

Introduction of QZSS

UN GNSS Training Programme

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1. QZSS Overview -System-

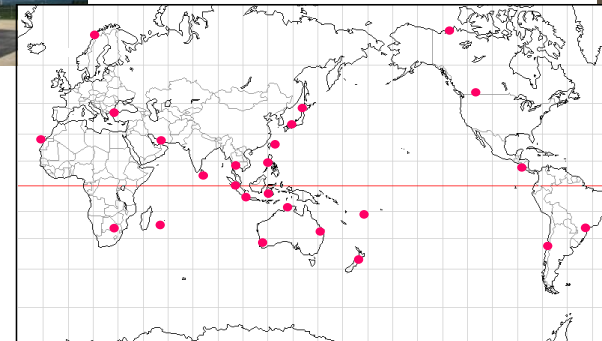
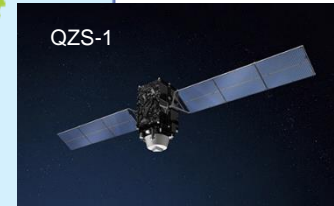


■ Constellation:

- 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
- Over 30 Monitor Stations around the world



1.QZSS Overview -Current Services-

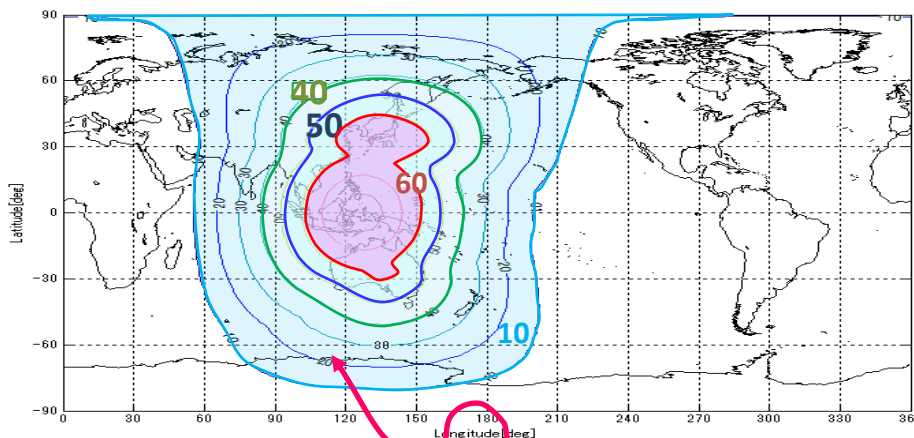
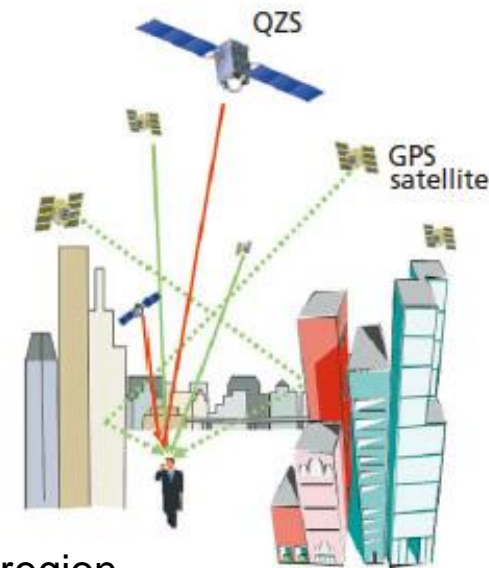


■ **Functional Capabilities:**

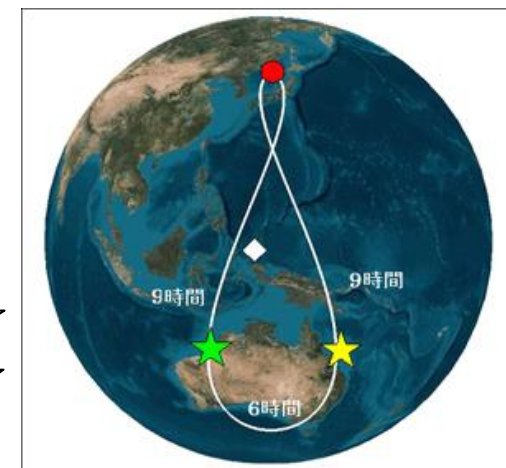
- GPS Complementary (Ranging signals)
- GNSS Augmentation (Error corrections)
- Messaging Service (Disaster relief, management)

