CHARACTERISTICS FOR DORIS CALIBRATION AND POD PROCESSING

(Version 0.5)

ABREVIATIONS

Sigle	Definition
BDR	Boîtier DORIS Redondant
BOL	Beginning of life
CNES	Centre National d'Etudes Spatiales
CoG	Center of Gravity
CS-2	CRYOSAT2
DIODE	Détermination Immédiate d'Orbite par DORIS Embarqué
DORIS	Doppler Orbitography and Radiopositionning Integrated from Satellite
DR	Document de Référence
EoL	End of Life
ESA	European Space Agency
ESOC	European Space Operation Center
ITRF	International Terrestrial Reference Frame
TAI	Temps Atomique International (IAT: International Atomic Time)
TC	TeleCommand
TMD4	Test Module DORIS number 4
UT	Unité de Traitement (Processing unit)
UT1	Universal Time taking into account the pole movings
UTC	Universal Time Coordinate
WGS84	World Geodesic System (1984)

CONTENTS

1. PURPOSE OF THE DOCUMENT

This document describes the information required for :

- tuning the DORIS measurement processing. The values of different parameters are necessary to ensure optimal parametrisation of on-board software, and ground processing software.
- definition of a test orbit as much representative of the flight as possible. This test orbit will in particular be used for DORIS receivers acceptance tests.

Some of the following specifications may be difficult to fulfill in the early phases of a project (e.g. 1 kg accuracy on the mass). The required accuracy (REQ.AC.) values are those necessary for an ultimate accuracy of the orbit restitutions and/or for DIODE navigation function. Preliminary approximate values are required and accuracy of these values will be precised.

This document includes differents sections :

- chapter 3 concern the mission,
- chapter 4 concern the satellite,
- chapter 5 concern the DORIS receiver,
- chapter 6 specifies the so called “TMD4” or “flight like” test context at mission / system level.

2. APPLICABILITY

This document is applicable to the DORIS CRYOSAT2 project during its development, system test, flight acceptance and exploitation phases.

3. MISSION RELATED DATA DESCRIPTION

The CRYOSAT mission is described in DR1.

3.1. BEGINNING OF LIFE

The CRYOSAT2 satellite status at DORIS switch-on will be 3-axes stabilized and Earth pointed.

3.2. ORBIT CHARACTERISTICS

The orbital elements provided in this section are osculating elements.

The nominal orbit for CRYOSAT2 during the Science Phase of the mission will have orbital elements, with respect to the J2000.0 inertial frame, as follows (Cf. DR 4 V3.1 January 2007):

- Semi-Major axis a = 7095.348557673 km
- Eccentricity e = 0.001406846
- Inclination i = 92.000678420 °
- Right Ascension of Ascending Node Ω = 129.997076727 °
- Argument of Perigee ω = 115.619512345 °
- True Anomaly M = 283.899507188 °

The nominal satellite altitude of this orbit is 717.242 km.

This Science Phase orbit has a repeat cycle of 5344 revolutions in 369 days, with a sub-cycle of 30 days.

3.3. MANOEUVRES

This chapter is related to rough order of magnitude of typical manoeuvres in order to adapt the onboard software parametrisation

3.3.1. ORBIT ACQUISITION MANOEUVRES

As DORIS is assumed to be operational in this phase, the characteristics of each orbit acquisition manoeuvre shall be indicated (durations, directions and amplitudes of the thrusts).

- Delta V on 3 axes Radial, Along-Track, Across-Track (TBD meter / second) or Accelerations on 3 axes Radial, Along-Track, Across-Track (TBD meter / second**2).
- Duration (second)

3.3.2. ORBIT CONTROL MANOEUVRES

Orbit control manoeuvres :
. direction: along track,
., typical duration: 300 s,
. Δv = 0,03 m/s.

3.4. ATTITUDE MODE

The attitude control law for CRYOSAT2 is earth pointing, with the following characteristic:

- the flight direction is 6° from the positive x_s-axis;
- the direction to the local normal to the WGS84 ellipsoïd is 6° from the negative z_s-axis;
- the Ys axis is orthogonal to the satellite ground track if Yaw steering is enabled (nominal operation)

Note: $x_{s,,}$ y_s and z_s-axis are shown in Figure 4.1 below

The attitude control system makes use of magneto-torquers to provide control torques to the satellite. These are supported by use of small attitude control thrusters to maintain the attitude dead-band. The thrusters are aligned so that all provide thrust orthogonal to the flight direction, and are operated in pairs with the intention to provide a pure torque with no residual acceleration (some residual accelerations in either the cross-track or radial directions can occur due to manufacturing tolerances).

There is no need of real time attitude information transmitted to DORIS.

3.5. SATELLITE SAFEHOLD MODES (IF ANY)

There is one exceptional specific Satellite Safehold Mode in which DORIS may be switched OFF.

