

PPP activity updates and plans of QZSS

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QZSS Overview -System-

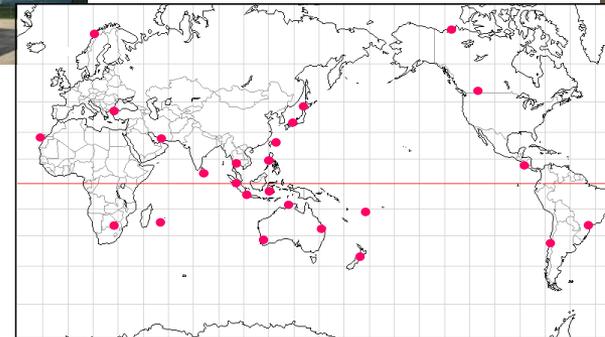


■ Constellation:

- 1 GEO Satellite, 127E
- 3 QZO Satellite (IGSO)

■ Ground System

- 2 Master Control Stations
 - Hitachi-Ota and Kobe
- 7 Satellite TTC Stations
 - Located south-western islands in Japan
- Over 30 Monitor Stations around the world



QZSS Overview –Signals and Services-

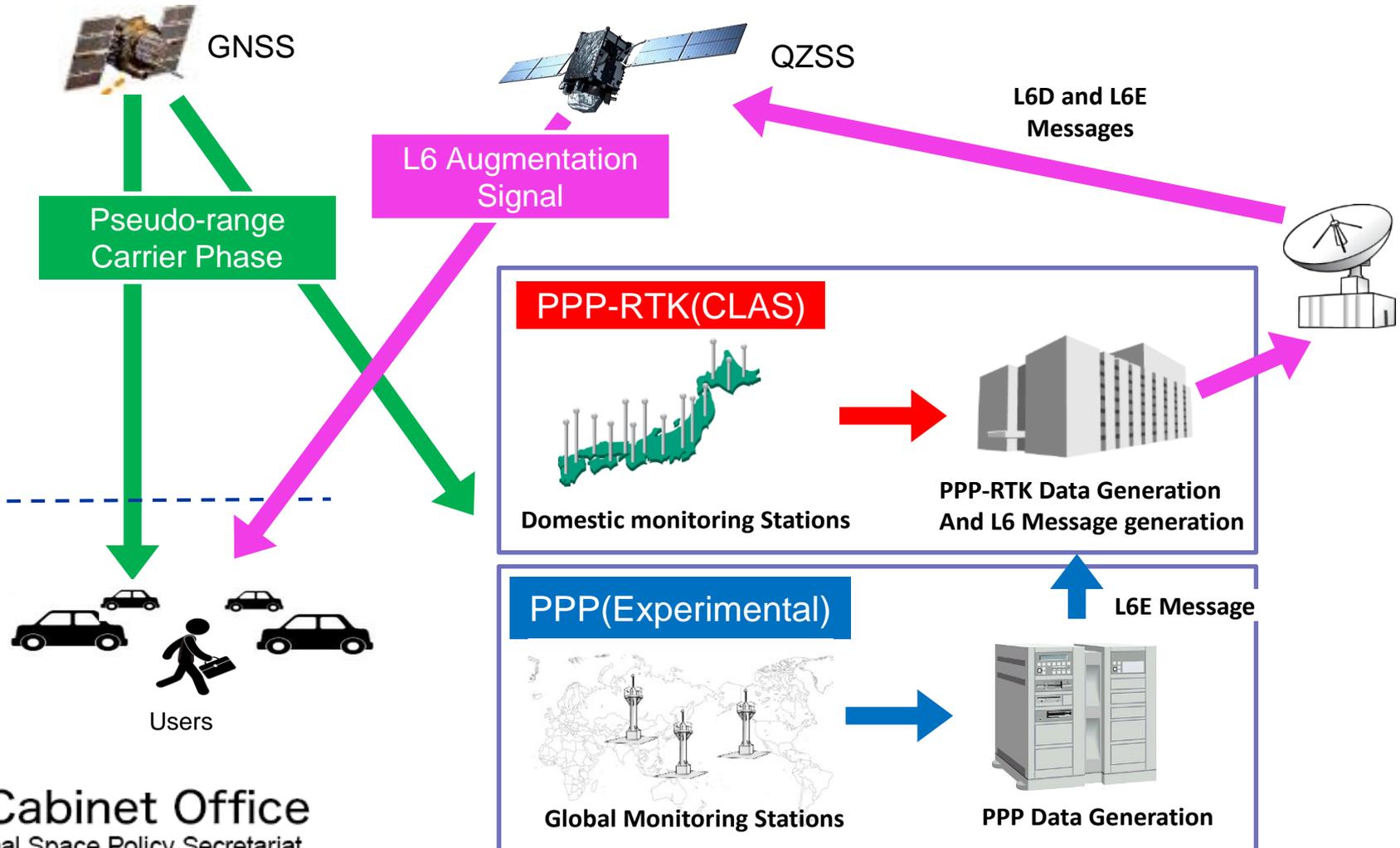


Signal	Frequency MHz	Service	Compatibility	QZS-1	QZS-2/4	QZS-3
				IGSO	IGSO	GEO
L1C/A	1575.42	Positioning	Complement GPS	✓	✓	✓
L1C		Positioning	Complement GPS	✓	✓	✓
L1S		Augmentation(SLAS)	DGPS (Code Phase Positioning)	✓	✓	✓
		Messaging	Short Messaging	✓	✓	✓
L1Sb		Augmentation(SBAS)	L1 SBAS Service	-	-	✓
L2C	1227.60	Positioning	Complement GPS	✓	✓	✓
