DORIS DGXX

and

RINEX Products

New DORIS DGXX and associated Products

Recall from last presentation by JP-Granier at previous IDS Workshop :

The DORIS DGXX equipment will be used on : Jason-2 ; SARAL ; Cryosat-2 ; Sentinel-3 ; HY2 ; Jason-3

This equipment includes :

- Full internal cold redundancy of USO, MVR, and with Antenna automatic switch

- Each MVR allows 7 (UT) measurement channels in parallel

The 2GXX receiver performs more accurate and more complete phase, delta-phase and pseudo-range measurements

DORIS DGxx dual frequency Instrument
401.25MHz / 2036.25MHz

DORIS antenna

DORIS DGxx BDR *

2 kg
h 420 x φ160 (mm)
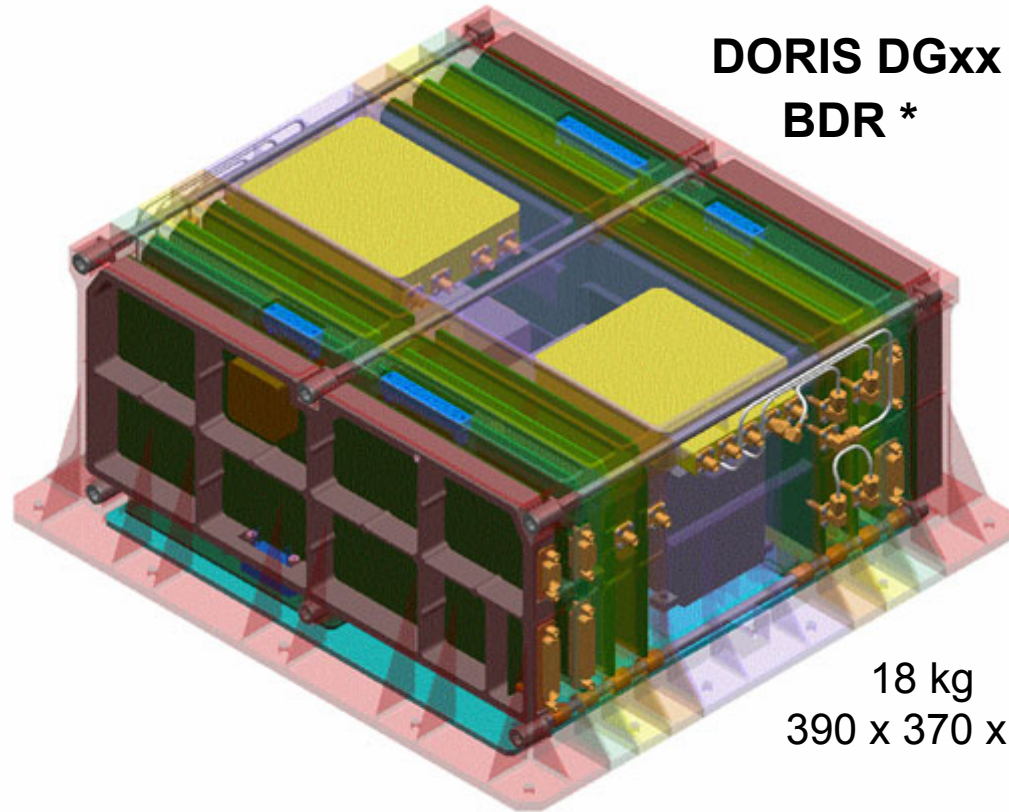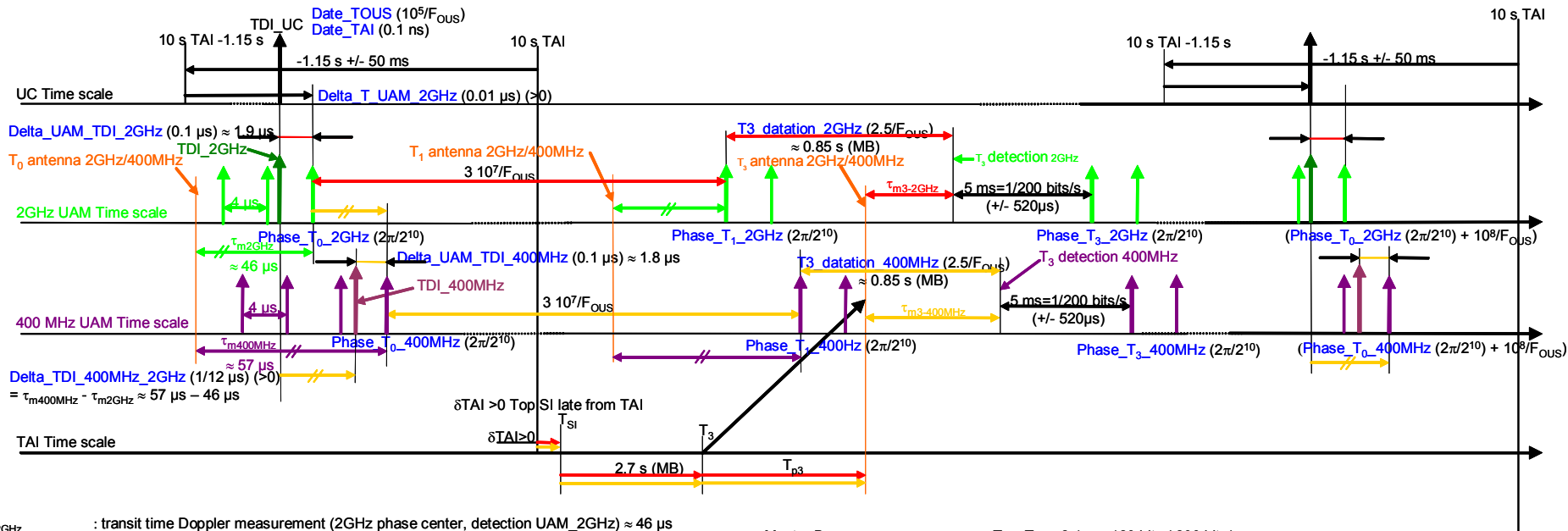
18 kg
390 x 370 x 165 (mm)