4. SATELLITE DESCRIPTION

In order to provide the most accurate information available at any time, the values will be reactualized :

- prior to launch, **not later than four months before the launch and one month before the last possibility of the on-board software upload before the launch**;
- during the satellite lifetime, if any major change occurs.

4.1. SATELLITE VIEW AND REFERENCE FRAME

The satellite flies in a "nose-down" attitude, inclined at 6° to the positive x_s-axis. The nadir direction is inclined 6° from the negative z_s-axis, as shown in figure 4.1.

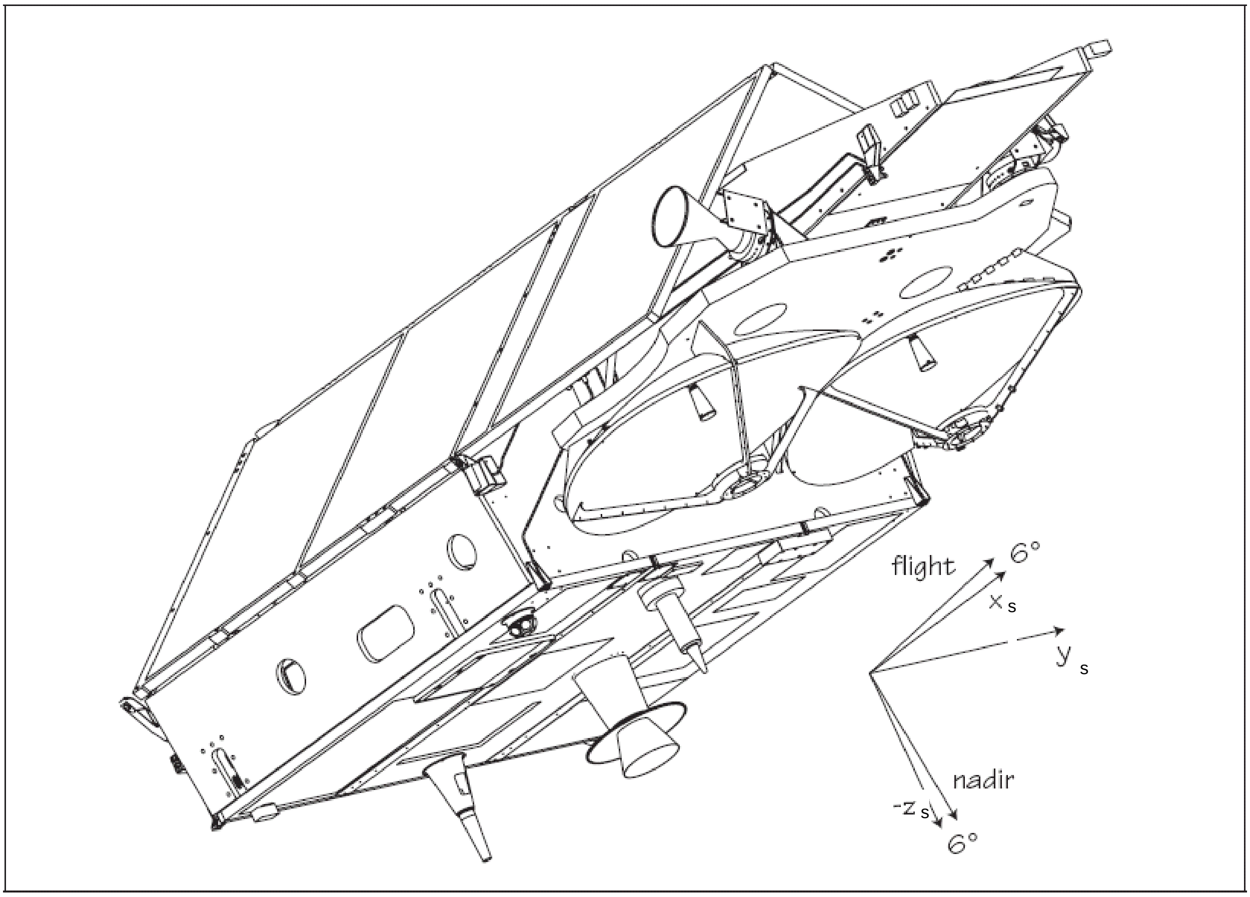


Figure 4.1 : view of the CRYOSAT2 satellite, indicating the reference frame (x_s, y_s, z_s).

4.2. SATELLITE MOBILE PARTS (IF ANY)

There are no moving parts.

4.3. MASS PROPERTIES

Originally CryoSat has been designed so that the centre of mass corresponds to the centre of a single, spherical fuel tank. Due to significant configuration changes for Cryosat2 however (redundant SIRAL, single box DORIS, etc) it is no more feasible to achieve that original design goal by counter balancing without violating the total launch mass requirement and the limiting requirements for the transversal Centre of Mass coordinates at launch.

