HY-2

INPUT DATA FOR HY2 PRECISE ORBIT DETERMINATION

(issue 3.0)

CNES – 18, avenue E. Belin 31401 Toulouse cedex 9 – Tel: 0561273131

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ABBRÉVIATIONS

Acronym	Definition
BDR	Redundant DORIS Box
LRA	Laser Reflector Array
SA	Solar Array
SC	SpaceCraft
POD	Precise Orbit Determination

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1. PURPOSE OF THE DOCUMENT

This document describes the information required to ensure optimal parameterisation of on-board and ground POD processing software in the HY2 context.

2. APPLICABILITY

This document is applicable to the HY2 project during the development, system test, and flight acceptance and operation phases.

3. OVERALL MISSION DESCRIPTION

A complete description of the mission is necessary, in order to perform DORIS mission analysis.

3.1. BEGINNING OF LIFE

At DORIS switch-on the satellite is:

- 3-axes stabilized
- Earth pointed

3.2. PLANNED CHANGES OF THE ORBIT

For each Mission Orbit, the characteristics are detailed in the following paragraph.

3.3. MISSION ORBIT CHARACTERISTICS

Two different orbits will be used during the mission (see NSOAS Slides).

3.3.1. LAUNCH ORBIT

The Launch Orbit is defined as :

- Semi major axis : 7288.477km
- Inclination: 99.33532°
- Eccentricity rat: 0.00044
- RAAN: 202.714°

3.3.2. OPERATION ORBIT 1

The ORBIT 1 is defined as:

- Repeat cycle Days: 14
- Semi major axis : 7341.732km，average height: 970.732km
- Inclination: 99.34015°
- Eccentricity: 0.00117
- Intersection period: 104.4560min
- Cycle number: 193，13+11/14 ring per day
- Intercept in equator: 207.64km
- Heliosynchronous, descending node: 6:00 am

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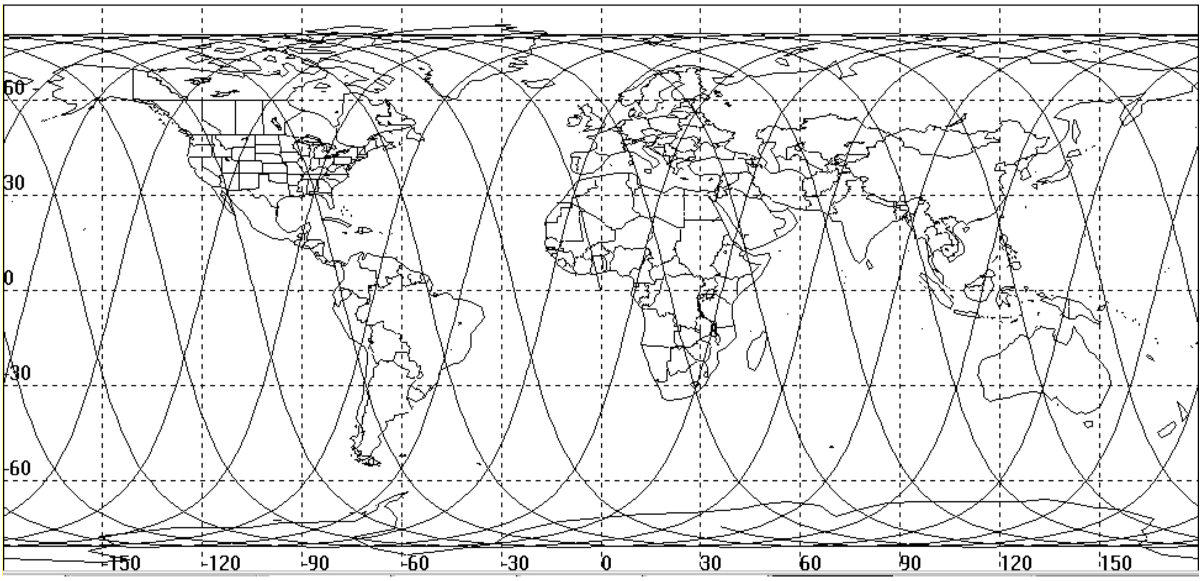
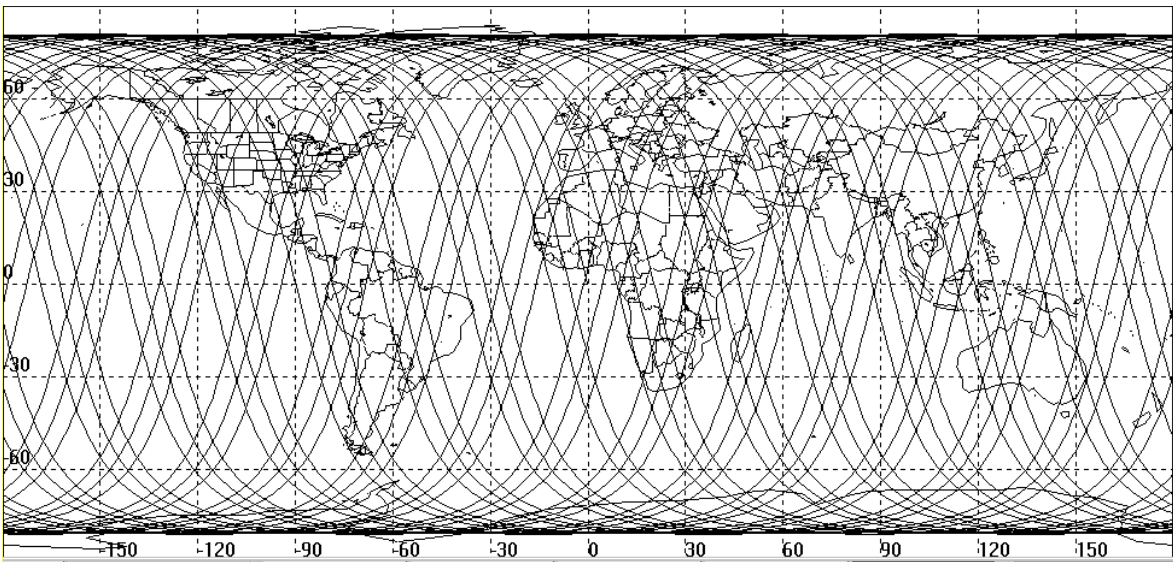