L5 I/Q	1176.45	Positioning	Complement GPS	✓	✓	✓
L5S		Experimental(L5 SBAS)	L5 SBAS (DFMC)	-	✓	✓
L6D	1278.75	Augmentation(CLAS)	PPP-RTK (Carrier Phase Positioning)	✓	✓	✓
L6E		Experimental(PPP)	PPP, PPP-AR (Carrier Phase Positioning)	-	✓	✓



QZSS Overview -For PPP Users-

System Architecture for PPP services



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PPP Service Specification

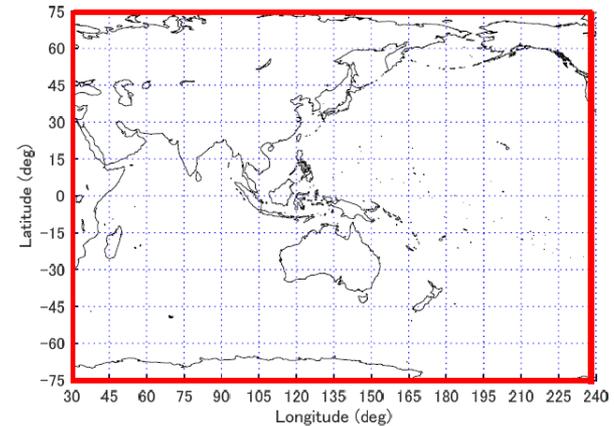
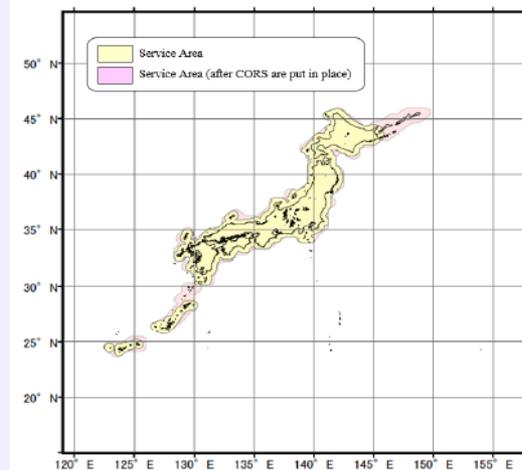
Performance Specification



PPP-RTK(CLAS) vs QZSS PPP

Item	PPP-RTK(CLAS)	QZSS PPP
Positioning Accuracy (open-sky)	Horizontal: 6 cm (95%) Vertical: 12 cm (95%)	Horizontal: 30 cm (95%) TBD Vertical: 50 cm (95%) TBD
Time to First Ambiguity Fix (TTFF)	≤ 60 s (95%)	$\leq 1,800$ s (95%) TBD
Service Availability	≥ 0.99 (constellation) ≥ 0.97 (satellite)	≥ 0.99 (constellation) TBD