Consequently the centre of mass will slightly move during the satellite lifetime. The standard format of manoeuvre report issued by the Flight Operation Centre at ESOC includes an estimate of the centre of mass position and the remaining satellite mass following every manoeuvre.

The location of the centre of mass and satellite mass at launch, and with various amount of propellant, are provided in Table 4.1:

Propellant	***Xcog (mm)***	***Ycog (mm)***	***Zcog (mm)***	***Mass (kg)***
Full (36.5 kg)	***1631,2 ± 1,9***	***11,2 ± 0,7***	***13,7 ± 0,7***	***724,6 +/- 0,4***
Half full (18.25 kg)	***1633,8 ± 1,9***	***11,5 ± 0,7***	***14,1± 0,7***	***706,4+/- 0,4***
Empty (0.0 kg)	***1636,6 ± 1,9***	***11,8 ± 0,7***	***14,4 ± 0,7***	***688.1 +/- 0,4***

Table 4.1 : CryoSat-2 centre of mass position and total mass at beginning of life (BOL), with half the propellant, and with an empty propellant tank (status 26 November 2009)

See DR7

Note: In order to take into account mean values during all the life the satellite, CNES will use the values that are compatible with the half-full tank.

4.4. SATELLITE SURFACES

4.4.1. 6 FACES SATELLITE MACROMODEL USED BY REAL-TIME POD

See DR3: CRYOSAT2 PRECISE ORBIT CONTEXT 2.0 February 2007

The six faces are orthogonal to the spacecraft reference frame axis ("box" model)

The CRYOSAT2 surface properties are provided in Tables 4.2 and 4.3 :

Surface	+X	-X	+Y	-Y	+Z	-Z
Area (m²)	2.515	2.515	5.114	5.114	8.882	8.882
Specular Reflectivity	0.063	0.047	0.048	0.040	0.015	0.132
Diffuse Reflectivity	0.093	0.096	0.066	0.066	0.056	0.085
Absorptivity (α)	0.844	0.857	0.887	0.894	0.929	0.784

Table 4.2: CRYOSAT2 surface properties in the visible (ultra-violet) spectrum

Surface	+X	-X	+Y	-Y	+Z	-Z
Area (m²)	2.515	2.515	5.114	5.114	8.882	8.882
Specular Reflectivity	0.023	0.015	0.017	0.014	0.005	0.054
Diffuse Reflectivity	0.175	0.182	0.124	0.127	0.110	0.150
Emissivity (ε)	0.802	0.803	0.859	0.859	0.885	0.796

Table 4.3: CRYOSAT2 surface properties in the infrared spectrum

4.4.2. 7 FACES SATELLITE MACROMODEL USED BY OFF-LINE POD

USED BY POD TEAM AT CNES (SEPTEMBER 2010). SEE ANNEX 5

(IR part is directly derived from ESA macromodel).

Surface m2	**Normal Unit Vector in satellite reference axes**			**Visible**			**Infrared**		
	X	Y	Z	specular	scattered	absorbed	specular	scattered	absorbed
2.4722	1.	0.	0.	0.2839	0.0000	0.7161	0.0230	0.1750	0.8020
2.4490	-1.	0.	0.	0.4980	0.0000	0.5020	0.0150	0.1820	0.8030

5.8445	0.	0.6112	0.7915	0.1796	0.0357	0.7846	0.0050	0.1100	0.8850
5.8445	0.	-0.6112	0.7915	0.1796	0.0357	0.7846	0.0050	0.1100	0.8850
2.2399	0.	0.9792	-0.2031	0.3299	0.2046	0.4655	0.0170	0.1240	0.8590
2.2399	0.	-0.9792	-0.2031	0.3299	0.2046	0.4655	0.0170	0.1240	0.8590
8.4229	0.	0.	-1.	0.3664	0.4764	0.1572	0.0540	0.1500	0.7960

4.5. DORIS ANTENNA REFERENCE FRAME W.R.T. SATELLITE REFERENCE FRAME

The reference point (i.e. origin of the antenna reference frame) is defined by the intersection between the RF axis (revolution axis which is the z-axis) of the antenna and the mounting plate. The axis x_a and y_a are printed on the bottom of the antenna. Although the satellite flies in a “nose-down” attitude inclined at 6° to the x_s-axis, the antenna is pointed to nadir (Z_a).

Distance X (mm)	Distance Y (mm)	Distance Z (mm)
1815,5	-200,0	-440,75

Table 4.4 : coordinates and orientation of the DORIS antenna baseplate reference point in the satellite reference frame.

