HY-2C

# INPUT DATA FOR HY2C PRECISE ORBIT DETERMINATION

**(issue 1.0)**

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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 HY 2C context.

# 2. APPLICABILITY

This document is applicable to the HY-2C project during the development, system test, and flight acceptance and operation phases.

# 3. OVERALL MISSION DESCRIPTION

A complete description of the mission is necessary.

## 3.1. PLANNED CHANGES OF THE ORBIT

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

## 3.2. MISSION ORBIT CHARACTERISTICS

Two different orbits will be used during the mission (HY-2Ground Segment NSOAS <-> CNES ICD).

### 3.2.1. OPERATION ORBIT 1

The ORBIT 1 is defined as:

- Repeat cycle Days: 10
- Semi major axis : 7328.583km，average height: 957.583km
- Inclination: 66°
- Eccentricity: 0.000012
- Intersection period: 104.1048min
- Cycle number: 137，13+7/10 ring per day
- Intercept in equator: 292.5185km

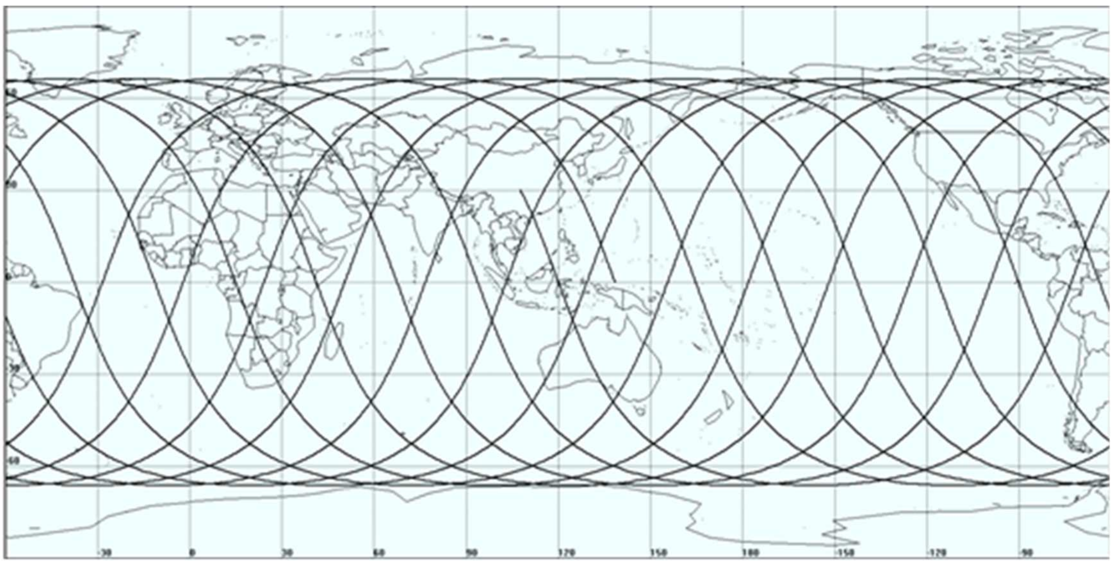


Figure 1 One day track

### 3.2.2. OPERATION ORBIT 2

The ORBIT 2 is defined as:

- Repeat cycle days: 400
- Semi major axis: 7329.490km，average height: 958.490km
- Inclination: 66°
- Eccentricity: 0.000012
- Intersection cycle: 104.1241min
- Total number of one cycle: 5479，13+279/400 ring every day