Service Area



Service Specification



PPP-RTK(CLAS) vs QZSS PPP

Item	PPP-RTK(CLAS)	QZSS PPP
SV orbit	3 QZO(Quasi Zenith Orbit) and 1 GEO	
Augmentation Signal/Frequency for PPP	L6D/1278.75 MHz	L6E/1278.75 MHz
Service Area	Japan	Asia-Oceania
Reference frame	IGS05	IGS14
PPP method	PPP-RTK(SSR-RTK)	PPP, PPP-AR
GNSS type	GPS: L1CA,L1C,L2P,L5 QZS: L1CA,L1C,L2C,L5 Galileo: E1b, E5a GLONASS(CDMA): L1, L2	GPS: L1,L2,L5 QZS: L1,L2,L5 GLONASS: L1, L2
Format type	Compact SSR*1	RTCM 3 based (current) Compact SSR (planned)

*1 Details of the Compact SSR will be introduced by the next presenter, Rui Hirokawa

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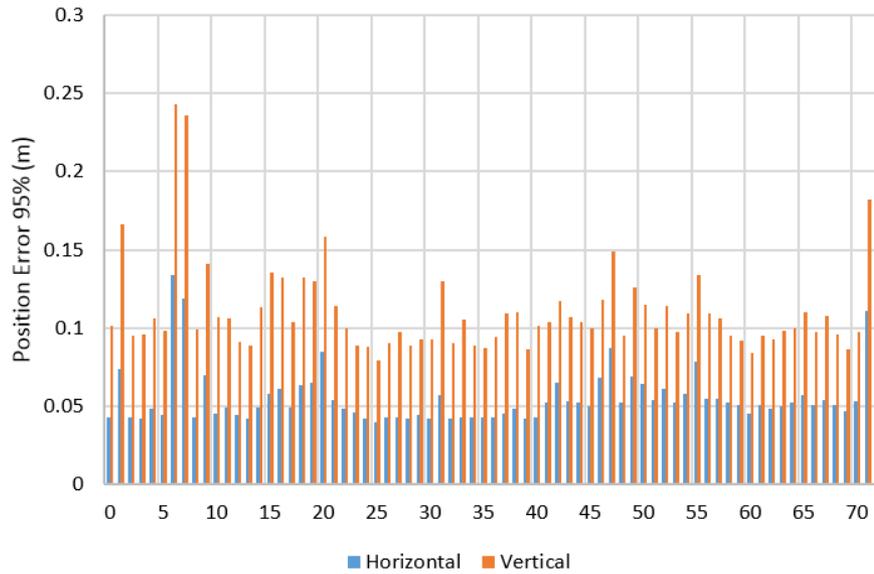
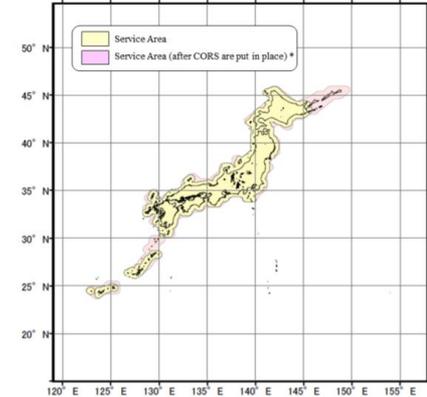
Recent Evaluation Results

Performance Evaluation –PPP RTK-



Recent results of PPP-RTK(CLAS)

- Evaluation period: 1 month April 2019
- Evaluation points: 72 points in Japan area
- Used Kinematic mode of CLASLIB which is the open source software for CLAS users
- Horizontal and vertical error as well as TFF are within the performance specifications.



