



**Time and Coordinate System
for
QZSS (Quasi-Zenith Satellite System)
PNT (Positioning, Navigation and Timing service)**

4 December 2017

QZS System Services Inc. (QSS)

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1. QZSS PNT Time system(QZSST)



- ◆ The QZSS(Quasi-Zenith Satellite System) PNT(Positioning, Navigation and Timing service) time system, called “QZSST”, is defined below.

1. Definitions

a. Length of 1 second

The length of 1 second in QZSST shall be identical to the International Atomic Time (TAI).

b. Offset between QZSST and TAI

QZSST shall be delayed from TAI by 19 seconds.

c. Starting point of week number for QZSST

The starting point of the week number for QZSST shall be the same as the GPS time system (GPST), which is 0:00 am (UTC) on January 6, 1980.

2. Navigation message reference time

The parameters relating to time such as the SV clock parameter, mean motion and UTC parameters shall all be based on QZSST.

1-1. Time Transfer Between QZSST and GPST(1/2)

- ◆ QZSST is almost aligned to GPST so that the difference between QZSST and GPST are nominally within 2ns.
- ◆ Figure 1 shows the schematic view of QZSST and GPST.
 - ① QZSSRT (QZSS reference time system) is defined by an ensemble average of receiver(*1) clock bias which is constrained to zero on the system equation.
 - *1: The QZSS has 4 "time reference monitor stations" which consists of an Atomic Hydrogen Maser.
 - ② All satellite and receiver clock bias is corrected by the estimated residual clock bias between QZSSRT and GPST.
 - ③ The difference between QZSSRT and GPST becomes almost zero, so the GGTO is broadcast always as zero.

1-1. Time Transfer Between QZSST and GPST(2/2)