■ **Coverage:** Asia and Pacific region

- Augmentation service covers only Japan
 - Experimental service provides error corrections in Asia Pacific region



- QZSS-1 ●
- QZSS-2 ★
- QZSS-4 ★
- QZSS-3 (127E) ◇

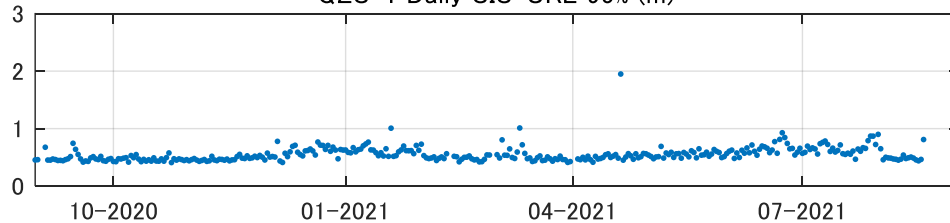


1. QZSS Overview -Current Services-

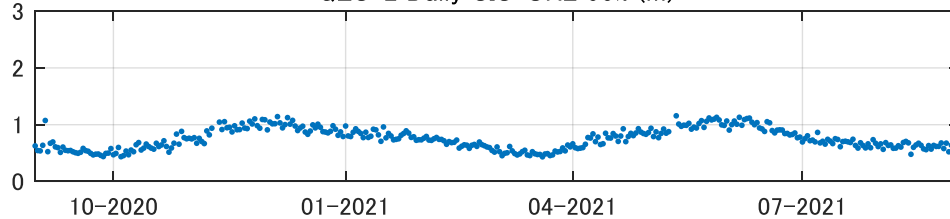


Current Performance (PNT service SIS User Range Accuracy)

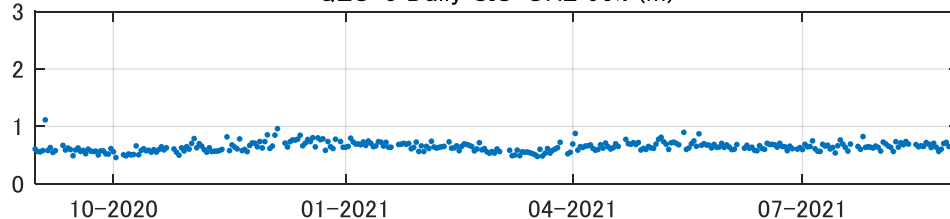
QZS-1 Daily SIS-URE 95% (m)



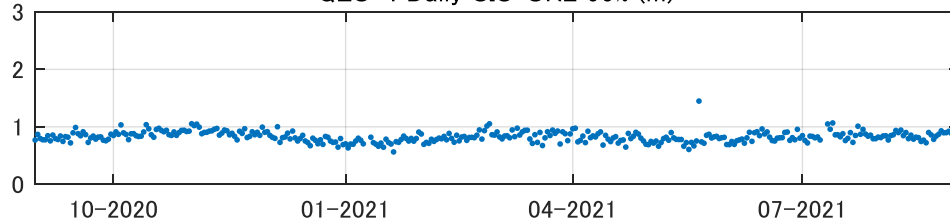
QZS-2 Daily SIS-URE 95% (m)



QZS-3 Daily SIS-URE 95% (m)



QZS-4 Daily SIS-URE 95% (m)



[Evaluation Period]

2020/08/31 ~ 2021/09/01

[Evaluation Results]

Specification: Less than 2.6 m (95%)

	Average	Best day	Worst day
QZS-1	0.55 m	0.41 m	1.94 m
QZS-2	0.75 m	0.43 m	1.15 m
QZS-3	0.64 m	0.46 m	1.20 m
QZS-4	0.83 m	0.56 m	1.45 m

Improvement of the ranging accuracy of QZS-1 to 4 is now on going.