Horizontal/Vertical Error of 72 evaluation points

Statistical value of 72 evaluation points

Directions	Error (95%)
Horizontal	5.3 cm
Vertical	10.7 cm

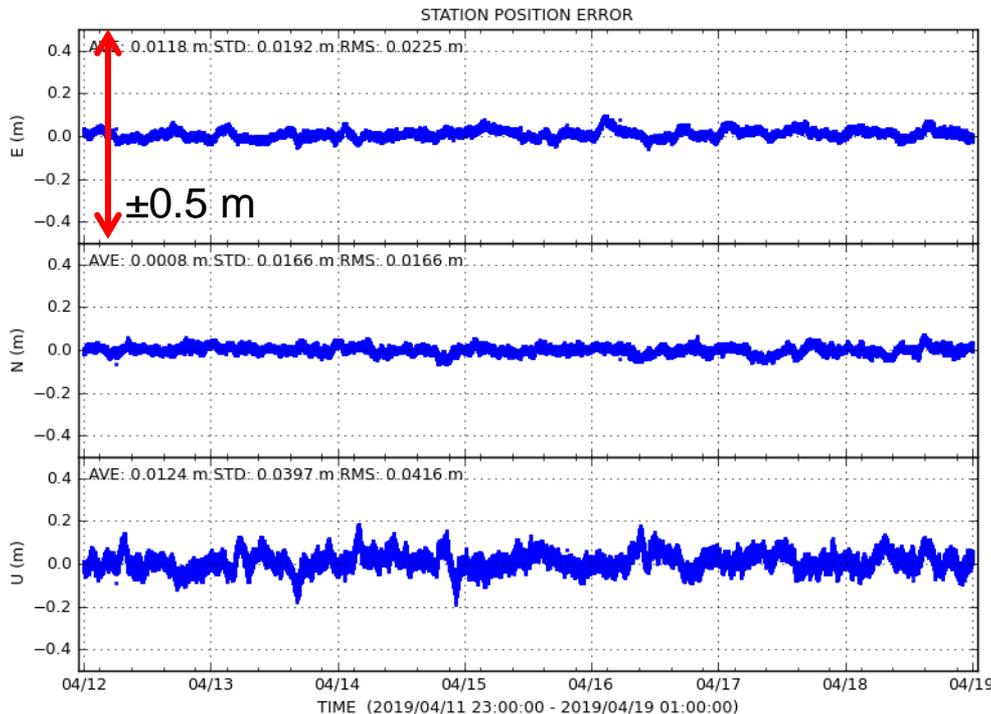
Time to First Fix: 38 sec(95%)

Performance Evaluation – QZSS PPP-



Recent Test results of QZSS-PPP

- Evaluation period: 1 week in the middle of April 2019
- Evaluation point: TKS2 in Japan (shown in right fig.)
- Used Kinematic PPP mode of RTKLIB
- Positioning results are quite stable throughout the period



Site: TKS2(Japan)

Directions	Error(RMS)
East-West	2.3 cm
North-South	1.7 cm
Vertical	4.2 cm

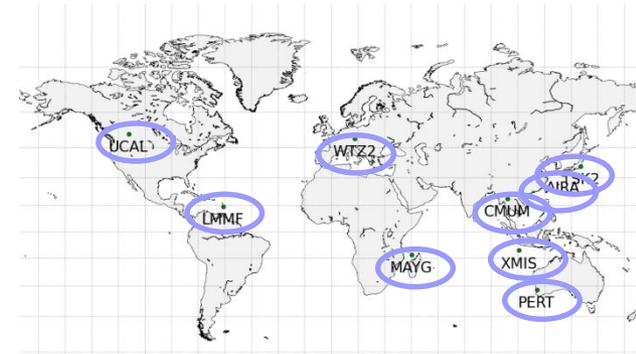
These results were obtained with the cooperation of JAXA