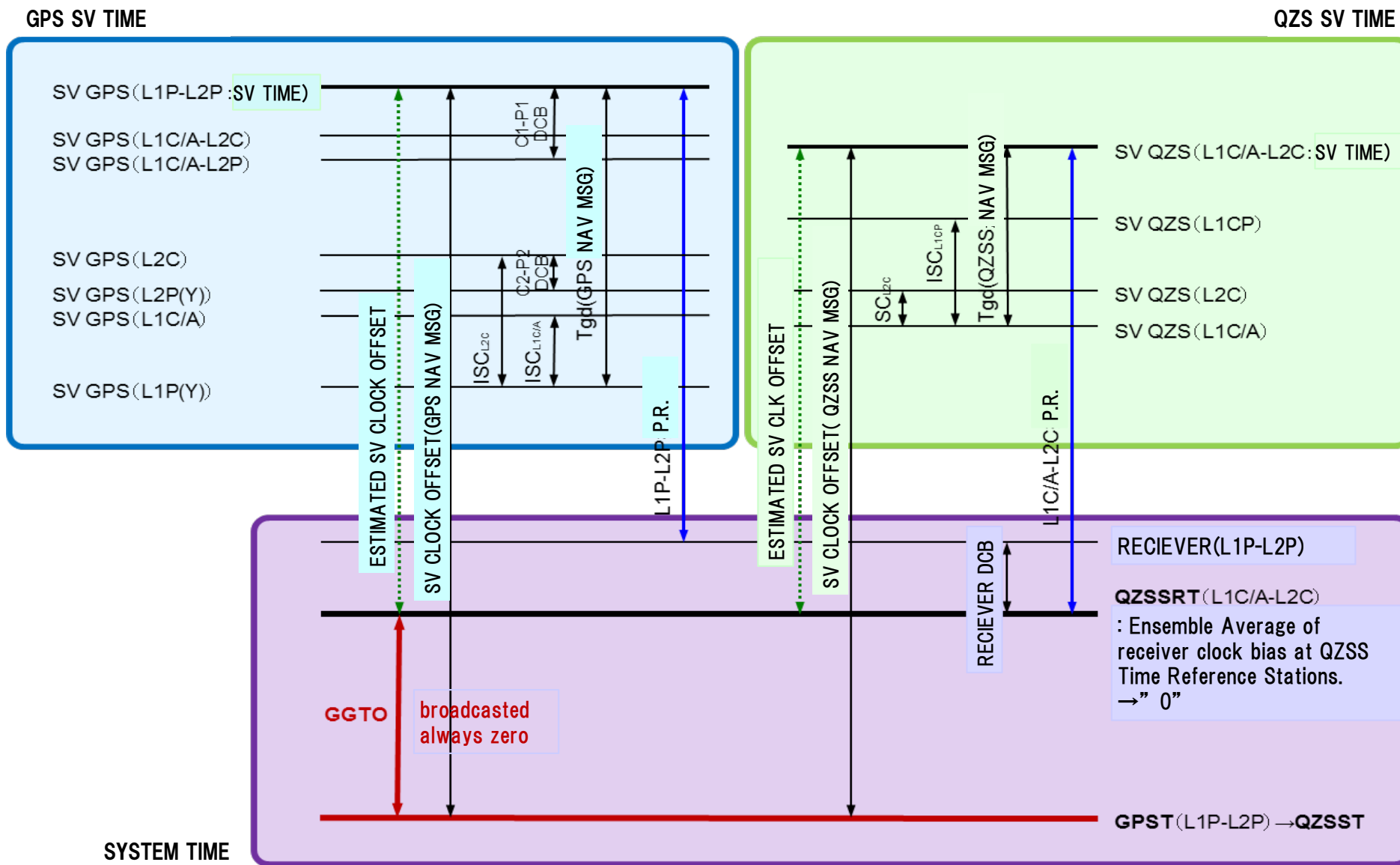


Figure 1: Schematic View of QZSST and GPST

1-2. Time Transfer Between QZSST and UTC



- ◆ UTC parameter is broadcasted on L1C/A, L1C, L2C and L5.
- ◆ Figure 2 shows the schematic view of QZSST and UTC(NICT).
 - ① Each monitor station's clock bias from UTC(NICT) is estimated using GPS common view method.
 - ② So the difference between UTC(NICT) and QZSST can be derived using Monitor station's clock bias from UTC(NICT) and QZSST.