* Boîtier DORIS Redondé

The DORIS Data measurements

PARAMETER_NAME in TM DGXX
TDI Time Tagging path, on 400 MHz channel
TDI Time tagging path, on 2 GHz channel

Date_TOUS ($10^5/F_{OUS}$)
Date_TAI (0.1 ns)

10 s TAI

TDI_UC

10 s TAI -1.15 s   10 s TAI

10 s TAI -1.15 s

-1.15 s +/- 50 ms

UC Time scale

Delta_T_UAM_2GHz (0.01 µs) (>0)

-1.15 s +/- 50 ms

Delta_UAM_TDI_2GHz (0.1 µs) ≈ 1.9 µs

T_0 antenna 2GHz/400MHz

TDI_2GHz

T_1 antenna 2GHz/400MHz

$3\ 10^7/F_{OUS}$

T3_datation_2GHz ($2.5/F_{OUS}$)
≈ 0.85 s (MB)

τ_3 antenna 2GHz/400MHz

T_3 detection 2GHz

$\tau_{m3-2GHz}$

5 ms=1/200 bits/s
(+/- 520µs)

2GHz UAM Time scale

4 µs

Phase_T_0_2GHz ($2\pi/2^{10}$)

Phase_T_1_2GHz ($2\pi/2^{10}$)

Phase_T_3_2GHz ($2\pi/2^{10}$)

(Phase_T_0_2GHz ($2\pi/2^{10}$) + $10^8/F_{OUS}$)

τ_{m2GHz}
≈ 46 µs

Delta_UAM_TDI_400MHz (0.1 µs) ≈ 1.8 µs

T_3 detection 400MHz

TDI_400MHz

T3_datation_400MHz ($2.5/F_{OUS}$)
≈ 0.85 s (MB)

400 MHz UAM Time scale

4 µs

$3\ 10^7/F_{OUS}$

$\tau_{m3-400MHz}$

5 ms=1/200 bits/s
(+/- 520µs)

Phase_T_0_400MHz ($2\pi/2^{10}$)

Phase_T_1_400Hz ($2\pi/2^{10}$)

Phase_T_3_400MHz ($2\pi/2^{10}$)

(Phase_T_0_400MHz ($2\pi/2^{10}$) + $10^8/F_{OUS}$)

$\tau_{m400MHz}$
≈ 57 µs

Delta_TDI_400MHz_2GHz (1/12 µs) (>0)
= $\tau_{m400MHz}$ - τ_{m2GHz} ≈ 57 µs – 46 µs