Intercept in equator: 7.3143km

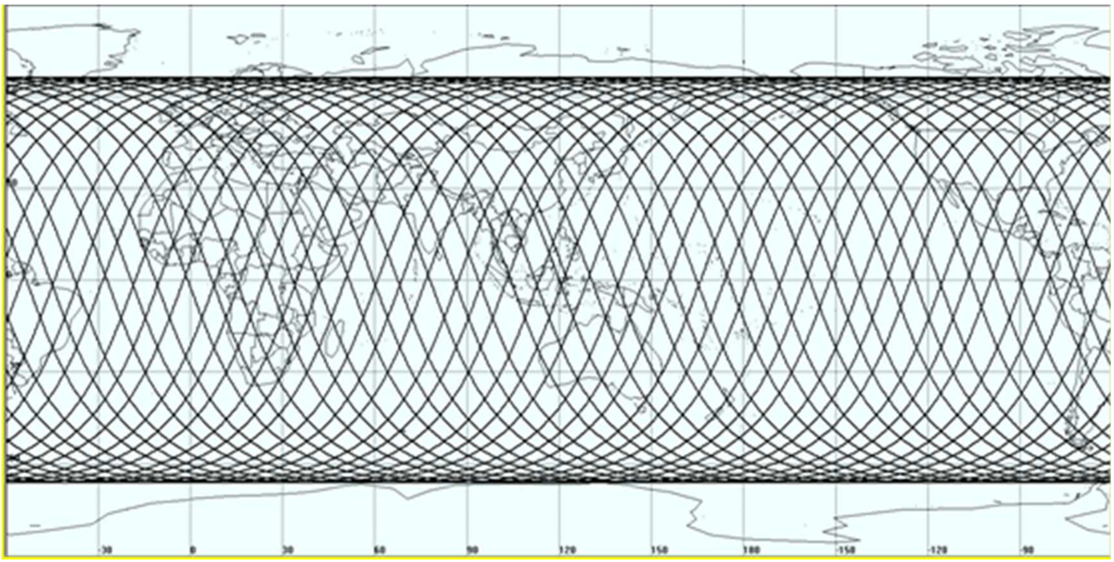


Figure 2 3 days track

## 3.3. ORBIT CONTROL MANOEUVERS

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

## 3.4. ATTITUDE MODE

### 3.4.1. NOMINAL ATTITUDE

The attitude is controlled by inertial wheels.

The nominal attitude of the satellite uses yaw steering model, with the X- axis pointing towards the sun and the Z+ axis pointing towards the earth surface. The specific yaw steering model is as follows (where $\beta_{min}$ =-1.5°， $\beta_{max}$ =75°) :

$$\psi_T = \begin{cases} \frac{\pi}{2}\operatorname{sgn}(\beta), & |\beta| > \beta_{max} \\ \psi_{2T}, & \beta_{min} < \beta < \beta_{max} \\ \psi_{1T}, & -\beta_{max} < \beta < \beta_{min} \end{cases}$$

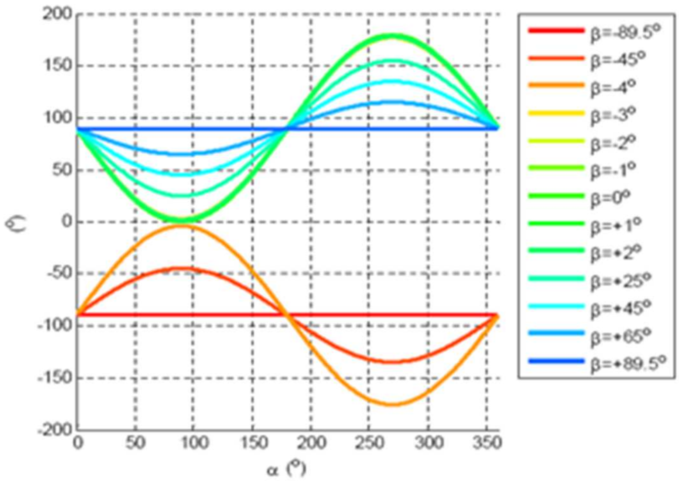



Figure 3 Yaw attitude

Where $\psi_{2T}$ is the sine curve in the range of | β | and 180° -| β |, and $\psi_{1T}$ is the sine curve in the range of -180° +| β | and -| β |.

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 < 0.03°
- Three axis pose stability <0.003°/s

### 3.4.2. 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*

*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.*

The attitude during manoeuvres is built to be around zero at the satellite reference frame orientation with Earth surface-pointed.