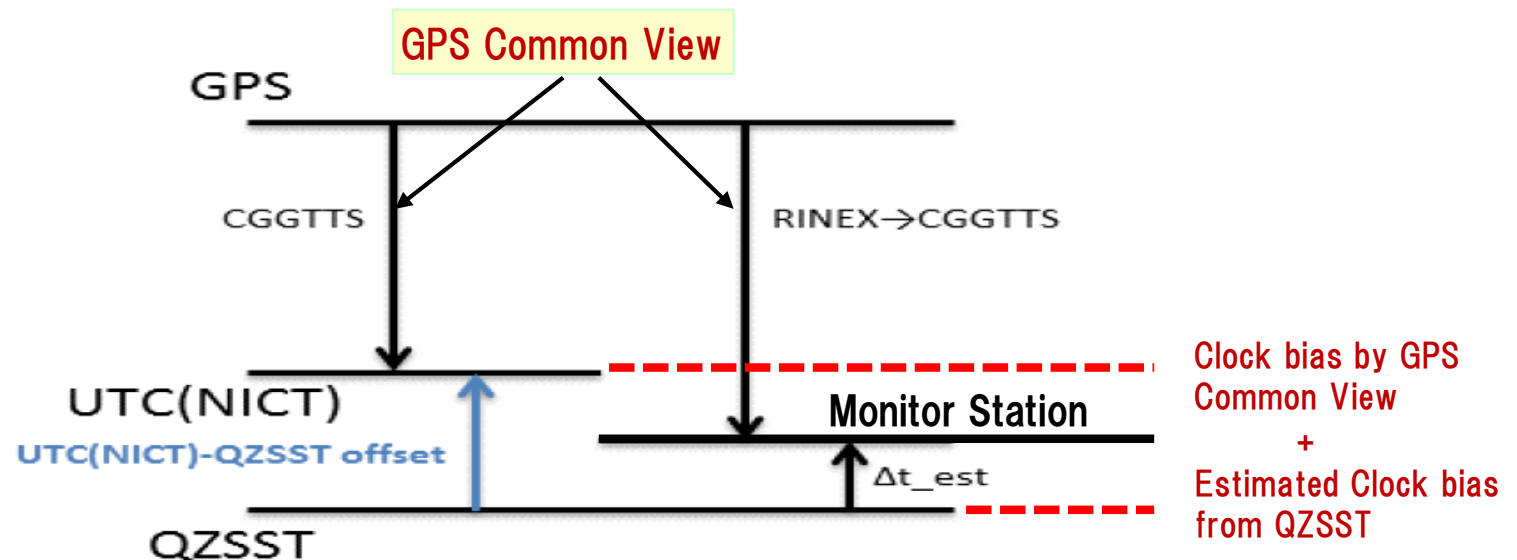


Figure 2: Schematic view of QZSST and UTC(NICT)

2. QZSS PNT Coordinate system



- ◆ The QZSS/PNT coordinate system(JGS) is defined as follows. Thus the frame uses the IGB08. The difference between ITRF and JGS is nominally within 20mm.

Definitions

The QZSS/PNT coordinate system is the same as the International Terrestrial Reference System (ITRS) stipulated by IERS, and conforms to the International Terrestrial Reference Frame (ITRF).

- **Origin:** Mass center of the earth
- **Z-axis:** the IERS Reference north pole
- **X-axis:** Intersection of the IERS Reference Meridian (IRM) and the equatorial plane
- **Y-axis:** Completes a right-handed, Earth-centered, Earth-Fixed (ECEF) orthogonal coordinate system

3. Evaluation of QZSS/PNT Data(1/2)



- ◆ QZSS/PNT is now under trial service.
- ◆ GGTO error is within 0.604ns (95%). (Figure 3)
- ◆ The evaluated error of “UTC(NICT)-GPST(PNT)” is good relation to “UTC(NICT)-GPST(BIPM). (Figure 4)

[From 2017/5/18 to 2017/6/22]