One day track

3.3.3. OPERATION ORBIT 2

The ORBIT 2 is defined as:

- Repeat cycle days: 168
- Semi major axis: 7343.836km，average height: 972.836km
- Inclination: 99.34015°
- Eccentricity: 0.00117
- Intersection cycle: 104.5008min
- Total number of one cycle: 2315，13+131/168 ring every day
- Intercept in equator 17.31km
- Heliosynchronous, descending node: 6:00am



3 days track

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3.4. ORBIT CONTROL MANOEUVERS

3.4.1. FROM LAUNCH ORBIT TO OPERATION ORBIT1

SC will take 15 days from launch orbit to operation orbit 1, and hold 2 days in the same orbit altitude. The DORIS data should give the SC to decide the next orbit manoeuvre.

3.4.2. OPERATION ORBIT

The orbit manoeuvres during the SC operation period are:

- Objective: Keeping the precise orbit altitude
- Directions: along flight axis
- Frequency of manoeuvres: about 30 days

3.5. ATTITUDE MODE

3.5.1. NOMINAL ATTITUDE

The attitude is controlled by inertial wheels.

The nominal attitude of the satellite is built to be zero at the satellite reference frame orientation.

The nominal attitude of the satellite shall be described in order to build at any time the satellite reference frame orientation with the following accuracy:

- Pointing precision: Pitch, roll and yaw in local orbital frame <0.1°
- Measure precision: pitching, roll and yaw < 0.05°
- Three axis pose stability <0.003°/s

3.5.2. ATTITUDES CHANGES

Any attitudes change from nominal law should be described. For example, if altimeter calibration manoeuvres are planned they shall be described here after, attitude evolution before and after the orbit control manoeuvre: TBD

3.6. SATELLITE SAFEHOLD MODES

In order to avoid DORIS receiver reference clock ageing recovery leading in POD degradation it is recommended to maintain DORIS ON during satellite safe hold modes.

On board HY2 DORIS is on during safe hold mode.

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4. SATELLITE DESCRIPTION

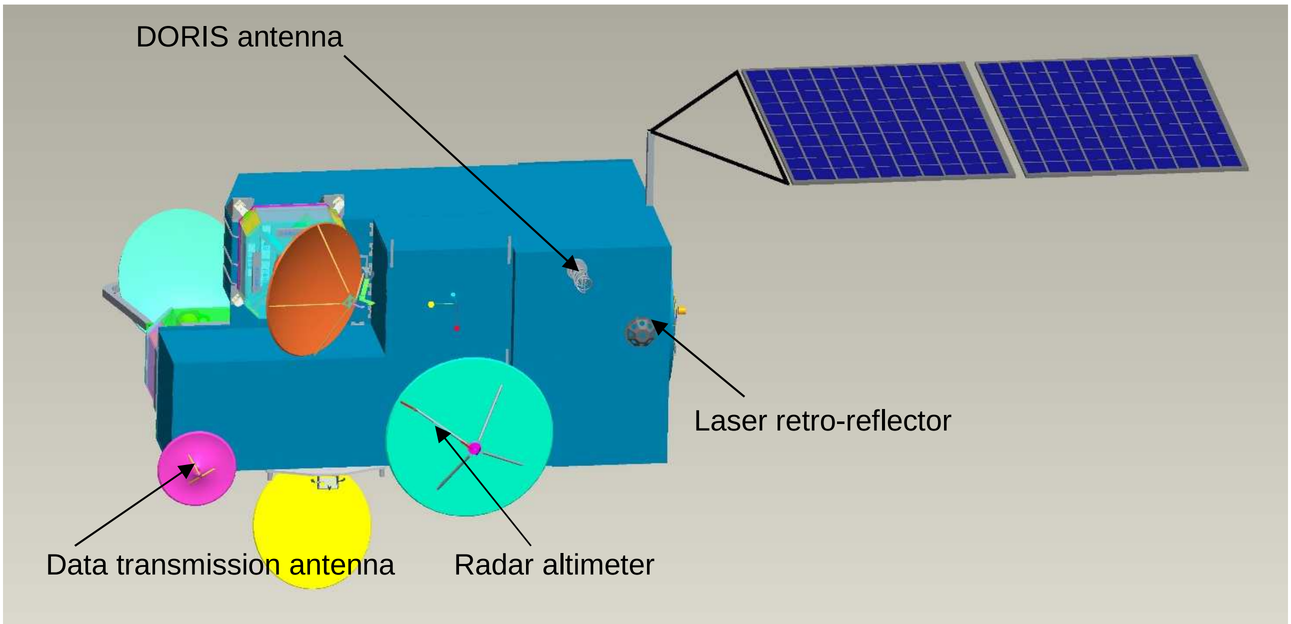
The following parameters shall be representative of the satellite characteristics; in order to reach the performances needed by the mission.