See Annex 2 : e-mail from ASG

The tilt between Xs/Xa axis of the satellite frame and antenna frame is 6°. Consequently, the tilt between -Zs/Za axis of the satellite frame and antenna frame is also 6°.

4.6. DORIS ANTENNA ENVIRONMENT

There is no identify mask in the antenna field of view.

4.7. CABLE LOSSES

Losses due to onboard cables in dB for each channel from the antenna connectors to the BDR interface connectors.

Parameters	**Calibrated value**	**acc.**
Losses (400 MHz channel)	0.34 dB	0.1 dB
Losses (2 GHz channel)	0.67 dB	0.1 dB
Cable length (400 MHz channel)	< 2m	0.1 m
Cable length (2 GHz channel)	< 2m	0.1 m

Table 4.5 : Cables losses and length

These values are required to compute link budget and define level thresholds.

See Annex 2 : e-mail from ASG

4.8. STAR TRACKERS

- Alignment matrix of STR1 wrt satellite control frame:

0.9999549960	0.0091873092	-0.0023677330
-0.0091811203	0.9999544448	0.0026106179
0.0023921600	-0.0025887568	0.9999937844

- Alignment matrix of STR2 wrt satellite control frame:

0.9999916938	0.0009046486	-0.0039869928
-0.0039820381	0.4227511939	-0.9062369985
0.0008593392	0.9062453361	0.4227512548

- Alignment matrix of STR3 wrt satellite control frame:

0.9999941001	0.0024147932	0.0024270864
-0.0031962963	0.4224188273	0.9063951687
0.0011746557	-0.9063975407	0.4224240898

Cf. ANNEXE 4

5. DORIS INSTRUMENT DESCRIPTION

The following parameters will be used both for the test orbit, and for processing. They shall be representative of the DORIS receiver characteristics.

5.1. DORIS RECEIVER PARAMETERS

Parameters	measured value	acc.
IT3 transit time on board 400 MHZ UT1 to 8	863 µS	+/- 1 µS
IT3 transit time on board 2 GHZ UT1 to 8	324 µS	+/- 1 µS
Doppler transit time 400 MHZ UT1 to 8	62,5 µS	+/- 1 µS
Doppler transit time 2 GHZ UT1 to 8	52,4 µS	+/- 1 µS
Sensibility of the 400 MHz IT3 transit time wrt Doppler frequency	0,18 s	+/- 1.0^{e}-3
Sensibility of the 2 GHz IT3 transit time wrt Doppler frequency	0,18 s	+/- 1.0e-3

Table 5.1: DORIS receiver parameters

See Annex3: e-mail from Thales for the transit times.

See DR6 for the justification of the values "sensibilities"

5.2. ANTENNA GAINS

Antenna gains tabulations :

Acc. = +/- 1dB

$\theta_{onboard}$ value (angle between the antenna z-axis and the propagation direction)	Values of gains (dBi) on the 400 MHz channel	Values of gains (dBi) on the 2 GHz channel
$\theta_{onboard} = 0°$	5	4
$\theta_{onboard} = 10°$	4.5	4
$\theta_{onboard} = 20°$	4	4
$\theta_{onboard} = 30°$	3	3
$\theta_{onboard} = 40°$	2,5	3
$\theta_{onboard} = 50°$	1	2
$\theta_{onboard} = 60°$	0	1

Table 5.2: DORIS antenna gains (Cf. DR2)

These values are required to compute the link budget and define level thresholds.

5.3. ANTENNA PHASE CENTRE

The antenna phase centres for both 400 MHz and 2 GHz channels are defined in the antenna reference frame.

Both antenna phase centres are assumed to be on the antenna z-axis. The following table gives the distances from the DORIS antenna reference point to the DORIS antenna center of phase Cf. DR2:

Frequency	Measured distance X (mm)	Measured distance Y (mm)	Measured distance Z (mm)	Req. acc.	Accuracy
401.25	0.	0.	- 158	10 mm	+/- 5 mm
2036.25	0.	0.	- 312	5 mm	+/- 2 mm

Table 5.3: DORIS antenna centers of phase coordinates (in the antenna reference frame)

5.4. ANTENNA PHASE LAWS

Elevation Antenna phase pattern shall be reported in the following table for the 400MHz and 2 GHz. (Cf. DR2)

Received phase $\psi(\theta_{onboard}) = Cte + X(\theta_{onboard})$.

$X(\theta_{onboard})$	$X(\theta_{onboard})$ 2GHz	$X(\theta_{onboard})$ 400MHz
0	0	0
10	0	0
20	0	0
30	0	0
40	0	0
50	0	0
60	0	0

6. TEST ORBIT CONTEXT

6.1. TEST DURATION

The whole test duration shall be about 12h.

See DR5.