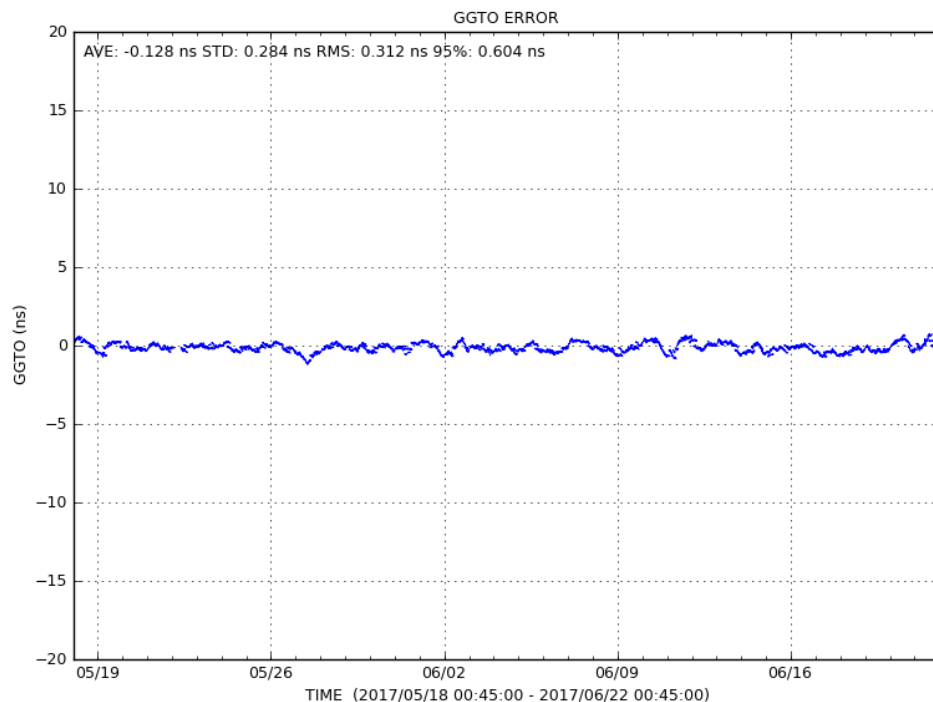


Figure 3: GGTO ERROR

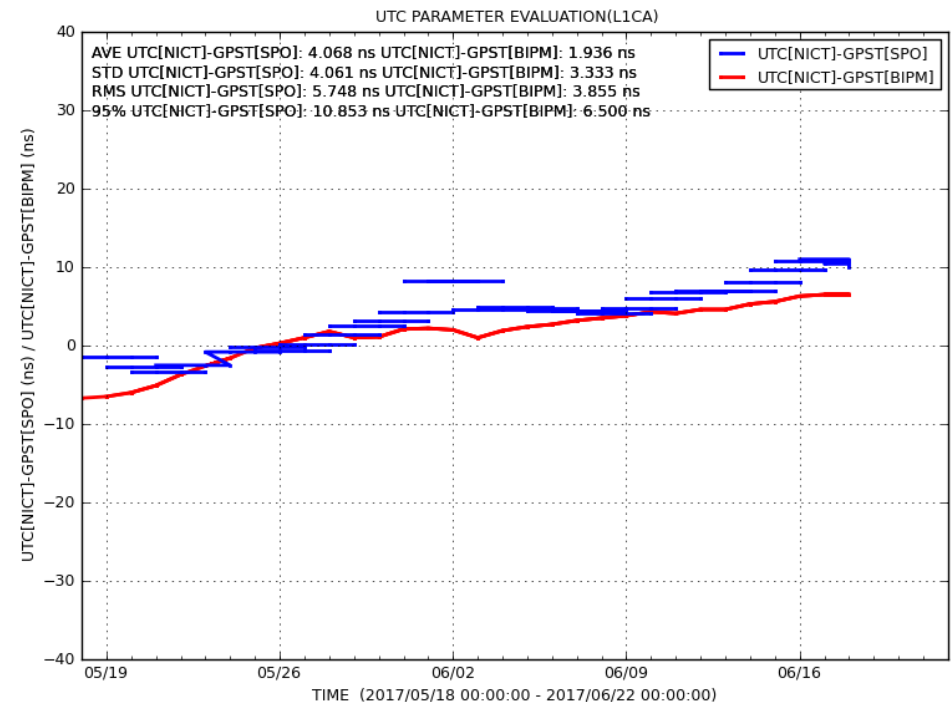


Figure 4: Difference between UTC(NICT) and GPST

3. Evaluation of QZSS/PNT Data(2/2)



- ◆ Difference between ITRF and JGS is within 8.4mm (95%). (Figure 5)