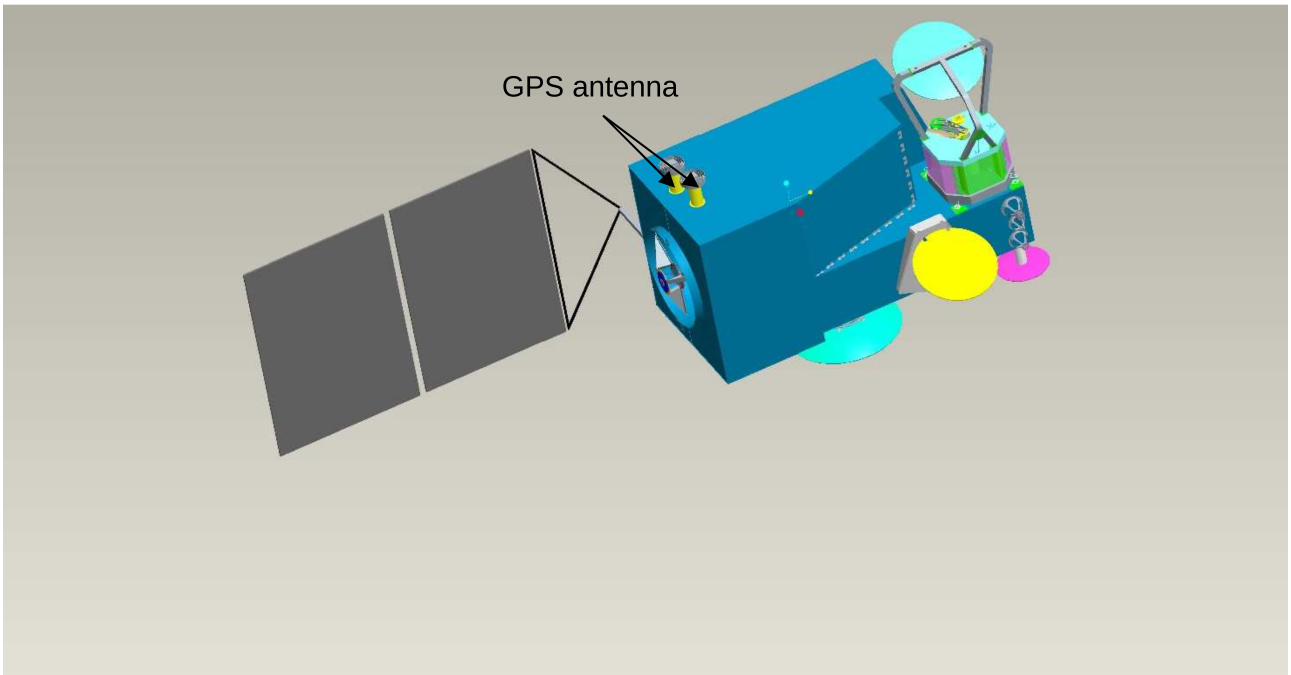
These values need to be updated during the satellite lifetime, if any major change occurs.

4.1. SATELLITE VIEW AND REFERENCE FRAME

A view of the satellite in flight configuration, indicating the satellite reference frame (X, Y and Z directions) is shown here after. The direction of the nadir is consistent with Z+ axis. The satellite speed is consistent with X axis.

The DORIS antenna shall be signalled on the graph, and also other RF transmitting equipment.





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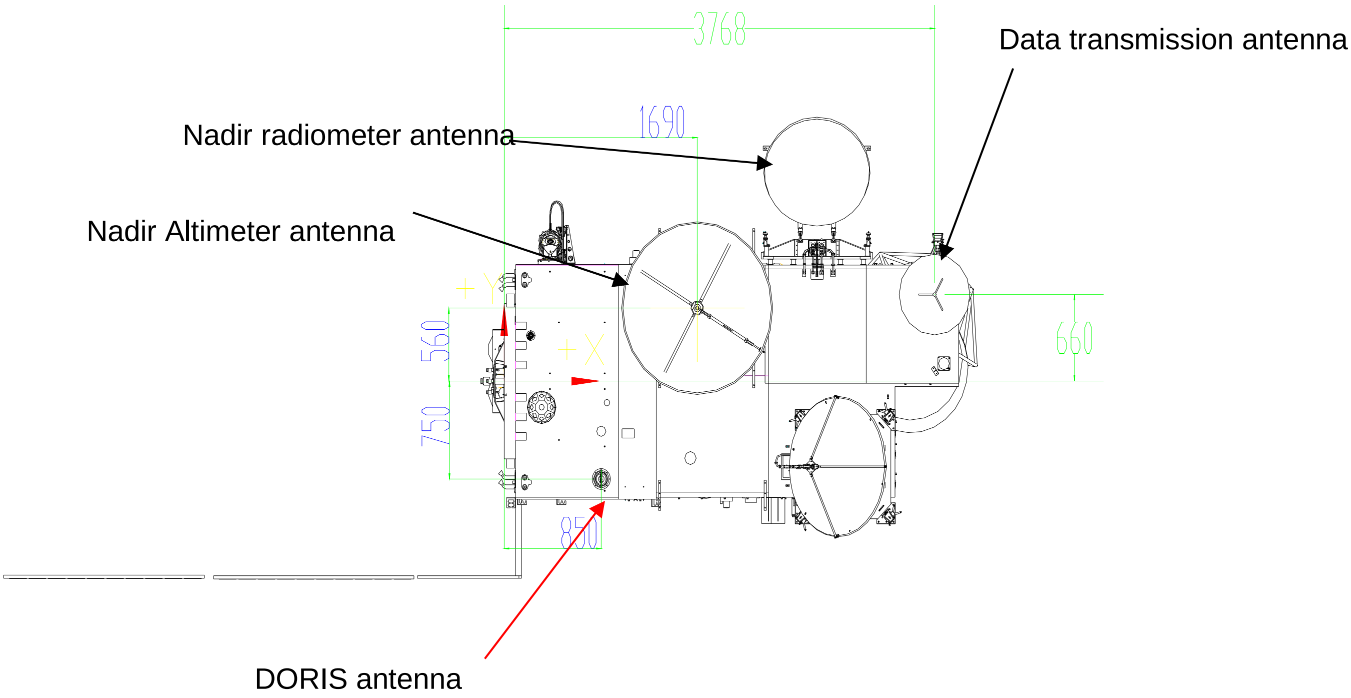