1. QZSS Overview -Current Services-



QZSS Augmentation Service

SLAS : sub m segmentation

Augmentation	Augment 13 satellites (GPS L1C / A, QZS L1C / A) to utilize 13 monitor station.		
	Disaster reports could broadcast at 4-second intervals using SLAS slots.		
Accuracy 95%		Horizontal	Vertical
	Narrow	1.0m	2.0m
	Wide	2.0m	3.0m



https://qzss.go.jp/info/archive/honda_210517.html

Level.3@Honda Legend

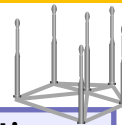
CLAS : cm augmentation

Augmentation	Utilize real-time Continuously Operating Reference System (CORS) data.		
	Ionosphere and troposphere correction information is provided in 13 block units.		
Accuracy 95%		Horizontal	Vertical
	Fixed	6cm	12cm
	Mobile	12cm	24cm

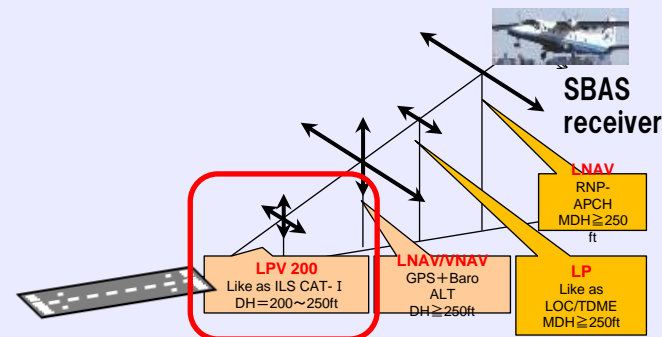
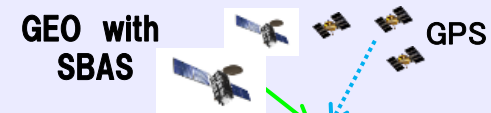


https://qzss.go.jp/info/archive/lbi_210510.html

Level.2@Nissan Ariya



SBAS@ LPV200



Approach		Horizontal alert limit	Vertical alert limit
NPA Non-Precision Approach	LNAV	556m	—
	LP	40m	—
APV Approach with vertical guidance	LNAV/VNAV	556m	—
	LPV	40m	50m
	LPV200	40m	35m
PA Precision Approach	CAT1	16m	35~10m

1. QZSS Overview -Current Services- CLAS Enhancement



Centi-meter Level Augmentation Service (CLAS) has been broadcasting the signal compliant with [IS-QZSS-L6-003 \(*1\)](#) using the L6D signal of the all the Quasi-Zenith Satellites (QZS-1, 2, 3, and 4), which increases the number of augmented satellites to a maximum of 17 for more stable positioning accuracy since Nov 30, 2020.

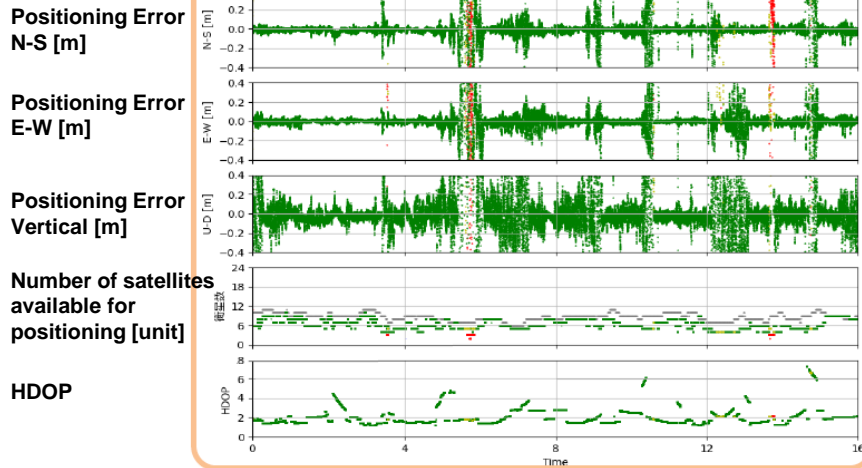
the number of augmented satellites
(Oct 6, 2020 during trial operation)

