

## QZS-1 SATELLITE INFORMATION

Cabinet Office, Government of Japan  
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## 1. Introduction

This documentation describes the information about QZS-1 satellite properties which need to be known in order to properly implement advanced processing algorithms for precise orbit determination (POD) and precise point positioning (PPP) etc.

## 2. Reference Frame

The QZS-1 satellite coordinate system is aligned with the main body axes and originates at the center of the launch adapter plane. The individual axes of QZS-1 satellite coordinate system are aligned in the following way: (see Figure 1)

- origin : Center of the launch adapter plane
- The +Z-axis is oriented to the bore sight direction of the L-ANT antenna.
- The +Y-axis is parallel to the rotation axis of the solar panels.
- The +X-axis is constituted by a right handed system with +Y/+Z axis.

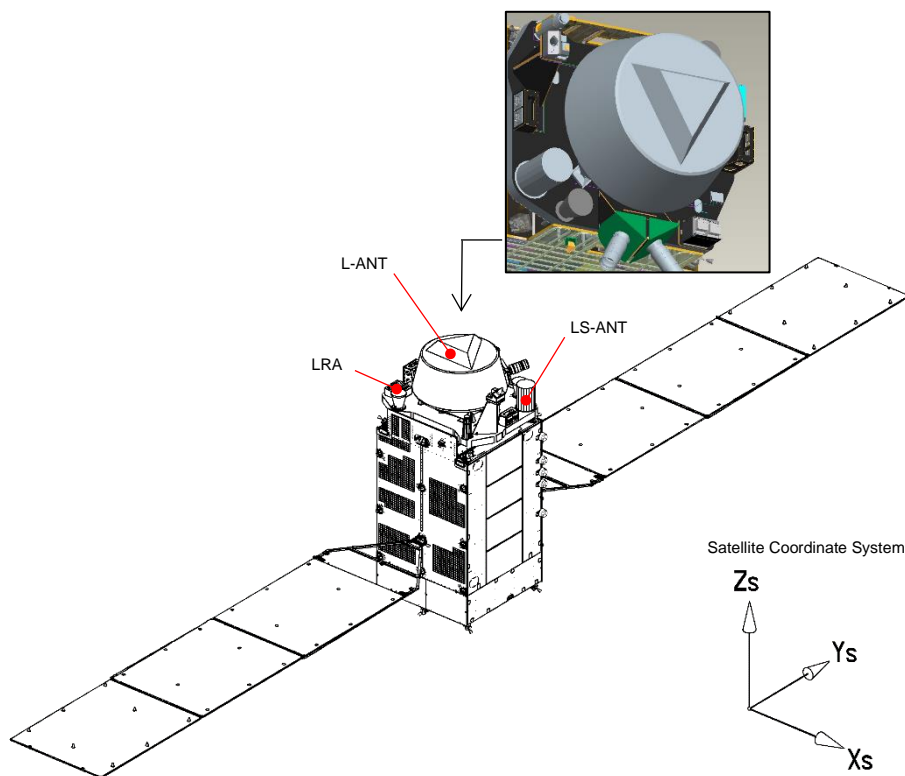


Figure 1 Reference frame

### 3. Attitude Law

There are two main attitude control modes, i.e. yaw steering mode and orbit normal mode, which are switched by ground commands according to the elevation of the Sun relative to the orbital plane ( $\beta$  angle). In addition, the orbit normal mode is used for orbital maneuvers.

(1)  $|\beta| > \text{approx. } 20^\circ$  : Yaw steering mode (see Figure 2)

The +z-axis is pointing to the Earth.

The y-axis is oriented perpendicular to the plane made up by the Sun, Earth and satellite.

The x-axis is oriented within the plane made up by the Sun, Earth and satellite. The Sun is located in the *negative* hemisphere.

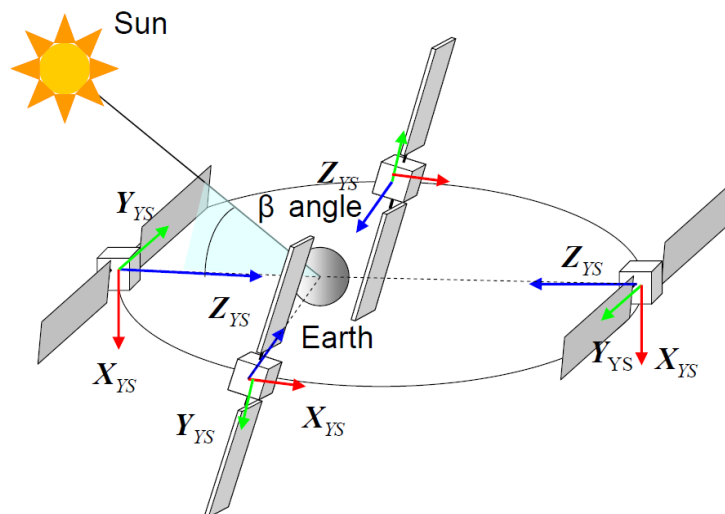


Figure 2 Yaw steering mode

(2)  $|\beta| \leq \text{approx. } 20^\circ$  : Orbit normal mode (see Figure 3)

The +z-axis is pointing to the Earth.