Performance Evaluation – QZSS PPP-

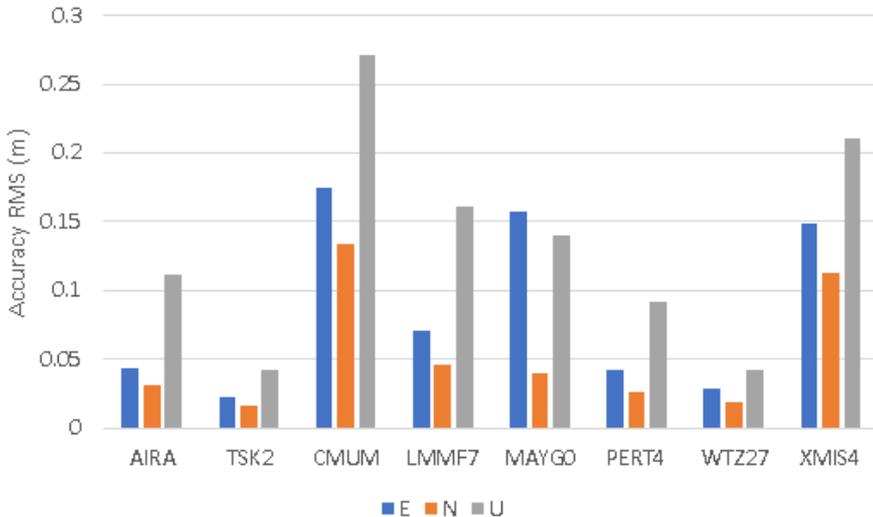


Recent Test results of QZSS-PPP

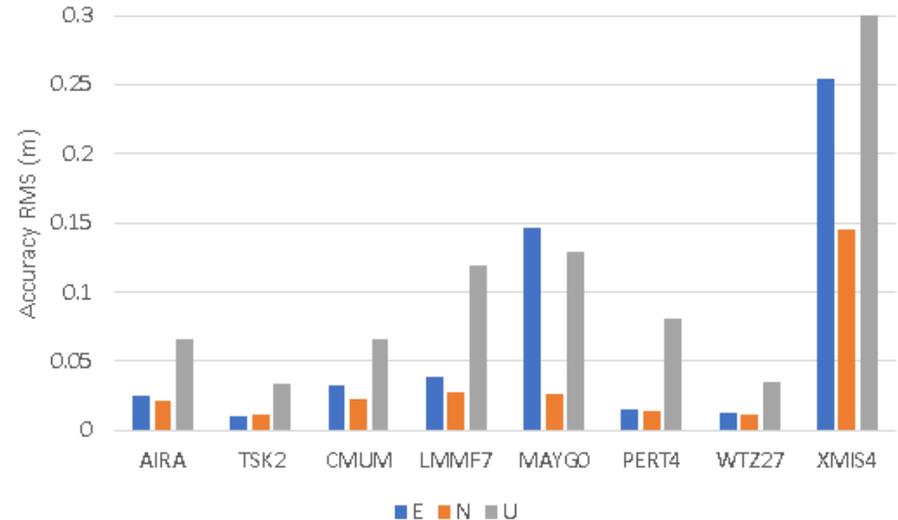
- Positioning result at each evaluation point around the world
- These result simulates the case where the augmentation message is used all over the world. (e.g. via internet)
- Positioning error is less than 20 cm (RMS) except for some evaluation points.
- Positioning accuracy improves at most points using PPP-AR.