6.2. ORBITAL PARAMETERS

The Reference orbit used for the satellite simulations is defined by the following initial bulletin (state vector) :

Parameters	Value
Initial TAI date	July 4th 2010 ; 48850 ss
Initial X position in the ITRF reference frame	6393834.592 m
Initial Y position in the ITRF reference frame	-3086245.561 m
Initial Z position in the ITRF reference frame	-8290.848 m
Initial Xdot relative velocity wrt ITRF reference frame	-338.827851 m/s
Initial Ydot relative velocity wrt ITRF reference frame	-699.684521 m/s
Initial Zdot relative velocity wrt ITRF reference frame	7490.011888 m/s

6.3. MANOEUVERS CHARACTERISTICS

Cf. DR5

Parameters	Value
Manoeuver beginning date	July 5th 2010 ; sec of day 7200
Delta V (Radial)	0.0 m/s
Delta V (Along-Track)	0.03 m/s
Delta V (Across-Track)	0.0 m/s
Manoeuver duration	300 s

6.4. ATTITUDE PARAMETERS

There is no TC attitude on DORIS CRYOSAT2.

6.5. ASSUMED ENVIRONMENTAL CONDITIONS

For the orbit simulation a reference set of environmental and earth parameters shall be defined and shall be representative of the conditions at the time of the reference orbit.

6.5.1. POLE POSITION
Cf. DR3

U_pole = 0.128894 arcsecond
V_pole = 0.296220 arcsecond

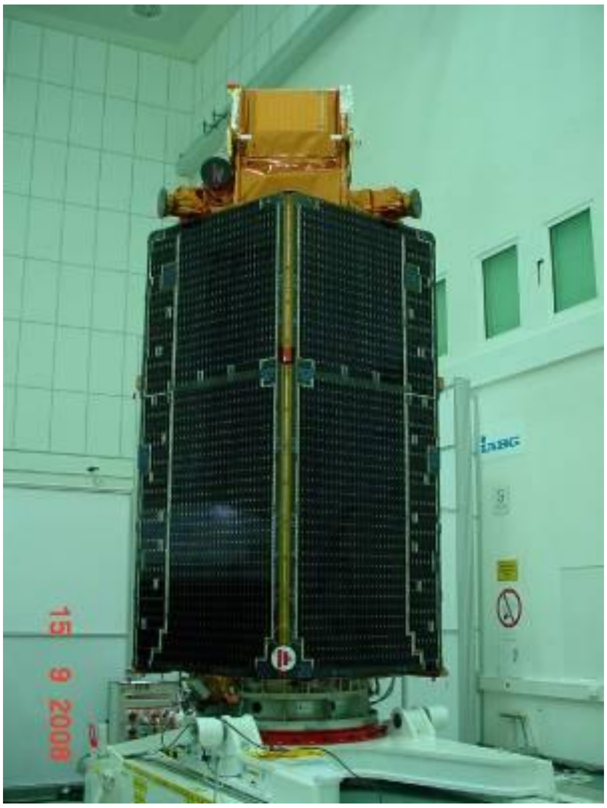
6.5.2. TIME REFERENCE
Cf. DR3

TAI-UTC = 33 s (in accordance with DR3)
UT1-UTC value = -0.5 s

7. SATELLITE PHOTOGRAPHS

+X view A

+Z view



-Y Solar Array

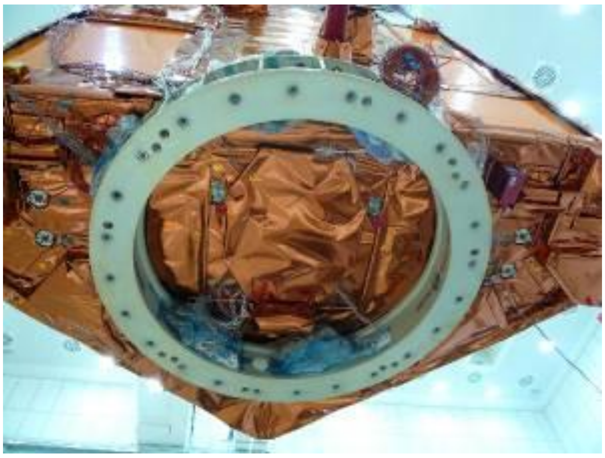
+Y side view

+Y Solar Array

Nadir View

+X view B

-X view.jpg



-Y side view.jpg

ANNEX 1:

CryoSat-2 Mass Properties Synthesis

4 Cryoat-2 Mass Property Summary

This chapter provides a summary of the most important mass property parameters contained in the present document.