δTAI >0 Top SI late from TAI

T_{SI}

δTAI>0

T_3

TAI Time scale

2.7 s (MB) T_{p3}

τ_{m2GHz} : transit time Doppler measurement (2GHz phase center, detection UAM_2GHz) ≈ 46 µs
$\tau_{m400MHz}$: transit time Doppler measurement (400MHz phase center, detection UAM_400MHz) ≈ 57 µs
$\tau_{m3-2GHz}$: transit time T_3 (2GHz phase center, detection UAM_2GHz) ≈ 324 µs
$\tau_{m3-400MHz}$: transit time T_3 (400MHz phase center, detection UAM_400MHz) ≈ 864 µs
4 µs : transfer time for 40 bits phase measurement (Acos, Asin)

Master Beacon	$T_3 - T_{SI}$ = 2.1 s + 120 bits / 200 bits/s
Beacon 3rd generation	$T_3 - T_{SI}$ = 4.7 s + 120 bits / 200 bits/s
Beacon 1st, 2nd generation	$T_3 - T_{SI}$ = 4.9 s + 80 bits / 200 bits/s

Delta_F = $(F_{OUS}-10^7)/10^7$ (10^{-14})
Delta_Phase_2GHz = φ_0 à (T_0 2GHz + $10^8/F_{OUS}$) - φ_0 à (T_0 2GHz) ($2\pi/2^{10}$) chained mode
Delta_Phase_2GHz = φ_0 à (T_0 2GHz + $10^8/F_{OUS}$) - φ_1 à (T_0 2GHz + $3.10^7/F_{OUS}$) ($2\pi/2^{10}$) not chained mode
Delta_Phase_400MHz = φ_0 à (T_0 400MHz + $10^8/F_{OUS}$) - φ_0 à (T_0 400MHz) ($2\pi/2^{10}$) chained mode
Delta_Phase_400MHz = φ_0 à (T_0 400MHz + $10^8/F_{OUS}$) - φ_1 à (T_0 400MGHz + $3.10^7/F_{OUS}$) ($2\pi/2^{10}$) not chained mode

δTAI : time bias provided by CNES laboratoire Temps/Fréquence

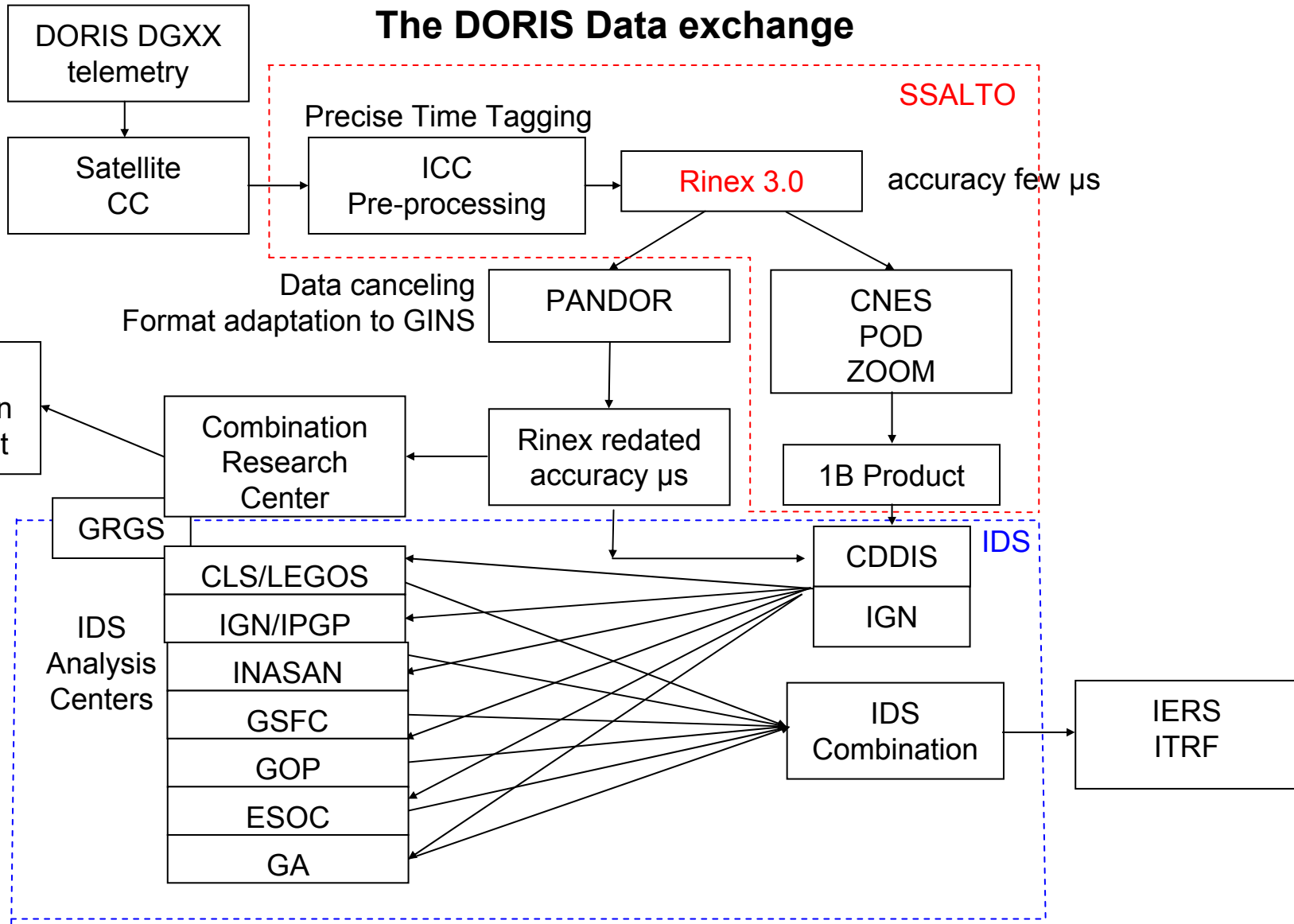D = Distance (Sat(T_{SI}+T_3+T_{p3}+δTAI), Sta(T_{SI}+T_3+δTAI))