The -y-axis is perpendicular to the orbital plane in the direction of the orbital angular momentum vector.

The +x-axis completes the right hand system with the y and z axes (roughly oriented in the flight direction).

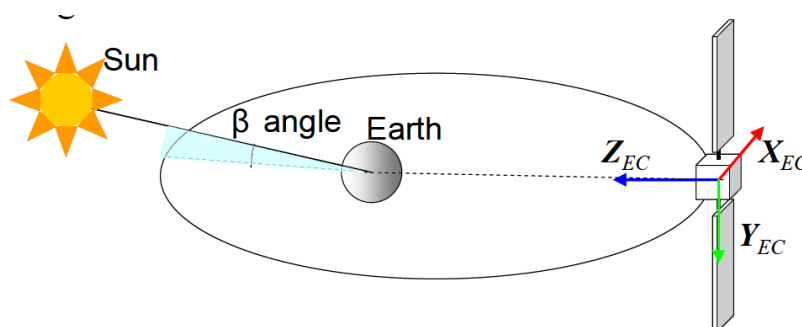


Figure 3 Orbit normal mode

#### 4. Mass and Center Of Mass

The spacecraft mass and the center of mass with respect to the satellite reference frame are provided in Table 1.

Table 1 Mass and center of mass (Prediction as a design)

	Mass [kg]	CoM (w.r.t. origin) [mm]		
		X	Y	Z
BOL	2281	-1.1	1.6	1818.4
EOL	2121	-1.2	1.7	1849.6

BOL : Completion of QZS-orbit insertion

EOL : 12 years after launch

#### 5. Navigation Antenna Phase Center Corrections

The phase center offsets of the navigation antennas are provided in Table 2. The offsets from the center of mass are obtained by subtracting the X/Y/Z coordinates in Table 1 from those in Table 2.

Table 2 Phase center location

Signal	Coordinates (w.r.t. origin) [mm]		
	X	Y	Z
L1	0.00	0.00	5017.74
L2	0.00	0.00	4812.74
L5	0.00	0.00	4897.74
L6	0.00	0.00	4967.74

Table 3 Phase center variations

N/A

## 6. Geometry

The spacecraft dimensions are described in Figure 4.

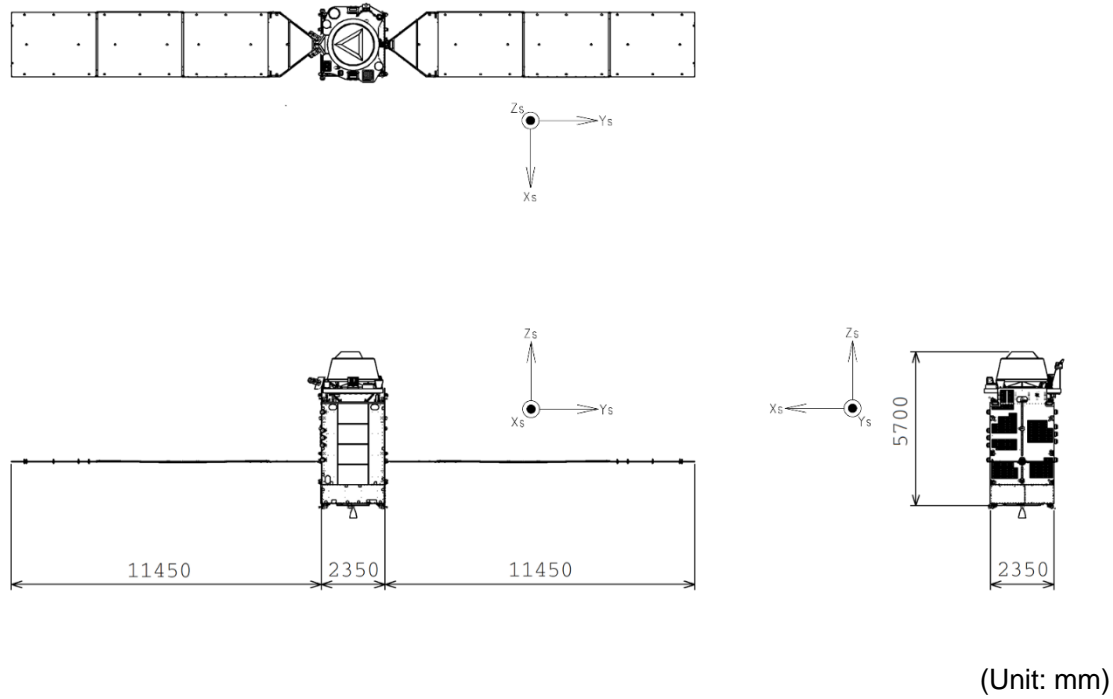


Figure 4 Satellite dimensions

Table 4 Optical properties(Prediction as a design)