The spacecraft flight configuration comprises

- The CryoSat-1 launcher adapter, including its MLI & fixation H/W (total 8,532kg)
- An amount of 36,5 kg GN2 at BOL

Spacecraft Mass & CoG

Mass S/C [kg]	Mass GN2 [kg]	X_{COG} [mm]	Y_{COG} [mm]	Z_{COG} [mm]
718,9 ± 2,0	36,5	1645,9 ± 5,1	10,9 ± 0,7	13,5 ± 0,7
700,7 ± 2,0	18,25	1648,9 ± 5,1	11,2 ± 0,7	13,9 ± 0,7
682,4 ± 2,0	0	1652,1 ± 5,1	11,5 ± 0,7	14,3 ± 0,7
		Wrt. S/C reference frame		

Spacecraft MoIs /PoIs

6° M/PoI [kg*m²]		
6°MoIxx	302,7	[kgm²]
6°MoIyy	944,9	[kgm²]
6°MoIzz	1053,6	[kgm²]
6°MoIxy	-0,9	[kgm²]
6°MoIyz	-0,9	[kgm²]
6°MoIzx	-7,5	[kgm²]

w.r.t. S/C control reference frame originated at S/C CoG

Principal MoI [kg*m²]:	
6°PMoIxx =	302,7
6°PMoIyy =	944,9
6°PMoIzz =	1053,6

	In Flight Principle Axis Alignment Angles [°]:			
Axis		Xsc	Ysc	Zsc
Roll	6°PMoIxx =	0,5713	89,9154	89,4293
Pitch	6°PMoIyy =	90,1386	0,4844	89,5358
Yaw	6°PMoIzz =	90,5698	90,4770	0,5872

Alignment Angles of Principle Axis MoIs w.r.t. Flight Control Reference Frame

ANNEX 2:

De: Jaeger, Klaus [Klaus.Jaeger@astrium.eads.net]

Envoyé: mercredi 4 juin 2008 11:46

À: Schiavon Francoise

Cc: Auriol Albert; Caille, Raphael; Christoph Goetz; ESA BuscaglioneFabio; Rausch, Achim

Objet: AW: Cryosat2 mass properties, references points for DORIS antennas

Hello Francoise,

To continue the mail below:

The DORIS antenna reference point has the SC coordinates: x=1815.5mm, y=-200mm, z=-440.75mm. This is the point of intersection of antenna axis and I/F plane between antenna and antenna bracket. SC mass properties will follow.

Regards

Klaus

Hallo Francoise,

I have seen several e-mails on your questions below. As your questions are related to the info given in the calibration plan, DCY2-PL-0-EA-15863-CN, version 0.1, 06.11.2006, I refer also to the relevant chapters. Unfortunately I cannot give you final answers today but I inform you on the status:

- mass properties, see chapter 4.3: currently we cannot give more reliable data than those in this chapter. An update of the SC mass properties is currently in progress considering the latest H/W deliveries. It will be ready in about 4 weeks. Be aware that the final confirmation by test is only in October.

- DORIS Antenna reference point, chapter 4.5: the CS-1 data should not change but we would like to verify them which needs a few days, I will inform you asap.

There are some more tbd´s in subject document which I would like to comment:

- chapter 4.7, cable losses: 400MHz: -0.34dB, 2GHz: -0.67dB, see attachment.

- chapter 5.1, DORIS receiver parameters: should come from CNES/THALES

- chapter 5.3, antenna phase center: values given by Raphael in mail 16th May (the accuracy is +,-5mm for 400 MHz and +,-2mm for 2 GHz see antenna ADP).

- chapter 5.4, antenna phase lows: I do not really know what you need therefore I would prefer if you (your expert) takes this info from the antenna ADP (Part-2-REM..., Appendix6) to make sure that you take the right values? I have put it on the CryoSat FTP server directory "CNE"

- chapter 6, orbit: should be reviewed by ESA.

Regards

Klaus

CryoSat-2 P/L Engin´ing & Launcher I/F

Astrium, an EADS Company

Friedrichshafen Germany

Phone / Fax: +7545-8-4155 / -3376

Mail: Klaus.Jaeger@astrium.eads.net

ANNEX 3

-----Message d'origine-----
De : Etienne Dubocquet [mailto:etienne.dubocquet@fr.thalesgroup.com]
Envoyé : vendredi 15 février 2008 14:57
À : Auriol Albert
Cc : .MAILLARD Denis; .POTIER Thierry; .BOUCHET Marc
Objet : Temps de transit : DGXX vs CS-2

Bonjour Albert,

suite à ta demande, nous avons rapidement (compte tenu du temps imparti) analysé les résultats de Tpg pour le BDR CRYOSAT-2.
En première approche, il n'y a pas de différence notable sur les résultats.
Ci après les résultats pour le BDR CRYOSAT-2 (les résultats pour DGXX sont dans l'email ci attaché) :

Temps de propagation interne mesuré lors de la recette des récepteurs :
TPG voie 2G : 52,4 us
TPG voie 400M : 62,5 us