T_{p3} = (D + Δtropo)/c ; after ionospheric correction

The DORIS Data exchange

DORIS DGXX telemetry

Satellite CC

Precise Time Tagging

ICC Pre-processing

Rinex 3.0   accuracy few µs

SSALTO

Data canceling
Format adaptation to GINS

PANDOR

CNES
POD
ZOOM

IERS Combination Pilot Project

Combination Research Center

Rinex redated accuracy µs

1B Product

GRGS

IDS Analysis Centers

CLS/LEGOS

IGN/IPGP

INASAN

GSFC

GOP

ESOC

GA

CDDIS

IGN

IDS

IDS Combination

IERS ITRF

The DORIS 1.0 RINEX product Data format

The Doris 1.0 RINEX format is an application of the standard Receiver Independent Exchange Format Version 3.0 issued by the Astronomical Institute University of Bern.

The RINEX format can be used for DORIS as it makes little assumption about the actual content of the data file, but only constrains the formatting of the data.

Reference documents :

-**Rinex Version 3.0 (Astronomical Institute University of Bern) dated 1st February 06**

@ www.aiub-download.unibe.ch/rinex

-**Rinex Doris 3.0 SALP-SP-M-EA-15578-CN Issue 1.1 dated 12th February 08**

Document providing details of algorithm for the Rinex computation :

-**Specification technique du traitement Doris/DGXX de niveau 1.0 (in French)**

The DORIS 1.0 RINEX product Data format

As for GNSS Rinex, the file consists of a header section and a data section.

Doris data in Rinex files are stored in chronological order.

Doris Rinex observables include three fundamental quantities :

Time , Phase , and Pseudo-Range .

It include also other information concerning the measurement :

Received power level , Oscillator relative frequency offset and meteorological data (pressure, temperature, humidity) .

Flags are added at each data type .

The DORIS 1.0 RINEX product Data format

Pseudo Range :

The pseudo-range is the distance from the station antenna to the satellite antenna including transmitter and receiver clock offsets and other biases, such as tropospheric and ionospheric delays.

In the DORIS system stations are not synchronized, so the pseudo-range reflects the behavior of the free running station clock.

However, the DORIS system contains a few time reference stations; These stations contain frequency standards that ensure a low short-term noise and long term variations in the time of these stations are permanently monitored with respect to TAI.

Pseudo-ranges for these stations are corrected for long term drifts with respect to TAI. Pseudo-ranges from these stations reflect the small short-term fluctuations of the station clocks, and they reference TAI on average.