Location <sup>(*2)</sup>	Material	Area [m <sup>2</sup> ]	Absorption	Specular	Diffuse
+X	MLI	9.0	0.95	0.0025	0.0475
-X	MLI	9.0	0.95	0.0025	0.0475
+Y	MLI	3.0	0.95	0.0025	0.0475
	Radiator	7.0	0.08	0.8280	0.0920
	SAP	22.5	0.64	0.3240	0.0360
-Y	MLI	5.0	0.95	0.0025	0.0475
	Radiator	5.0	0.08	0.8280	0.0920
	SAP	22.5	0.64	0.3240	0.0360
+Z	MLI	3.0	0.95	0.0025	0.0475
	L-ANT Cover	(*1)	0.53	0.2350	0.2350
-Z	MLI	5.6	0.95	0.0025	0.0475

\*1 : L-ANT shape is approximately depicted as a truncated circular cone comprised of  $\varnothing 1.5\text{m}$  and  $\varnothing 1.8\text{m}$  circles  $0.8\text{m}$  apart.

\*2 : "Location" indicates the face of the satellite body where the components and materials are attached. Note that it doesn't necessarily indicate the direction normal to them.

For more accurate analytical solar radiation pressure model of QZS-1 satellite, the box-wing-hat model has been proposed in Ref. [3]. You can use the shape information of L-ANT shown in Figure 5 to implement the box-wing-hat model.

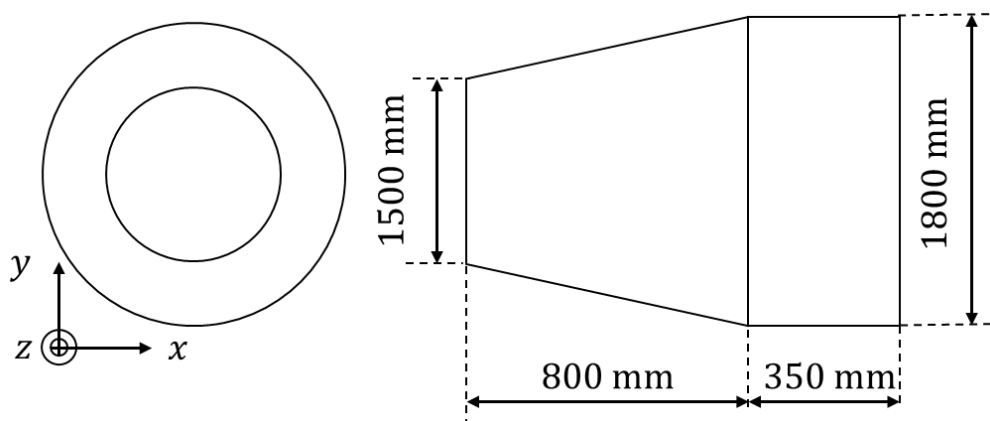


Figure 5 Approximated shape of L-ANT Cover for box-wing-hat model

## 7. Laser Retro Reflector Location

The location of the optical center of the laser retro-reflector array (LRA) with respect to the satellite reference frame is provided in Table 5.

Table 5 Location of LRA optical center

	Coordinates (w.r.t. origin) [mm]		
	X	Y	Z
Optical Center	-1150.0	-550.0	+4505.3

## 8. Satellite Group Delay

### 8.1 Satellite Group Delay

N/A

### 8.2 Differential Code Bias

The differential code bias (DCB) between L1, L2, and L5 signals are provided in Table 7.

Table 7 Differential code bias

Signal	DCB [ns]
L1-L2	1.14
L1-L5	0.82

## 9. Antenna Transmit Power

Total transmit power is approximately 250W.

## 10. GNSS Bibliography

- [1] Quasi-Zenith Satellite System Interface Specification Satellite Positioning, Navigation and Timing Service, the Cabinet Office, Government of Japan, 2017.
- [2] ILRS SLR Mission Support Request Form
- [3] S. Ikari, E. Ebinuma, R. Funase, and S. Nakasuka, "Analytical Non-Conservative Disturbance Modeling for QZS-1 Precise Orbit Determination", Proceedings of the 27th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+ 2014), page 2440 – 2447, 2014

## Revision History

Rev.No	Date	Page	Revisions
Org	October 6, 2017		Original
A	June 28, 2019	5	Add optical properties and box-wing-hat model information