Kinematic PPP



Kinematic PPP-AR

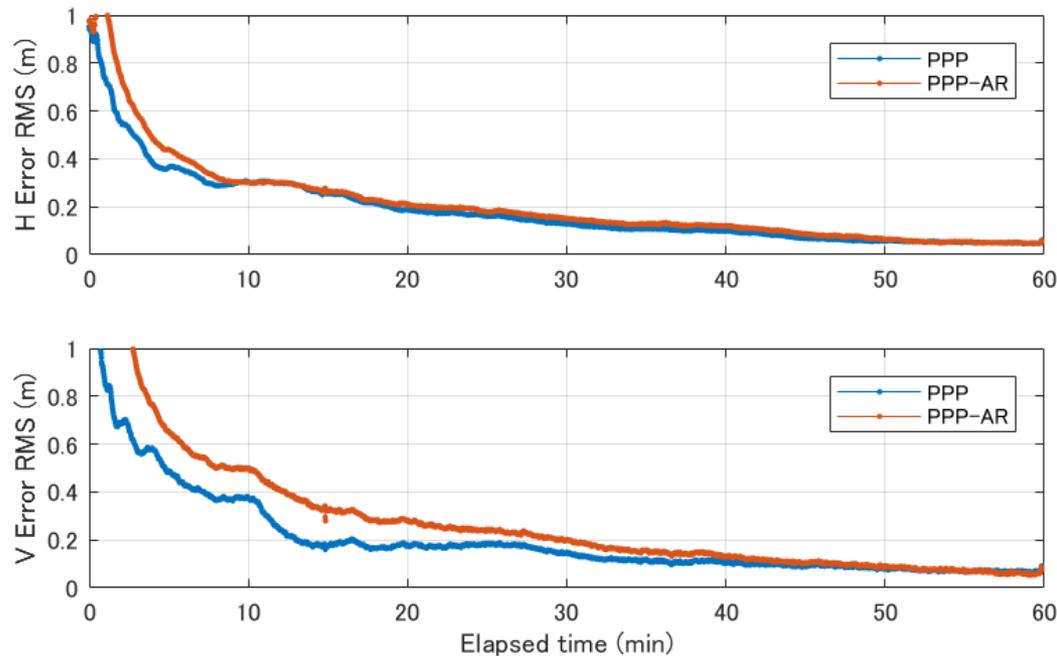


Horizontal/Vertical Error in global network



Recent Test results of QZSS-PPP

- Relationship between elapsed time and positioning accuracy of PPP
- Evaluation point: TKS2 in Japan (shown in right fig.)
- Blue line and orange line show the convergence time of PPP and PPP-AR, respectively.
- Horizontal error converges to less than 20 cm within about 20 minutes.
- Vertical error also converges within about 30 minutes.



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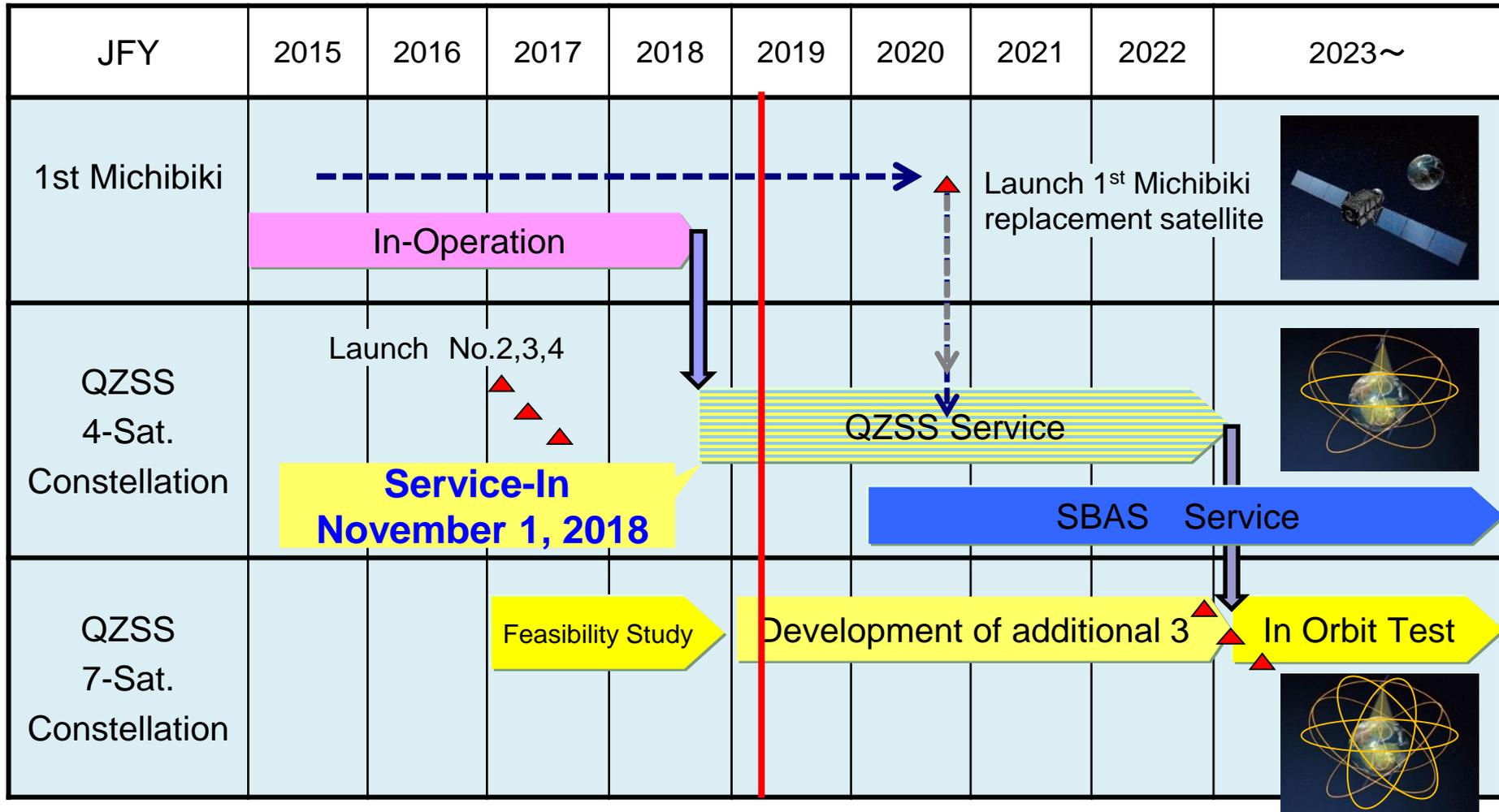