## 3.5. SATELLITE VIEW AND REFERENCE FRAME

1. Satellite Orbit Coordinate System(O-$X_0Y_0Z_0$)

Orbit Coordinate System is a right-handed orthogonal coordinate system with origin in the satellite center of mass. The $Z_0$+ axis is pointing towards the center of the earth, $X_0$+ axis to the direction of satellite's velocity, and $Y_0$+ axis completes the coordinate system such that it is right-handed and orthogonal.

2. Satellite Navigation Reference Coordinate System(O- $X_SY_SZ_S$)

$X_S$,$Y_S$,$Z_S$ represent an orthogonal reference system related to the satellite (satellite axes). With perfect geocentric pointing, this gives:

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

3. Satellite Navigation Body Coordinate System(O- $X_BY_BZ_B$)

Satellite Navigation Body Coordinate System is a right-handed orthogonal coordinate system with origin in the center of satellite-rocket separation surface. The $Z_B$+ axis is pointing towards the Nadir Altimeter antenna within the satellite-rocket separation surface, $X_B$+ axis to the longitudinal direction which is perpendicular to the satellite-rocket separation surface, and $Y_B$+ axis completes the coordinate system such that it is right-handed and orthogonal.

$O\vec{X}_s, O\vec{Y}_s, O\vec{Z}_s$ rotates according to the attitude $\psi_x$, $\psi_y$, $\psi_z$ respectively with the order of yaw-roll-pitch, and reaches $O\vec{X}_B, O\vec{Y}_B, O\vec{Z}_B$.

A view of the satellite in flight configuration is shown here after.