	the number of visible satellites (average)	the number of augmented satellites(average)	
		Conventional format	New format
All epochs	16.4	9.8	16.0

Assumed condition for Urban Area
(Elevation Mask: 40[deg])

- Fix
- Float
- Independent positioning
- Number of satellites visible

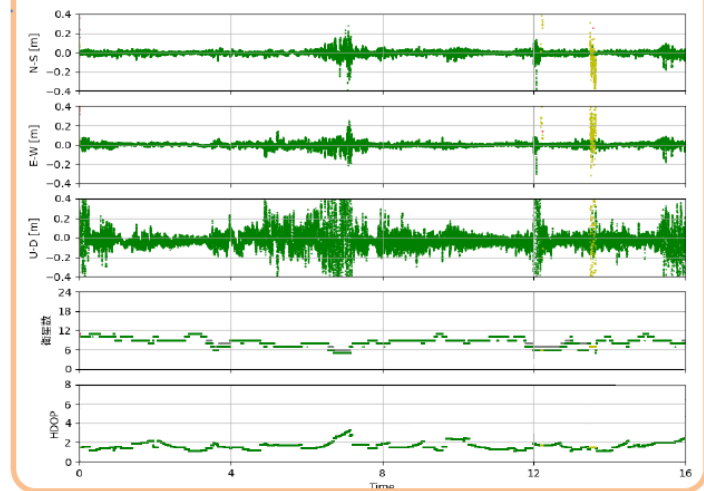
Positioning Accuracy in the Conventional format



•Horizontal (95%) : 40.6 [cm]
•Vertical (95%) : 128.3 [cm]
•FIX rate : 98.2 [%]