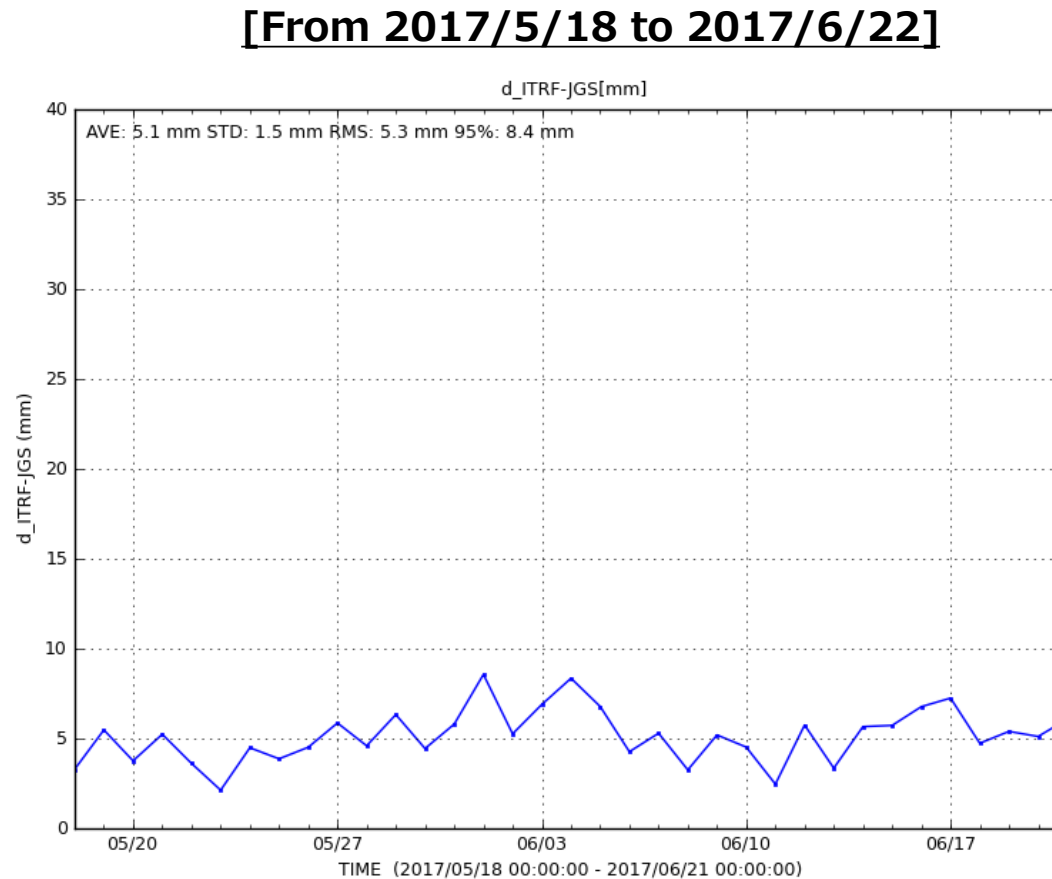


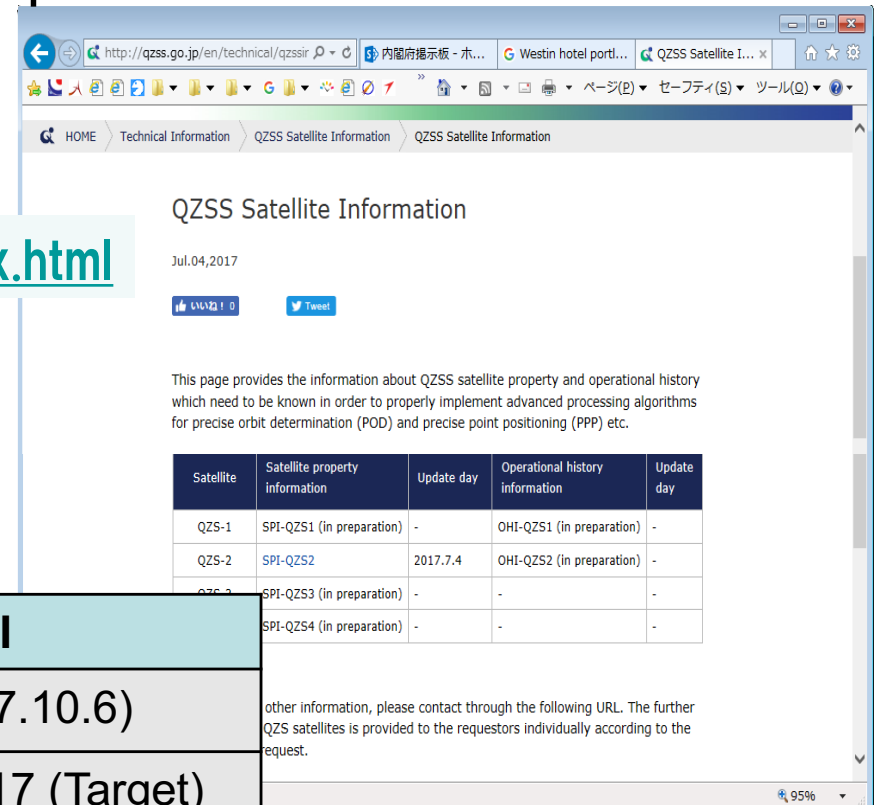
Figure 5: Difference between ITRF and JGS

4. Satellite Information for POD



Considering ICG WG-D recommendation #23 and IGS White Paper, Satellite Property Information (SPI) and Operational History Information (OHI) for each QZS SV are published on our web-site.