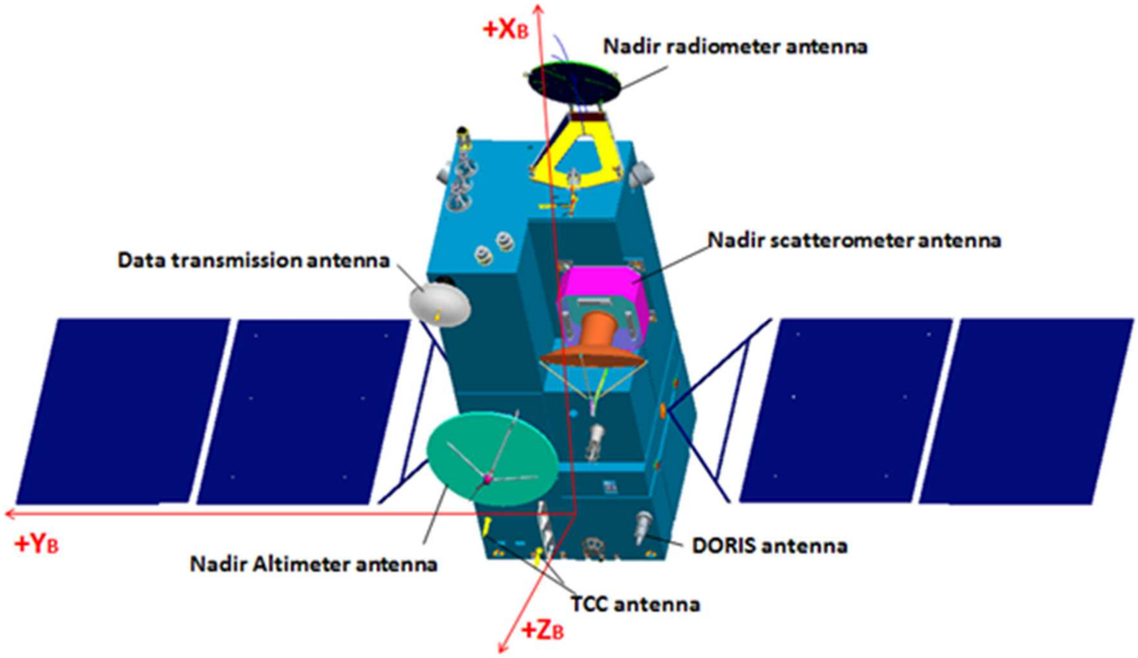



Figure 4 Satellite nominal status

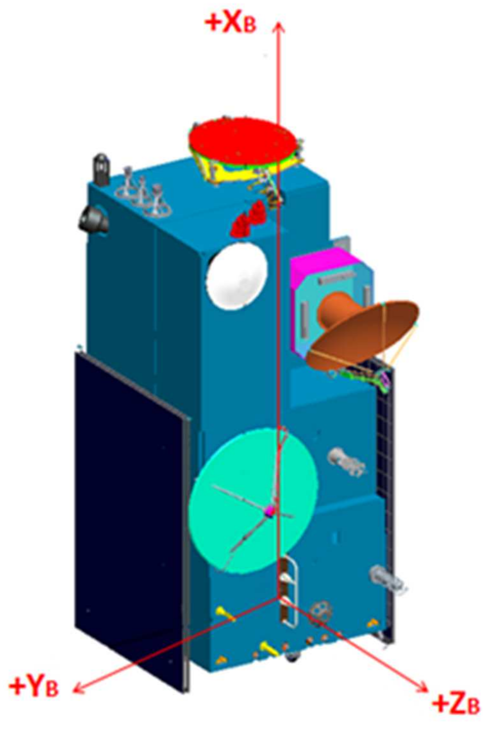


Figure 5 Satellite launch status

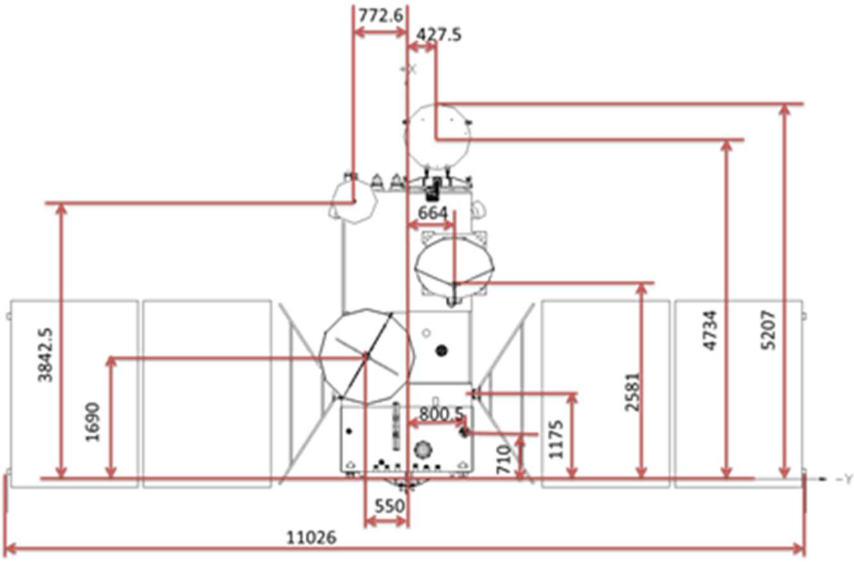
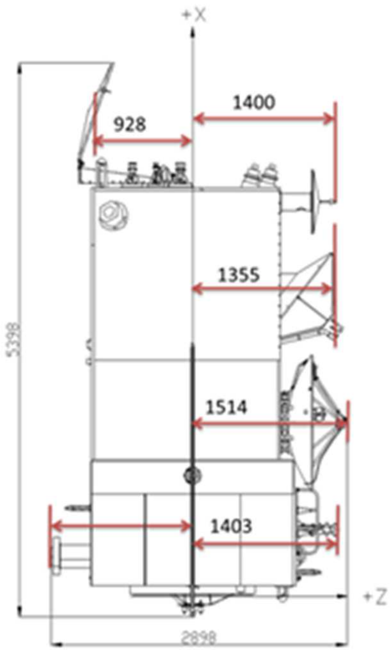
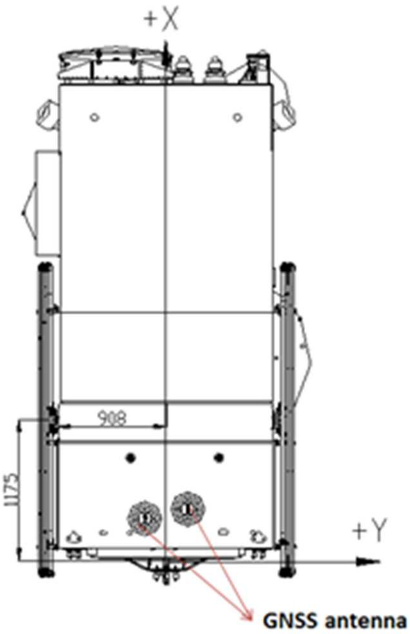