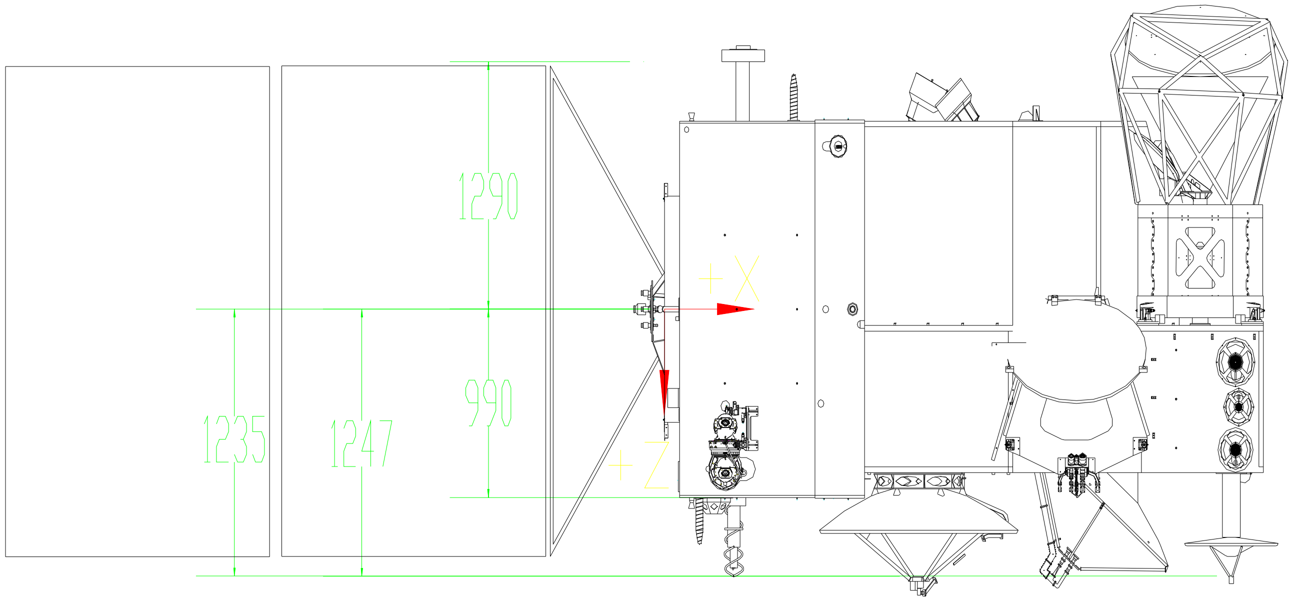

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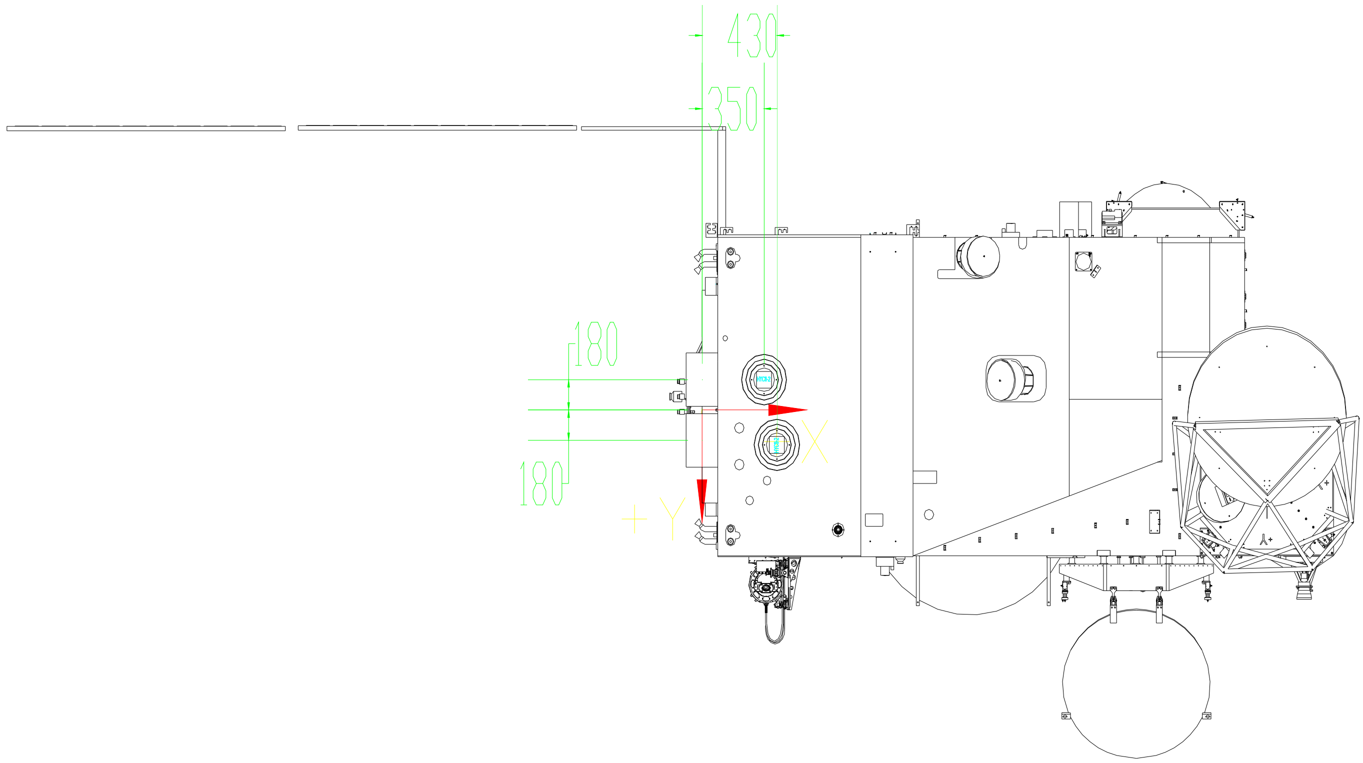
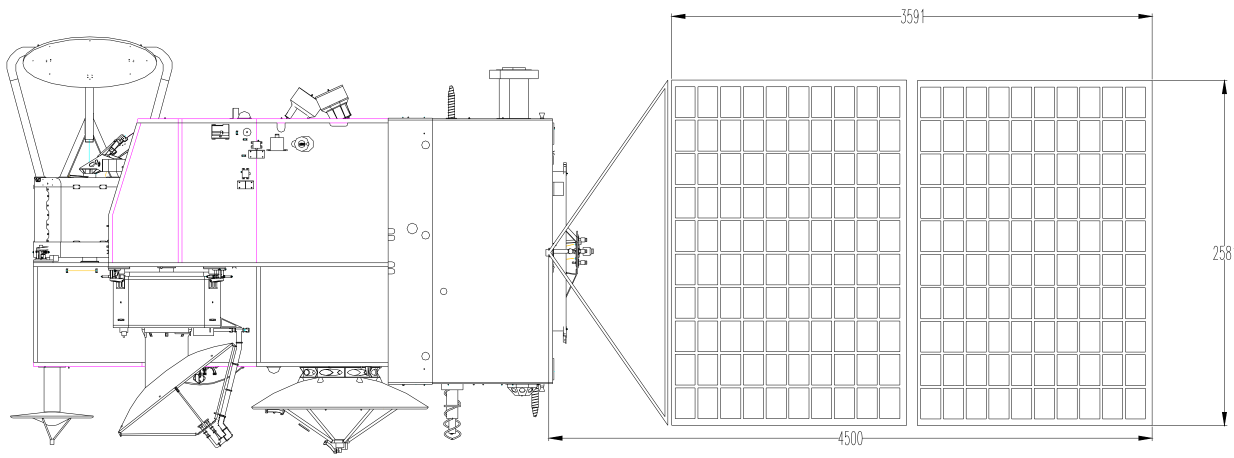


The dimensions of each SA panel in the next picture:



Satellite launch status is following in figure 1,Satellite nominal status on orbit is following in figure 2.

4.2. SATELLITE ORBIT COORDINATE SYSTEM (O-$X_0Y_0Z_0$)

Orbit Coordinate System is a right-handed orthogonal coordinate system with origin in the satellite centre of mass. The Z0-axis is pointing towards the centre of the earth, X0-axis to the direction of

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satellite’s velocity, and Y0-axis completes the coordinate system such that it is right-handed and orthogonal.

4.3. SATELLITE NAVIGATION REFERENCE COORDINATE SYSTEM (O- $X_S Y_S Z_S$)

Axes XS, YS, ZS represent an orthogonal reference system related to the satellite (satellite axes). With perfect geocentric pointing, this gives:

$$O\vec{X}_s = O\vec{X}_0\,;\quad O\vec{Y}_s = O\vec{Y}_0\,;\quad O\vec{Z}_s = O\vec{Z}_0$$