<http://qzss.go.jp/en/technical/qzssinfo/index.html>



Current status on the SPI and OHI Publication

Satellite	SPI	OHI
QZS-1	Published(2017.10.6)	Published(2017.10.6)
QZS-2	Published(2017.7.4), Updated(2017.11.30)	December, 2017 (Target)
QZS-3	Published(2017.11.30)	March, 2018(Target)
QZS-4	Published(2017.11.30)	March, 2018(Target)

4. Satellite Information for POD



■ Satellite Property Information(SPI)

➤ Contents

1. Reference Frame
2. Attitude Law
3. Mass and Center of Mass
4. Navigation Antenna Phase Center Corrections
5. Geometry
6. Satellite dimension
7. Optical Property
8. Laser Retro Reflector Location
9. Differential Code Bias
10. Antenna Transmit Power



✓ **Current status : In preparation**

QZS-1 → Not Published

(The material can't be obtained any more.)

QZS-2 to QZS-4

→ Under analysis

✓ **Plan: These information aim at publish on January 2018.**

4. Satellite Information for POD



■ Optical Property

➤ Activity Status on Data acquisition of Optical and Thermal property

Property	Acquisition Data	Disclosure/ Non-disclosure	Status
Optical	Absorption coefficients(Ca) Specular reflectivity(Cs) Diffuse reflectivity(Cd) of each material	Disclosure	Under measuring and analysis (MLI ^(*2) , OSR ^(*3) and so on)
	BRDF ^(*1)	Non-disclosure	Scheduled to be measured after acquisition of the above optical property data
Thermal	Surface temperature	Non-disclosure	Under consideration of possibility of installing sensor necessary for measuring surface temperature on QZS-1R. (infrared camera , temperature sensor and so on)
	Infrared emissivity	Disclosure	

*1 : BRDF (Bidirectional Reflectance Distribution Function)

*2 : MLI (Multi Layer Insulation)

*3 : OSR (Optical Solar Reflector)

4. Satellite Information for POD



■ Operational History Information(OHI)

➤ Contents

1. Attitude Change history

- mode/start•end time

Since January 2018, the plan and the result information will be included.

2. Orbit maintenance maneuver history (Planned value only)

- time/duration/delta-V/direction

3. Estimated mass history

➤ Sample

The history information of QZS-1 operation

date	event	attitude change (*3)			orbit maintenance maneuver							estimated mass (kg) (*6)
		mode	start(UT)	stop(UT)	No.	start	stop	duration	ΔV_x	ΔV_y	ΔV_z	
2011/11/9	orbit maintenance maneuver(*1)				#1	2011/11/9 13 32	2011/11/9 13 35	0 03:11	-0.877	-0.034	-0.105	2281
					#2	2011/11/9 18 30	2011/11/9 18 36	0 06:48	1.625	-0.029	-0.07	
					#3	2011/11/9 23 31	2011/11/9 23 36	0 05:15	-1.449	-0.057	0.04	
2012/1/4	unbading											2281
2012/3/3	change of attitude mode	YS→0N	9 54									2281
2012/3/7	unbading											2281
2012/4/16	change of attitude mode	0N→YS	7 39									
2012/5/2	orbit maintenance maneuver(*1)				#1	2012/5/2 1 59	2012/5/2 2 00	0 01:47	-0.492	0.007	-0.057	2277
					#2	2012/5/2 6 57	2012/5/2 7 02	0 04:44	1.275	-0.006	-0.041	
					#3	2012/5/2 11 57	2012/5/2 12 02	0 05:24	-1.488	0.021	0.049	

5. Summary



- ◆ Definition of QZSS/PNT's time system(QZSST) and coordinate system(JGS) was explained.
 - *QZSST is nominally aligned to GPST within 2ns.*
 - *JGS is nominally aligned to ITRF within 20mm.*

- ◆ QZSS/PNT started trial service from March 28th 2017, and these system errors are well sustained within target values.

- ◆ Web-site of QZSS Satellite information for Precise Orbit Determination is introduced.

Thank you for your attention.

**For more information, please visit our web site
<http://qzss.go.jp/en/>**



- A large circle illustrated “Q” as Quasi-Zenith Satellite System
- Green and blue circle composes 8 shapes; the coverage area of QZSS and they are represented earth and satellite.
- Blue line symbolized precise positioning information as well as enlargement of brand new service to society.
- Color of green stands for environment and safety, and blue stands for space and technology.