Positioning Accuracy in the New format



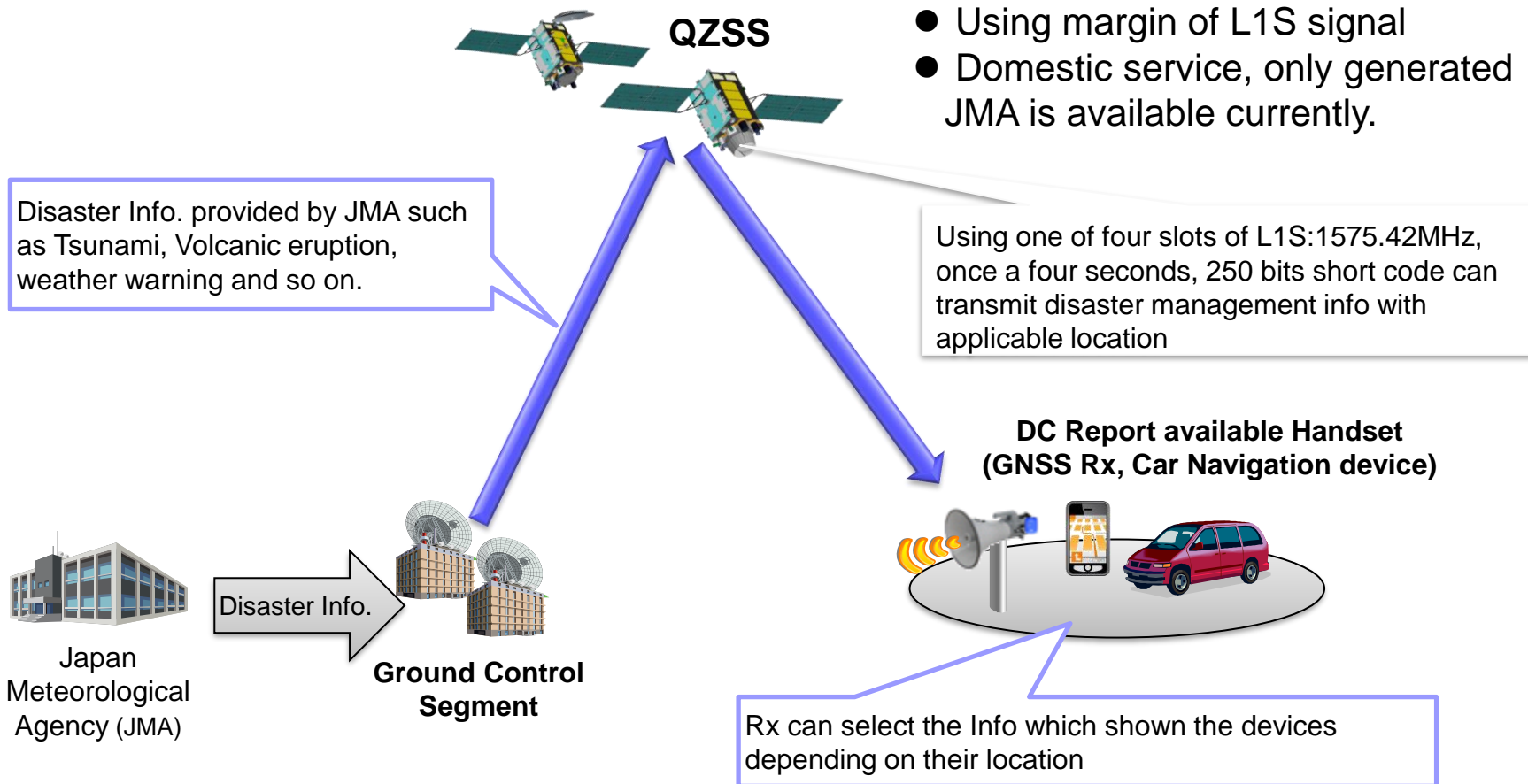
•Horizontal (95%) : 6.1[cm]
•Vertical (95%) : 22.1[cm]
•FIX rate : 99.4[%]