Temps de transit modulation estimés à partir des résultats de test TMD6-02/Balise2 (moyenne sur 2 tests) à température et pression ambiante :
Tpg400M = deltaT3_400M + EBT_400M + delta_TDI = 850,5 + 2,7 + 10 = **863,2 us (863 us pour DGXX)**
Tpg2G = deltaT3_2G + EBT_2G = 323,0 + 0,7 = **323,7 us (324 us pour DGXX)**

Cordialement

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==
Etienne DUBOCQUET
THALES SYSTEMES AEROPORTES
EWS/I2S

Centre Charles Nungesser, 2 avenue Gay Lussac
78851 ELANCOURT cedex,FRANCE

tel : +33 (0) 1 34 81 78 43
fax : +33 (0) 1 34 81 72 22
e-mail : etienne.dubocquet@fr.thalesgroup.com
==

ANNEX 4

De : Stefano.Pessina@esa.int [mailto:Stefano.Pessina@esa.int]

Envoyé : mercredi 14 avril 2010 09:05

À : Cerri Luca

Cc : Christoph Goetz; Bailly-Poirot Francoise; Franco.Marchese@esa.int; Schiavon Francoise; Xavier.Marc@esa.int

Objet : Re: TR: AOCS operations the 11 April

Dear Luca,

nice to hear from you again.

The STR depointing bias you showed in your plots could be due to a misalignment in body-fixed axes.

After a quick check, the bias angles you reported are suspiciously similar to those between nominal and actual (measured) STR-1 alignment (in Control reference frame).

Please find attached some numerical data and comparisons (with citation of reference documentation as well).

Kind regards

Stefano Pessina

```
% Default AOCS S/W Parameter Values for Cryosat-2,
% Doc title: Default AOCS S/W Parameter Values
% Doc. No: CS-RS-DOR-DC-0024
% Issue: 4.2
% Date: 09.02.09
%   3.3.1.3.4 STR Alignment Transformation
TCdefault_A_C_STR1 = [ ...
0.9999549960            0.0091873092            -0.0023677330
-0.0091811203           0.9999544448            0.0026106179
0.0023921600            -0.0025887568           0.9999937844       ];
% Alignment Matrix of STR1 wrt. Satellite control frame
(NOTE: Rotates from STRx to CTRL frame)

TCdefault_A_C_STR2 = [ ...
0.9999916938            0.0009046486            -0.0039869928
-0.0039820381           0.4227511939            -0.9062369985
0.0008593392            0.9062453361            0.4227512548       ];
% Alignment Matrix of STR2 wrt. Satellite control frame
(NOTE: Rotates from STRx to CTRL frame)

TCdefault_A_C_STR3 = [ ...
```

```
0.9999941001            0.0024147932            0.0024270864
-0.0031962963           0.4224188273            0.9063951687
0.0011746557            -0.9063975407           0.4224240898      ];
% Alignment Matrix of STR3 wrt. Satellite control frame
(NOTE: Rotates from STRx to CTRL frame)


%Nominal STR mounting
Nominal_A_C_STR1 = [ ...
1.0         0.0         0.0
0.0         1.0         0.0
0.0         0.0         1.0    ];
% Alignment Matrix of STR1 wrt. Satellite control frame
(NOMINAL as from Doc. No: CS-MA-DOR-SY-0001, CUM Iss.8, vol.1, pag 4-267)

Nominal_A_C_STR2 = [ ...
1.0  0.0  0.0
0.0  0.42261826  -0.90630779
0.0  0.90630779  0.42261826         ];
% Alignment Matrix of STR2 wrt. Satellite control frame
(NOMINAL as from Doc. No: CS-MA-DOR-SY-0001, CUM Iss.8, vol.1, pag 4-267)

Nominal_A_C_STR3 = [ ...
1.0  0.0  0.0
0.0  0.42261826  0.90630779
0.0  -0.90630779  0.42261826          ];
% Alignment Matrix of STR3 wrt. Satellite control frame
(NOMINAL as from Doc. No: CS-MA-DOR-SY-0001, CUM Iss.8, vol.1, pag 4-267)


EulerAngles_RotationSequence=[1 2 3]
RPY_depointing between (Nominal_A_C_STR1,TCdefault_A_C_STR1) in [deg]
        -0.149577977499138        -0.135661234670472        -0.526402921509842
RPY_depointing between (Nominal_A_C_STR2,TCdefault_A_C_STR2) in [deg]
       -0.0086171057642303       -0.0495657763879626        -0.228941076300046
RPY_depointing between (Nominal_A_C_STR3,TCdefault_A_C_STR3) in [deg]
       -0.0124718814817191       -0.0666243986846942        -0.184505638463548
```

Stefano Pessina Space Flight Dynamics consultant Space

Terma GmbH

at ESA/ESOC, OPS-GFT
European Space Operations Centre
Robert Bosch St. 5
D-64293 Darmstadt, Germany

