement is more accurate.

Phase:

Phase measurement is accurate to a few millimetres.

Time tagging

DIODE epoch (raw RINEX)

Pandor epoch (Pandor redated for RINEX)

- How to treat flags

Some flag values need to be monitored so that the data can be edited if necessary.

A more detailed description is given in DR1.

NOTA :

L2 / L1 DATE OFFSET : this parameter gives the delay between :

- L1 measurement time : 2GHz phase sampling
- And L2 measurement time : 400MHz phase sampling

This delay is due to the independence of the two sampling scales. Both sampling scales have an elementary schedule of 4 microseconds. This means that this delay is between 0 and 4 microseconds.

It is measured by the instrument and updated for each RINEX file.

5. ADDITIONAL DATA USEFUL FOR RINEX EXPLOITATION:

- Ephemeris:

The position of the satellite will be provided in an ephemeris file (values to interpolate with the dates of the measurements)

- Coordinates:

The coordinates (positions/speed) of DORIS stations (antenna points) are available, either via the site logs available on the site under ids-doris.org http://ids-doris.org/network/sitelogs.html, or via a database (SIMBAD) in the current ITRF coordinate framework (currently ITRF_2008).

6. SUPPLYING RINEX FILES TO USERS

DORIS RINEX data are made available **daily** on IDS for the Jason2, Cryosat2 and Hy-2A missions.

The HY-2A files are sometimes incomplete (gap in the telemetry); in this case, a second version may be published within a month.

Update the document: RINEX DORIS 3.0 (SALP 15578)

A description of the "RINEX DORIS" format can be found at: ftp://ftp.ids-doris.org/pub/ids/data/RINEX_DORIS.pdf

7. ANNEXES

These annexes contain a few additional details

7.1. ANN 1:

The date (for example: > 2012 02 26 00 00 27.359947870) is expressed in the onboard (BT) scale. To convert it to the TAI scale, just add the given offset in seconds on the same line, after the indicator of the number of measurements.

Example:

> 2012 02 26 00 00 27.359947870 0 2   1.497442592 0

TAI date of the measurements = 2012 02 26 00 00 27.3599 + 1.49744259247870 = 2012 02 26 00 00 28.857390462

It should be noted that the first series of measurements in the sequence falls nominally on a TAI date whose modulo [10 seconds] = ~ -1.15 seconds (a value better known by the name of nominal time shift between onboard and ground time frame).

The flag that follows the offset ("0" in the example above) indicates whether the offset for correspondence between BT and TAI is derived from an interpolation ("0") or an extrapolation ("1"). It is usually "0" and can be ignored (it does not affect the accuracy of the dating in TAI, which is always, and regardless of the method used, to about the nearest microsecond, as this error is dominated by the noise of the measurement of pseudo-range).

7.2. ANN 2:

As can be seen, the phase measurements are expressed in cycles with 3 decimal places. The term "full cycles" which has been used in the RINEX 3.0 document is slightly confusing - an update will be considered.