The pseudo-range is stored in units of 0.01 kilometers.

Observables are not corrected for external effects like atmospheric refraction, etc.

The DORIS 1.0 RINEX product Data format

PHASE :

DORIS DGXX receivers measure the unambiguous received phase over a pass at two frequencies.

The phase measurement does not contain any systematic contribution from intentional offsets of the transmitter or receiver oscillators leading to non zero beat frequencies.

Introduction of the 2 Doris frequencies in the RINEX version 3.0 observation code :

System	Freq. Band	Frequency	Channel or Code	Observation Codes			
				Pseudo Range	Carrier Phase	Doppler	Signal Strength
DORIS	S1	2036.25		C1	L1	-	W1
	U2	401.25		C2	L2	-	W2

```
----|---1|0---|---2|0---|---3|0---|---4|0---|---5|0---|---6|0---|---7|0---|---8|0--
     3.00              O                       D                RINEX VERSION / TYPE
Expert             CNES                      20071220 154538 UTC PGM / RUN BY / DATE
G = GPS R = GLONASS E = GALILEO S = GEO M = MIXED D = DORIS COMMENT
Example of a DORIS RINEX FILE VERSION 3.00              COMMENT
The file contains Doris measurements performed by JASON2  COMMENT
Satellite on the nominal chain of a DGXX instrument       COMMENT
JASON-2                                              SATELLITE NAME
9205201                                              COSPAR NUMBER
STILO              CNES                              OBSERVER / AGENCY
CHAIN1             DGXX               1.00           REC # / TYPE / VERS
DORIS              STAREC                            ANT # / TYPE
     0.0921         1.0921          0.8647           APPROX POSITION XYZ
     0.1230         0.4560          0.7890           CENTER OF MASS: XYZ
D   10  L1  L2  C1  C2  W1  W2   F   P   T   H       SYS / # / OBS TYPES
  2001     8    21     0     0   39.0000000     DOR  TIME OF FIRST OBS
D  100   2  C1  C2                                   SYS / SCALE FACTOR
D        -2.000                                      L2 / L1 DATE OFFSET
    48                                               # OF STATIONS
D01  STJB ST JOHN S                         10 3   0 STATION REFERENCE
D02  TLHA TOULOUSE                          10 3   0 STATION REFERENCE
...
D47  EASB EASTER ISLAND                     10 3   0 STATION REFERENCE
D48  KRAB KRASNOYARSK                       10 3   0 STATION REFERENCE
    1                                               # TIME REF STATIONS
D02          0.000           0.000                  TIME REF STATION
  2001     8    21     0     0    0.0000000          TIME REF STAT DATE
                                                    END OF HEADER
> 2001 08 21 00 00 39.939956370  0  2       -1.084696938 0
D01  -1907631.062 1   -375988.691 1  32743488.281 1  32743301.603 1      -130.250 7
        -116.250 7      2361.256          1000.820 1        0.000 1        72.732 1
D02       -0.000 1        -0.000 1  32884249.705 2  32884916.645 2      -139.000 7
        -126.400 7      2361.256          1000.773 1       16.628 1        72.738 1
> 2001 08 21 00 00 42.939956370  0  2       -1.084696938 0
D01  -1805705.773 1   -355899.685 1  32744988.881 1  32744801.882 1      -130.250 7
        -116.250 7      2361.256          1000.820 1        0.000 1        72.732 1
D02    -53937.326 1    -10628.958 1  32883455.396 2  32884122.388 2      -139.000 7
        -126.400 7      2361.256          1000.773 1       16.628 1        72.738 1
```

TEST and VALIDATION

-Internal validation and comparison of the Rinex format with the previous Doris 1.0
 level product using simulated data have shown coherent results.

-Simulated Doris measurements have been used to produce over three days of
RINEX products files based on a prototype software .

-By mid April, equivalent RINEX products files will be available based on the
application software that will be used in routine.

$\Rightarrow$Point of contact for the validation :

Format :   emmanuel.lourme@cnes.fr
Orbit :   flavien.mercier@cnes.fr

CONCLUSION

This file will be produced once a day.

All the data provided in this file will have a time tagging accuracy of few µs and 1µs for the files redated after Pandor processing.

This file contains all the data needed to compute your own time tagging.

All the data of this file are as close as possible of the Raw Data.

All instrumental's corrections are applied to the Raw Data, and described at the beginning of the file.