Future Plans

QZSS Development Plan



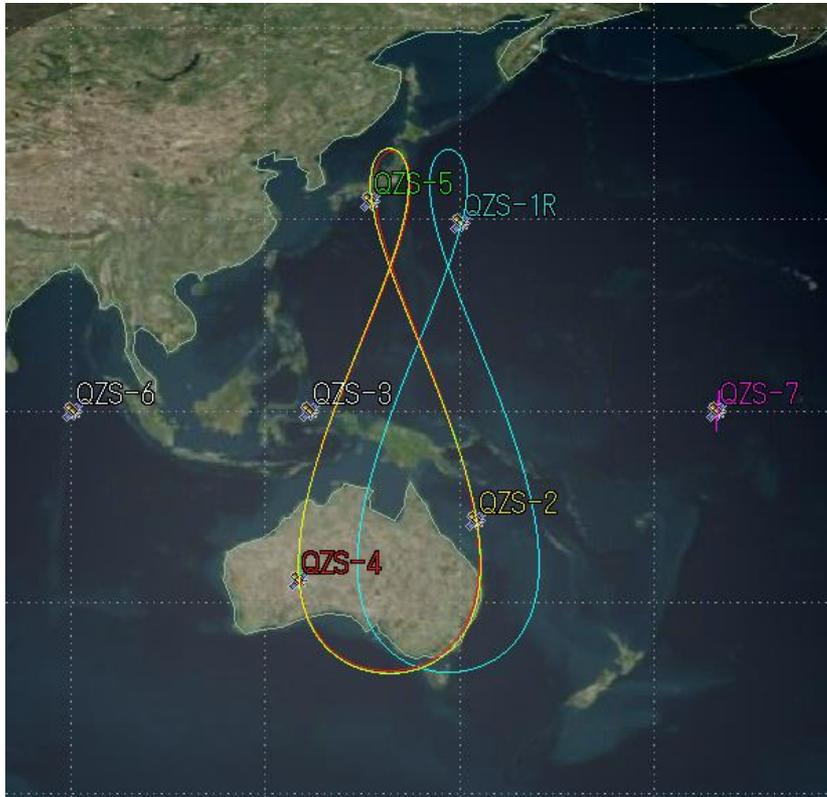
QZSS Program Schedule (latest)