1. QZSS Overview -Current Services-

Messaging Services outline

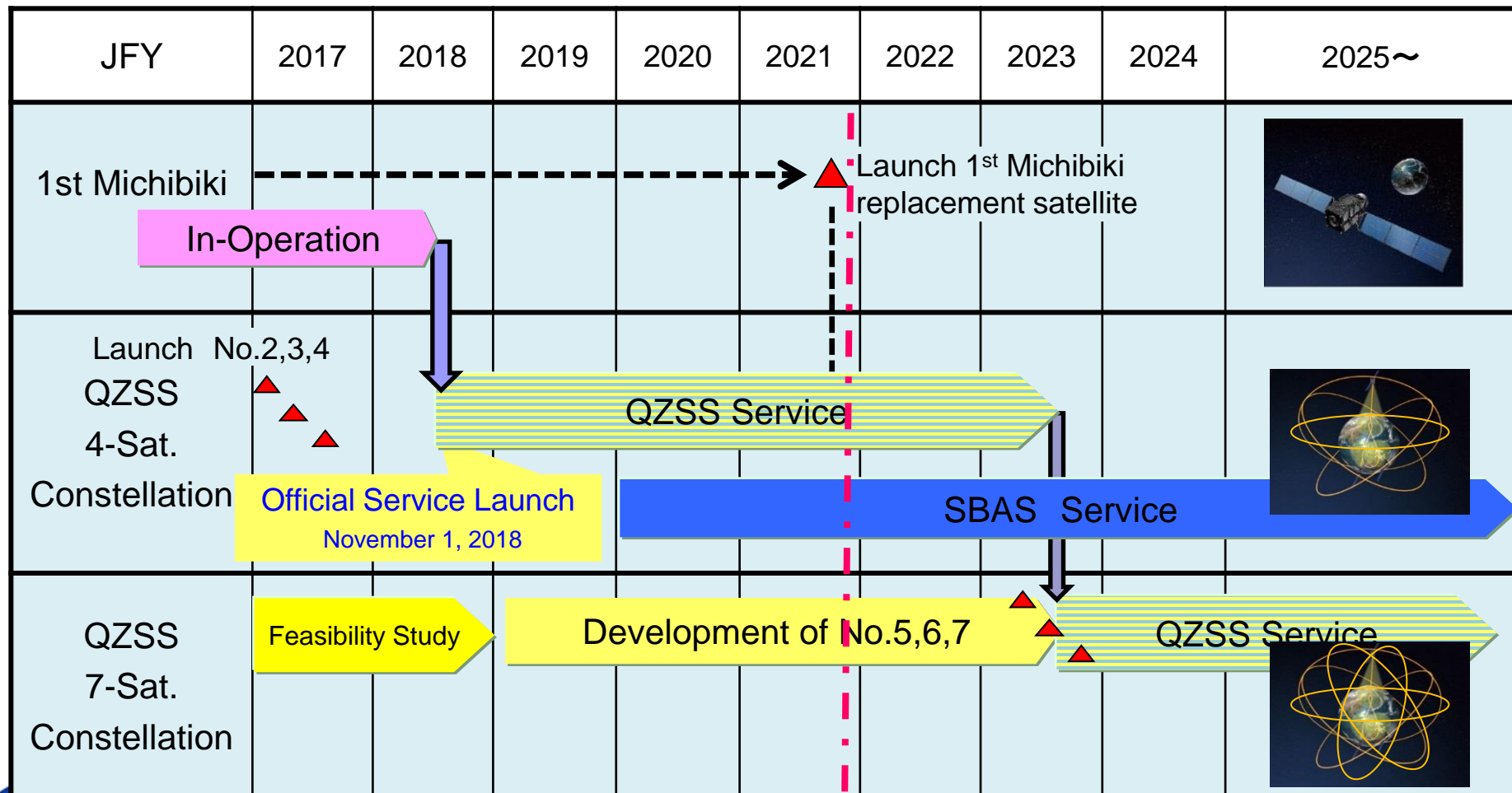
Satellite Report for Disaster and Crisis Management (DC Report)



QZSS Development Plan



- Development of 3 additional satellites have been started from 2019.
- QZSS will start 7 satellite constellation service around 2023



Latest Launch



© Mitsubishi Heavy Industry



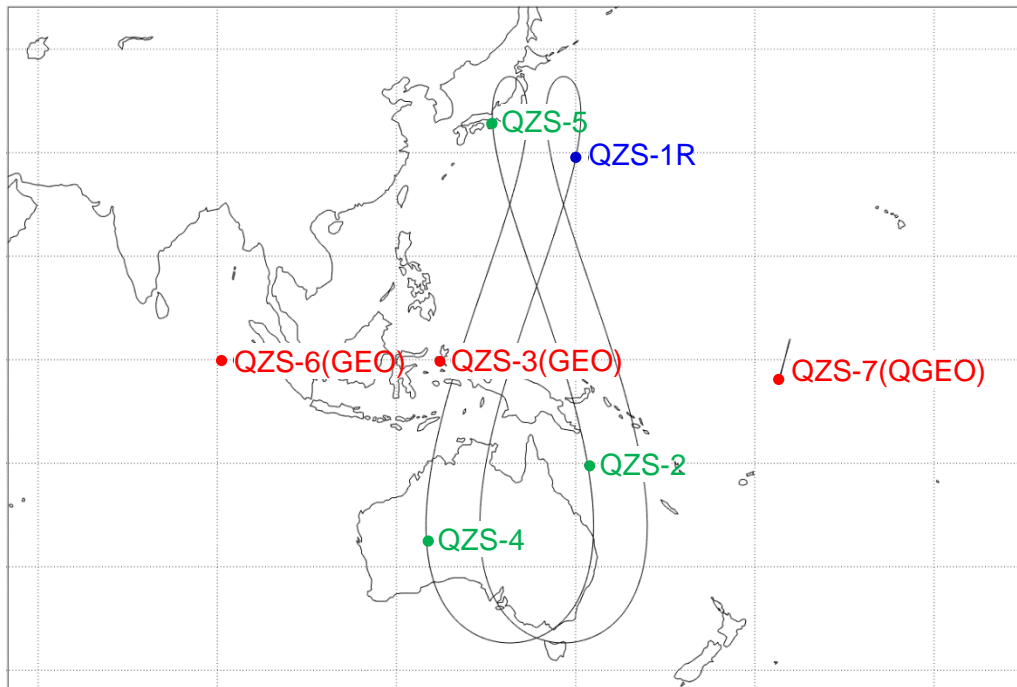
© Mitsubishi Electric Corp.