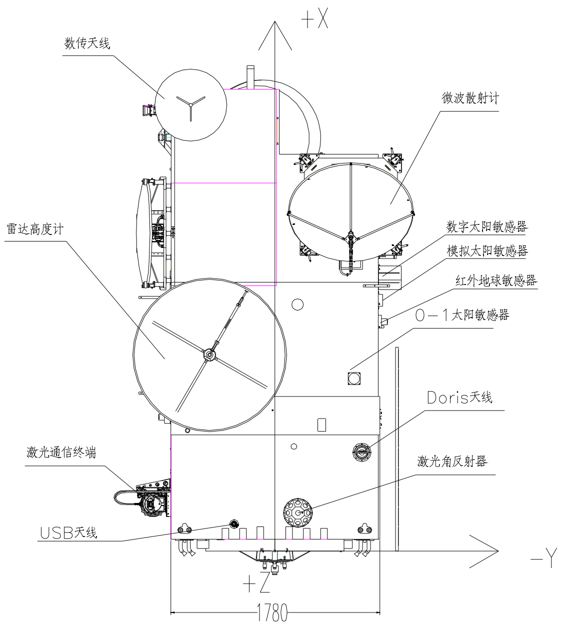

Figure 1 HY-2 Satellite Orbit Coordinate System

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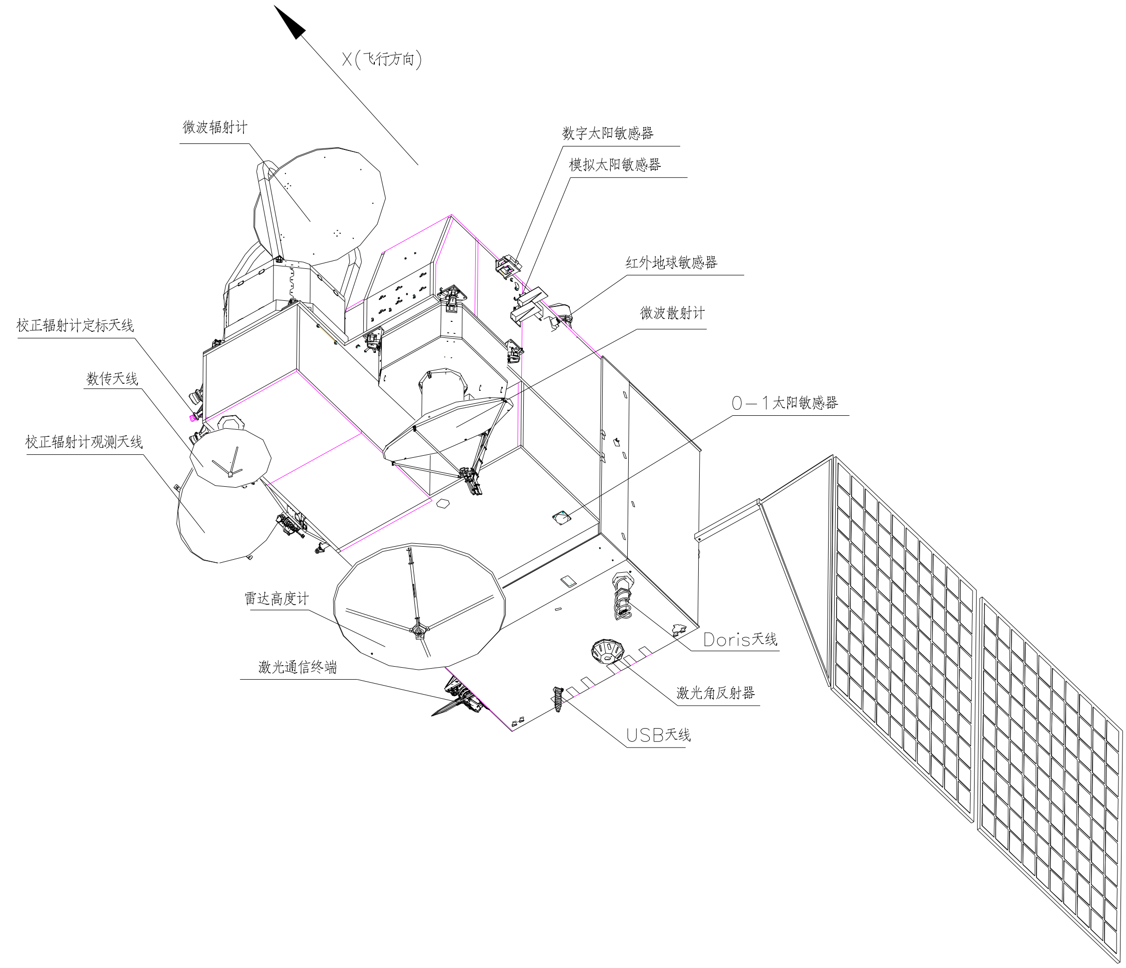

Figure 2 HY-2 Satellite Navigation Status on orbit

4.4. SATELLITE MOBILE PARTS

4.4.1. SOLAR ARRAY

Dimensions of SA are given in the satellite view here above

The impact of the motion of SA on the centre of mass is including in the paragraph mass properties here after.

4.4.2. OTHER

Mass, size and motion of other moving parts on board HY2 (if any) shall be precised.

4.5. MASS PROPERTIES

The values of:

- Beginning of Life Satellite mass (before orbit acquisition manoeuvre),
- Nominal Satellite total mass (beginning of mission, including moving parts if any),
- End of Life Satellite Mass

Shall be given with accuracy better than 1.0 kg.

The Centre of Mass coordinates shall be given in the Satellite Reference Frame with accuracy better than 2 mm.

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The Centre of Mass coordinates uncertainties and their evolution during the satellite lifetime shall be precised. During the operational mission the evolution of the satellite mass and gravity centre shall be provided if changes exceed 1mm in CoG and 1Kg.

The values shall be updated regularly in operation if relevant.