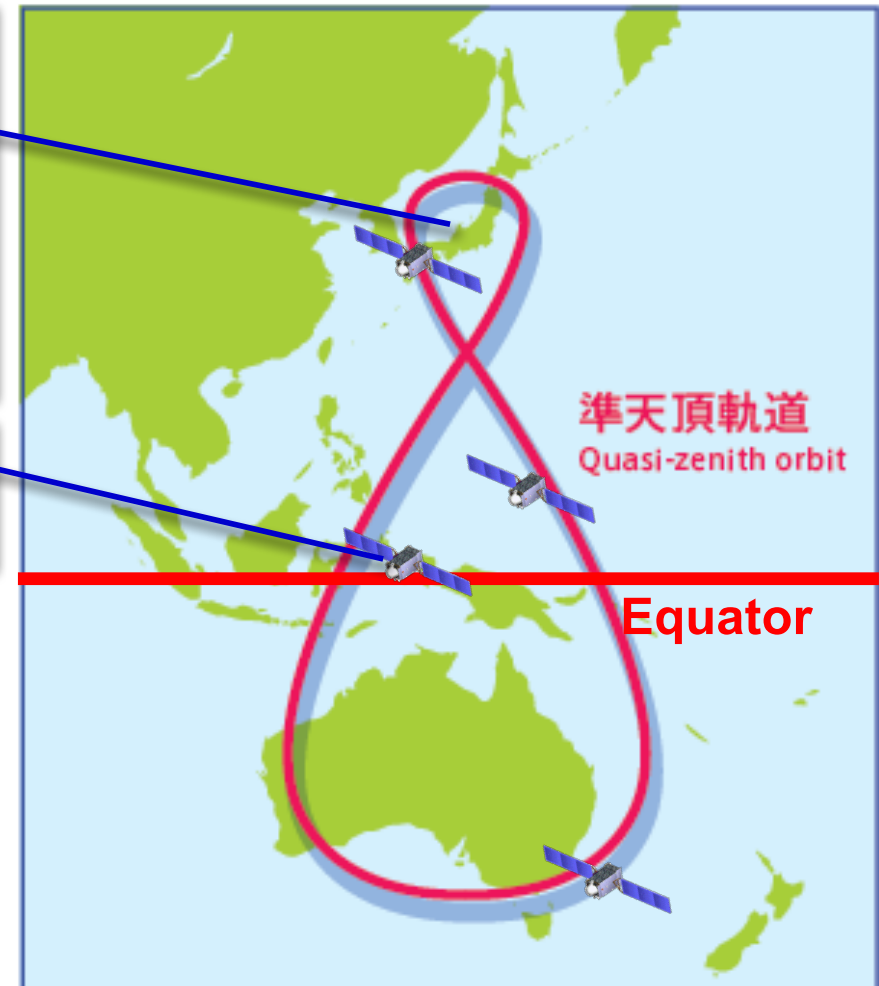
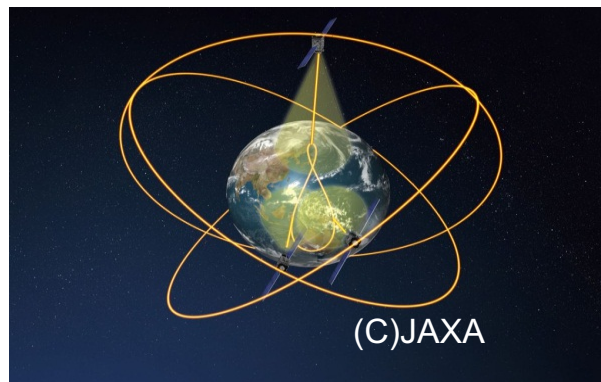
Backup: Satellites system

4-Satellite Constellation; 3 QZ Orbit, 1 Geostationary Orbit

Japan Region

- Over 20 degrees elevation
More than 2-QZS are available
- Over 60 degrees elevation
1 QZS is available

1 Geostationary satellite



Backup: QZSS Monitor Stations in the World