Figure 6 A view of the satellite




a b

Figure 7 A view of the satellite

The dimensions of each SA panel in the next picture:

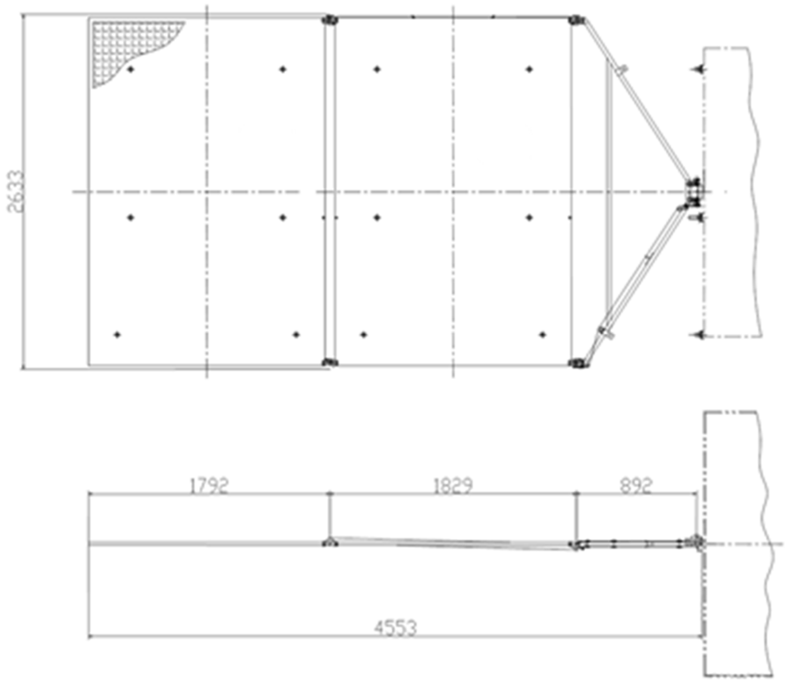



Figure 8 A view of the satellite

## 3.6. SATELLITE MOBILE PARTS

*Mass, size and motion of other moving parts on board HY-2C (if any) shall be precised.*

## 3.7. 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.*

*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.*

**Table1 mass properties**

| | **Satellite mass (kg)** | **X_cog (mm)** | **Y_cog (mm)** | **Z_cog (mm)** |
|---|---|---|---|---|
| **Beginning of life** | 1677.0 | 1332.0 | -8.6 | 3.4 |
| **Operational mission** | 1631.0 | 1354.7 | -8.8 | 3.5 |
| **End of life** | 1591.0 | 1375.5 | -9.0 | 3.6 |

## 3.8. SATELLITE RADIATION PRESSURE 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.*

*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.*

**Table2 Projected areas of radiator**

| SC box and wing simplified model | | X+ | X- | Y+ | Y- | Z+ | | | Z- | SA+ (Toward sun) | SA- |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | OSR | SR-107 ZK | Carbon fibre | | | |
| Projected area ($m^2$) | | 0.3329 | 0.375 | 2.614 | 2.326 | 1.891 | 2.325 | 0.665 | 1.717 | 18.1186 | 18.1186 |
| Power dissipated typical operation (W) | | 56.5 | 63.7 | 444.0 | 395.1 | 471.5 | 373.2 | 86.8 | 247.4 | 12819.9 | 10721.1 |
| Typical mean temperature in operation (°C) | | -25 | -25 | -25 | -25 | 0 | -35 | -45 | -35 | 70 | 55 |
| Visible | Specular | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | / | / | 0.87 | 0.1 | / |
| | Diffuse | / | / | / | / | / | 0.14 | 0.15 | / | / | 0.1 |
| | Absorbed | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.86 | 0.85 | 0.13 | 0.9 | 0.9 |
| Infrared | Specular | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | / | / | 0.22 | 0.08 | / |
| | Diffuse | / | / | / | / | / | 0.12 | 0.15 | / | / | 0.1 |
| | Absorbed | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.88 | 0.85 | 0.78 | 0.92 | 0.9 |