	Satellite mass (kg)	**X_cog (mm)**	**Y_cog (mm)**	**Z_cog (mm)**
Beginning of life	1550	1331.64	16.05	0.85
Operational mission	1550	1246.39	0	0.85
End of life	1464	1393.01	-0.14	0.90

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4.6. SATELLITE RADIATION PRESURE MODEL

The following values are used to build the radiation pressure model.

The satellite surface properties and solar panel shall be given:

- External Geometry satellite
- Thermo optical surface properties (Seculars Absorbed Diffuse in Visible and Infrared)
- Power (W) dissipated during typical operation by each radiating surface.

In addition, lessons learnt from previous DORIS mission's show that photos of each face of the satellite in final configuration are useful. These photos shall be annexed to the present document. In order to have a complete set of photos defining the satellite sequences of photos are necessary.

- One before SA mounting in order to show the radiators without any mask;
- One in final configuration before launch.
- One of the SA in deployed configuration (for example during SA deployment test). The both faces shall be shown.

Thermo optical characteristics of the different materials (specular, absorbed, and diffuse) in visible and infrared shall be displayed related to the pictures. Required accuracy: better than 10%.

With this data the CNES build the SC box and wing simplified model which is a standard input for orbit determination.

Projected areas of radiator

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SC box and wing simplified model		X+	X-	Y+	Y-	Z+	Z-	SA+ (Toward sun)	SA-
Projected area (m^2)		0.7065	0.603	0.887	0	1.504	1.801	9.056	9.056
Power dissipated typical operation (W)		151	110	166		299	281	4250	4600
Typical mean temperature in operation (°C)		-10	-20	-25		-15	-30	42	40
Visible	Specular	0	0	0		0	0	0	0
	Diffuse	0.85	0.85	0.73		0.85	0.85	0.365	0.06
	Absorbed	0.15	0.15	0.27		0.15	0.15	0.635	0.94
Infrared	Specular	0	0	0		0	0	0	0
	Diffuse	0.21	0.21	0.13		0.21	0.21	0.16	0.06
	Absorbed	0.79	0.79	0.87		0.79	0.79	0.84	0.94

Projected areas of multilayer

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SC box and wing simplified model		X+	X-	Y+	Y-	Z+	Z-
Projected area (m²)		2.5	2.92	5.85	6.74	4.93	4.6
Power dissipated typical operation (W)		217	252	199.2	3874	836	243
Typical mean temperature in operation (°C)		-56	-56	-101	75	-16.5	-81.7
Visible	Specular	0	0	0	0	0	0
	Scattered	0.54	0.54	0.54	0.54	0.54	0.54
	Absorbed	0.46	0.46	0.46	0.46	0.46	0.46
Infrared	Specular	0	0	0	0	0	0
	Scattered	0.31	0.31	0.31	0.31	0.31	0.31
	Absorbed	0.69	0.69	0.69	0.69	0.69	0.69

4.7. DORIS ANTENNA REFERENCE POINTS

The DORIS Antenna Reference Point is defined by the intersection of the antenna Z axis (revolution axes) and the mounting plane. The DORIS Reference point coordinates shall be given in the satellite reference frame with accuracy better than 1 mm

X Coordinate of the DORIS reference point (m): 0.850

Y Coordinate of the DORIS reference point (m): -0.750

Z Coordinate of the DORIS reference point (m): 1.010

DORIS antenna RF axis assumed orthogonal to the mounting plane is consistent with satellite Z axis with accuracy better than 1°.

NB: DORIS antenna RF axis shall be nominally pointed towards geocentric.

4.8. DORIS ANTENNA ENVIRONMENT

Masks shall be nominally avoided in the field of view of the antenna. However, if any limited mask remains it shall be carefully described: size, distance from the antenna, RF characteristics.

Masks, emitting/reflecting surfaces will lead to an accommodation feasibility study.

4.9. CABLE LOSSES

Losses due to onboard cables for each channel from the antenna bracket to the BDR bracket, including intermediate connector brackets if any.

	400 MHz	**2 GHz**
Losses (dB)	**0.1 +/- 0.01 dB**	**0.2 +/- 0.01 dB**
Attenuation drift	**0.3%/C°**	**0.3%/C°**
Phase stability	**0.02°/m/GHz/°C**	**0.02°/m/GHz/°C**

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Cable length (m)	**0.55 +/- 0.01 m**	**0.55 +/- 0.01 m**

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

5. DORIS INSTRUMENT DESCRIPTION

This data shall be gathered from acceptance data package.

5.1. DORIS RECEIVER PARAMETERS

The following parameters are necessary to process the DORIS data.

400 MHZ IT3 transit time UT1 to 7
= 863 E-06 second +/- 1 microsecond

Sensibility of the 400 MHz IT3 transit time WRT Doppler frequency
=0,178 s +/-0.01s

2 GHZ IT3 transit time UT1 to 7
= 324 E-06 second +/- 1 microsecond

Sensibility of the 2 GHz IT3 transit time WRT Doppler frequency
=0, 18 s +/-0.01s

400 MHZ Doppler delay UT1 to 7
= 62.5 E-06 second +/- 1 microsecond

2 GHZ Doppler delay UT1 to 7
= 52.4 E-06 second +/- 1 microsecond

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5.2. DORIS ANTENNA GAINS

Antenna gains tabulations:

$\theta_{onboard}$ value (angle between the onboard geocentric centripetal axis, and the propagation direction)	Values of gains (dBi) on the 400 MHz channel Accuracy = 1 dB	Values of gains (dBi) on the 2 GHz channel Accuracy = 1 dB
$\theta_{onboard} = 0°$	4.5	4
$\theta_{onboard} = 10°$	4.3	4
$\theta_{onboard} = 20°$	4	3.8
$\theta_{onboard} = 30°$	3.5	3
$\theta_{onboard} = 40°$	2.5	2.5
$\theta_{onboard} = 50°$	1	1.5
$\theta_{onboard} = 60°$	-0.8	0.5
$\theta_{onboard} = 70°$	-3	-1

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

5.3. DORIS ANTENNA PHASE CENTER

The antenna phase centres for both 400 MHz and 2 GHz channels shall be defined in the antenna reference frame, with accuracy better than 2 mm.