T   +49 6151 90 3183 (direct)
T   +49 6151 86005 0 (Terma GmbH)
F   +49 6151 90 2067
E   Stefano.Pessina@esa.int
W   www.terma.com, www.esa.int

Terma GmbH - Sitz Darmstadt
Handelsregister: AG Darmstadt - Handelsregisternummer: HRB 7411
Geschäftsführer: Poul Vigh / Morten Halskov

ANNEX 5

-----Message d'origine-----

De : Cerri Luca [mailto:luca.cerri@cnes.fr] Envoyé : mercredi 28 juillet 2010 18:19 À : ids.awg@ids-doris.org Objet : [IDS AWG] CRYOSAT-2 Models for POD and Positioning

Dear DORIS analysts,

As you know CRYOSAT-2 DORIS data is now available since arc number 008.

Data before arc 008 has not been delivered so far due to several station

acquisition maneuvers and attitude events that make processing quite difficult and of limited interest for precise positioning applications.

The purpose of this message is to provide you with the necessary information to process Doris data as we are currently doing it in our software at CNES.

1) ATTITUDE MODEL AND REFERENCE AXES: (ref 1)

In nominal attitude conditions, the SIRAL antenna-bench reference frame (AB)

can be defined by:

Z_AB axis is directed as the normal to the ellipsoid,

Y_AB = Z_AB x V_ITRF, where V_ITRF is the satellite velocity in the

Earth-Fixed reference frame, so that X_AB is directed along the satellite

ground-track.

The satellite reference frame (SAT) is tilted of 6 degrees around the y axis of

the antenna bench, the matrix to transform SAT coordinates in AB coordinates being

```
SAT-->AB = [ 0.9945    0.0000    0.1045
             0.0000    1.0000    0.0000
            -0.1045    0.0000    0.9945]
```

So X_sat is roughly directed along the direction of flight, except for occasional

yaw flips that will be announced by ESOC.

All the coordinates that follow are given in the SAT reference frame.

2) MASS , CoM COORDINATES, MANEUVERS

Mass (kg) 724.6 kg

x/y/z (m) 1.6312 / 0.0112 / 0.0137

Mass/CoM evolution

ftp://ftp.ids-doris.org/pub/ids/satellites/cs2mass.txt

Maneuvers are reported in file

ftp://ftp.ids-doris.org/pub/ids/satellites/cs2man.txt

3) DORIS ANTENNA (ref. 3)

reference point coordinates (m) : 1.8155 / -0.2000 / -0.44075

antenna axis unit vector : 0.1045 / 0.0000 / -0.9945

2GHz/400MHz phase center pos. Along axis (m) : 0.312 / 0.158

4) SLR ANTENNA (ref 3)

optical center coordinates (m) : 1.8085 / -0.9350 / -0.450

antenna axis unit vector : 0.1045 / 0.0000 / -0.9945

range correction: currently using 0.019 m , manufacturer model available

5) ESA MACROMODEL (ref 1)

Satellite surfaces and optical/infrared properties can be found in ref 1.

6) CNES MACROMODEL

F. Mercier from CNES POD Team has computed an alternative 7-plates model that you might want to test.

(IR part is directly derived from ESA macromodel).

surface/ (m^2)	normal unit vector in sta ref axes		
2.4722	1.	0.	0.
2.4490	-1.	0.	0.
5.8445	0.	0.6112	0.7915
5.8445	0.	-0.6112	0.7915
2.2399	0.	0.9792	-0.2031
2.2399	0.	-0.9792	-0.2031
8.4229	0.	0.	-1.

C visible			infrared		
C spec	diff	abs	spec	diff	abs
[					
0.2839	0.0000	0.7161	0.0230	0.1750	0.8020
0.4980	0.0000	0.5020	0.0150	0.1820	0.8030
0.1796	0.0357	0.7846	0.0050	0.1100	0.8850
0.1796	0.0357	0.7846	0.0050	0.1100	0.8850

0.3299	0.2046	0.4655	0.0170	0.1240	0.8590
0.3299	0.2046	0.4655	0.0170	0.1240	0.8590
0.3664	0.4764	0.1572	0.0540	0.1500	0.7960

]

Don't hesitate to ask if you have any question.

Kind regards

Luca Cerri

References

[1] Cryosat-2 Precise Orbit Context

ftp://ftp.ids-doris.org/pub/ids/satellites/CryoSat-2_Precise_Orbit_Context.pdf

[2] Cryosat-2 characteristics for DORIS calibration and POD processing

ftp://ftp.ids-doris.org/pub/ids/satellites/CryoSat-2_CharacteristicsForDORIScalibrationPODprocessing.pdf

[3] E-mail from C. Goetz, here attached