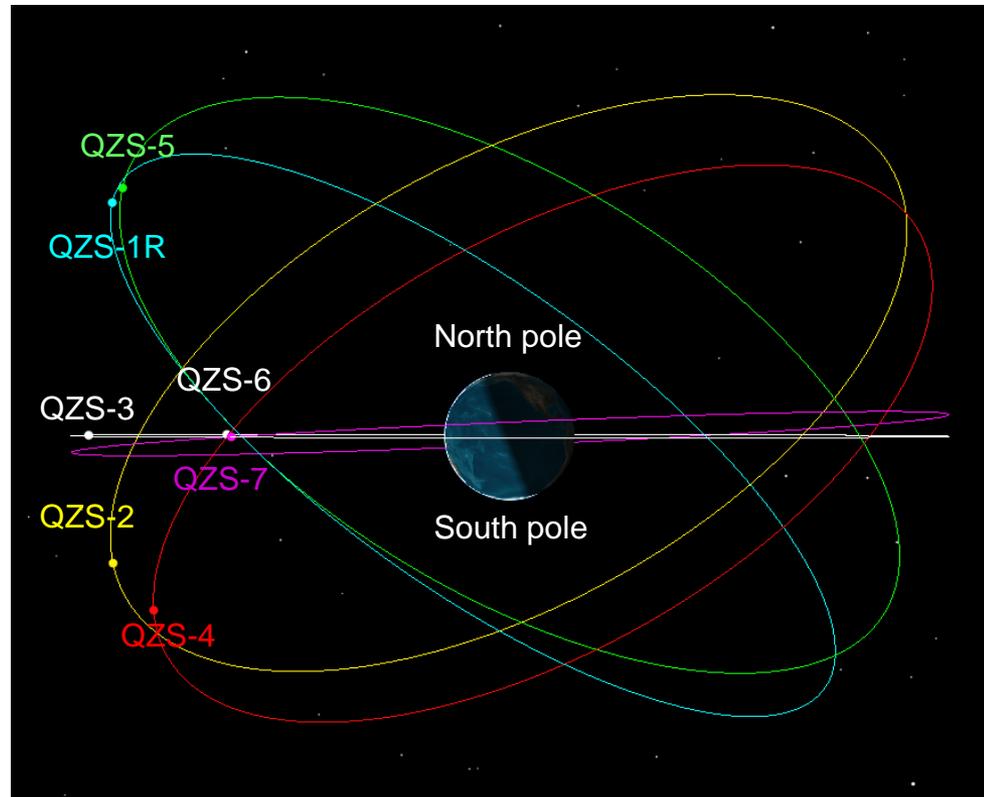


Future Plans for PPP services

QZSS Constellation Plan



7-QZSS Ground Track



7-QZSS orbits viewed from the equatorial plane



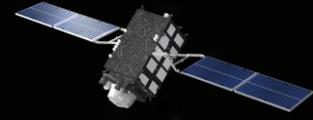
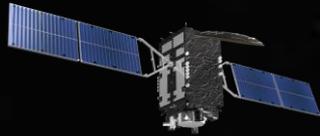
Future Plans for PPP services

CLAS (PPP-RTK)

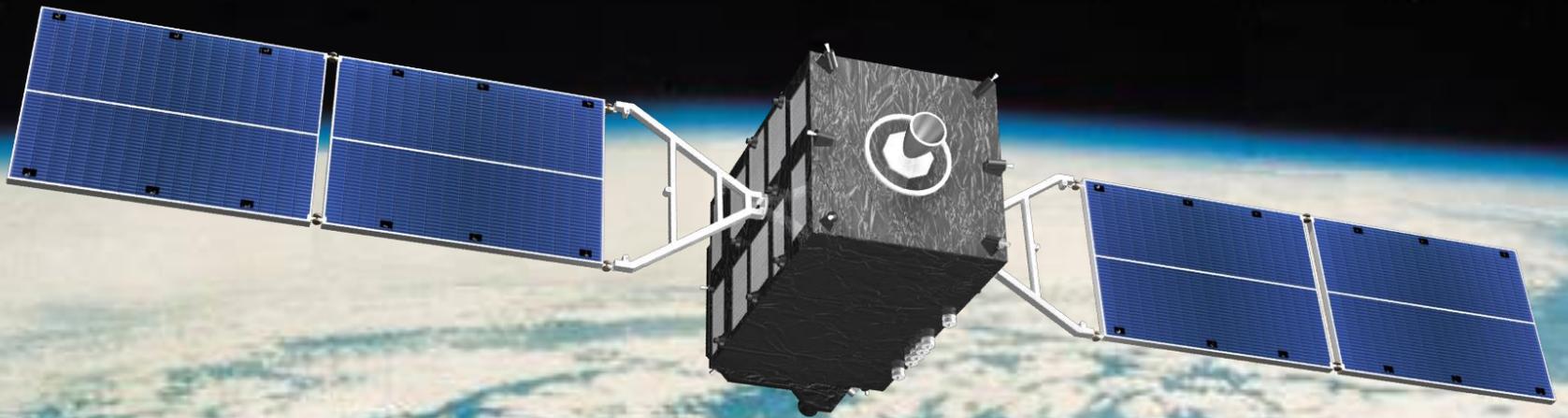
- Improvement of GNSS orbit, clock and ionosphere model
- Increase in the number of augmented satellites by more efficient compression (Details will be introduced by Rui Hirokawa)

QZSS-PPP

- Official service will be launched after 2020
 - Publication of performance specification
 - Compatible with Compact SSR
 - PPP-AR service by using FCB(TBD)



Thank you for your attention!



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