400 MHz Phase centre: 154 mm

2 GHz Phase centre: 316 mm

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5.4. DORIS ANTENNA PHASE LAWS

Azimuth and Elevation Antenna phase laws shall be described according to the phase centre defined here above

	Azimuth Received phase ψ(θonboard) = Cte x ψ(θonboard) + X(θonboard).	
X(θonboard)	**X(θonboard) 2GHz**	**X(θonboard) 400MHz**
0		
10	**+/-1.5**	**+/-1.0**
20	**+/-2.0**	**+/-1.0**
30	**+/-2.0**	**+/-1.5**
40	**+/-2.0**	**+/-1.5**
50	**+/-2.0**	**+/-2.0**
60	**+/-2.0**	**+/-3.0**

	Elevation Received phase ψ(\onboard) = Cte + X(\onboard).	
X(\onboard)	**X(\onboard) 2GHz**	**X(\onboard) 400MHz**
0	**+/-1.5**	**+/-1.5**
22.5	**+/-1.5**	**+/-1.5**
45	**+/-1.5**	**+/-1.5**
67.5	**+/-1.5**	**+/-2.5**
90	**+/-1.5**	**+/-2.5**
112.5	**+/-1.5**	**+/-3.0**
135	**+/-2.5**	**+/-2.5**
157.5	**+/-2.5**	**+/-2.5**

Required. Accuracy. : +/- 2° (2 GHz) and +/- 4° (400 MHz)

Accuracy (2GHz) : +/- 1.9°

Accuracy (400 MHz) : +/- 1°

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6. LASER REFLECTOR ARRAY (LRA) DEFINITION

A view of the LRA shall be provided, indicating in the satellite reference frame (X, Y and Z directions) the position of the reference point (optical centre). Range corrections shall be also provided.

The 3-D location of the phase centre of the LRA relative to a satellite-based origin:

The phase centre of LRA is only for normal incidence of laser beam.

X Coordinate of the phase centre of LRA (m): +0.311

Y Coordinate of the phase centre of LRA (m): -0.268

Z Coordinate of the phase centre of LRA (m): +1.068

The range correction of LRA from spherical centre is 0.074m.

The position and orientation of the LRA reference point (LRA mass-centre or marker on LRA assembly) relative to a satellite-based origin:

The spherical centre point (reference point) of LRA is:

X Coordinate of the spherical centre point (reference point) of LRA (m): +0.311

Y Coordinate of the spherical centre point (reference point) of LRA (m): -0.215

Z Coordinate of the spherical centre point (reference point) of LRA (m): +0.984

The LRA mass-centre point Coordinate is:

X Coordinate of the mass-centre point of LRA (m): +0.311

Y Coordinate of the mass-centre point of LRA (m): -0.215

Z Coordinate of the mass-centre point of LRA (m): +1.055

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7. GPS INSTRUMENT DESCRIPTION

Some geometrical and electrical information are needed to use the GPS data in the POD.

7.1. GPS ANTENNA

The data needed for the GPS antennae are for each antenna at each frequency channel L1 L2

7.1.1. GPS ANTENNA PHASE CENTRE

The GPS antenna phase centre point coordinates for each frequency channel shall be given in the satellite reference frame with accuracy better than 1 mm.

GPS antenna 1

L1

X_1 Coordinate of the GPS antenna phase (m): +0.349

Y_1 Coordinate of the GPS antenna phase (m): -0.179

Z_1 Coordinate of the GPS antenna phase (m): +1.367

L2

X_1 Coordinate of the GPS antenna phase (m): +0.349

Y_1 Coordinate of the GPS antenna phase (m): -0.179

Z_1 Coordinate of the GPS antenna phase (m): +1.389

GPS antenna 2

L1

X_2 Coordinate of the GPS antenna phase (m): +0.429

Y_2 Coordinate of the GPS antenna phase (m): +0.180

Z_2 Coordinate of the GPS antenna phase (m): +1.366

L2

X_2 Coordinate of the GPS antenna phase (m): +0.429

Y_2 Coordinate of the GPS antenna phase (m): +0.180

Z_2 Coordinate of the GPS antenna phase (m): +1.388

7.1.2. GPS ANTENNA PHASE CALIBRATION

The phase diagram of the GPS Antennae at each frequency channel are needed

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7.1.3. GPS ANTENNA AXES

The antenna axes orientation shall be given in the satellite reference frame with the accuracy better than 1 degree.

X Coordinate of the GPS antenna axes orientation in the satellite reference frame (°): 90

Y Coordinate of the GPS antenna axes orientation in the satellite reference frame (°): 90

Z Coordinate of the GPS antenna axes orientation in the satellite reference frame (°): 180

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