**Table3 Projected areas of multilayer**

| SC box and wing simplified model | | X+ | X- | Y+ | Y- | Z+ | Z- |
|---|---|---|---|---|---|---|---|
| Projected area (m²) | | 3.621 | 3.920 | 5.173 | 5.461 | 3.060 | 6.224 |
| Power dissipated typical operation (W) | | 127.3 | 1086.9 | 312.0 | 329.4 | 531.7 | 338.9 |
| Typical mean temperature in operation (°C) | | -100 | 17 | -75 | -75 | -15 | -80 |
| Visible | Specular | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 |
| | Diffuse | / | / | / | / | / | / |
| | Absorbed | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Infrared | Specular | / | / | / | / | / | / |
| | Diffuse | 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. 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 in the Satellite Navigation Body Coordinate:**

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

**X Coordinate of the phase centre of LRA (m): +0.31281**

**Y Coordinate of the phase centre of LRA (m): -0.21568**

**Z Coordinate of the phase centre of LRA (m): +1.06046**

The range correction of LRA from spherical centre is 0.07448m.

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

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

**X Coordinate of the spherical centre point (reference point) of LRA (m): +0.31281**

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

**-0.21568**

**Z Coordinate of the spherical centre point (reference point) of LRA (m): +0.98598**

The LRA mass-centre point  Coordinate is following :

**X Coordinate of the mass-centre point of LRA (m): +0.31281**

**Y Coordinate of the mass-centre point of LRA (m): -0.21568**

**Z Coordinate of the mass-centre point of LRA (m): +1.05716**

# 5. GPS INSTRUMENT DESCRIPTION

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

## 5.1. GPS ANTENNA

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

### 5.1.1. GPS ANTENNA PHASE CENTER

The GPS antenna phase centre point coordinates for each frequency channel is given in the Satellite Navigation Body Coordinate with accuracy better than 1 mm.

**GPS antenna 1**

**L1**

**$X_1$ Coordinate of the GPS antenna phase (m): +0.34729**

**$Y_1$ Coordinate of the GPS antenna phase (m): -0.17514**

**$Z_1$ Coordinate of the GPS antenna phase (m): -1.37468**

**L2**

**$X_1$ Coordinate of the GPS antenna phase (m): +0.34859**

**$Y_1$ Coordinate of the GPS antenna phase (m): -0.17304**

**$Z_1$ Coordinate of the GPS antenna phase (m): -1.39538**

**GPS antenna 2**

**L1**

**$X_2$ Coordinate of the GPS antenna phase (m): +0.43163**

**$Y_2$ Coordinate of the GPS antenna phase (m): +0.18232**

**$Z_2$ Coordinate of the GPS antenna phase (m): -1.37571**

**L2**

**$X_2$ Coordinate of the GPS antenna phase (m): +0.43213**

**$Y_2$ Coordinate of the GPS antenna phase (m): +0.18372**

**$Z_2$ Coordinate of the GPS antenna phase (m): -1.39631**

### 5.1.2. GPS ANTENNA PHASE CALIBRATION

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

*Numbers in the first row indicate angles in the azimuth plane；

*Numbers in the first column indicate angles in the vertical plane.

*Other Numbers in the table indicate the phase calibration values corresponding to different angles. The positive values mean phase advance, while the negative values mean phase lag.

### 5.1.3. GPS ANTENNA AXES

The antenna axes orientation shall be given in the Satellite Navigation Body Coordinate 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**