- QZS-1R was successfully launched on 26th of October 2021
 - By H-IIA launch vehicle #44, from Tanegashima Space Center
 - Replacing the first Michibiki satellite, QZS-1
 - QSS, system operator, is tuning their POD S/W to start providing operational service performance.

2. Future Expansion to 7SV constellation



- 3 additional satellites will be on Inclined Geosynchronous Orbit, Geostationary orbit on 90.5 East Longitude, and Quasi Geostationary Orbit on 175 West Longitude.
- 7 SVs QZSS can provide independent PNT capability for more resilient applications



7-QZSS Ground Track

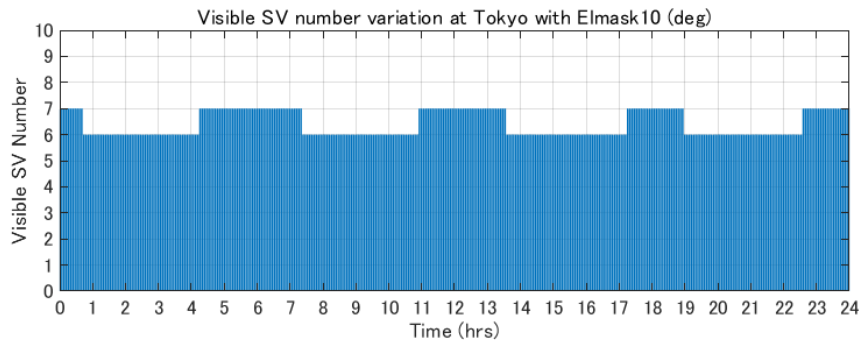
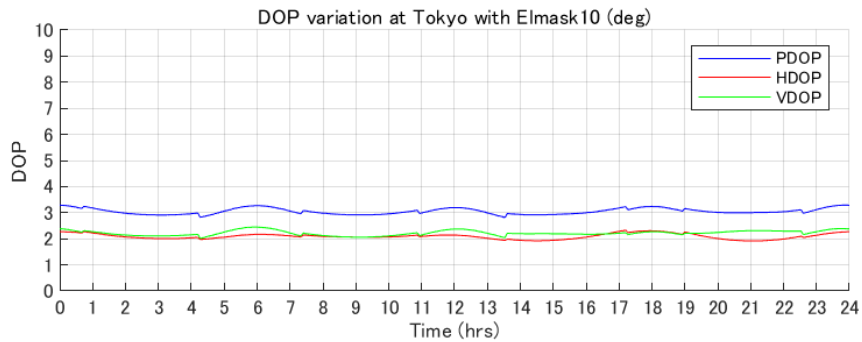
Satellite orbit	Satellite Number	Orbital Position
Inclined Geosynchronous Orbit (4 satellites)	QZS-1R	148 deg E
	QZS-2	139 deg E
	QZS-4	139 deg E
	QZS-5	139 deg E
Geostationary Orbit (2 satellites)	QZS-3	127 deg E
	QZS-6	90.5 deg E
Quasi Geostationary Orbit (1 satellite)	QZS-7	175 deg W

**4 IGSO + 2 GEO +1 QGEO
constellation will be completed
around 2023**

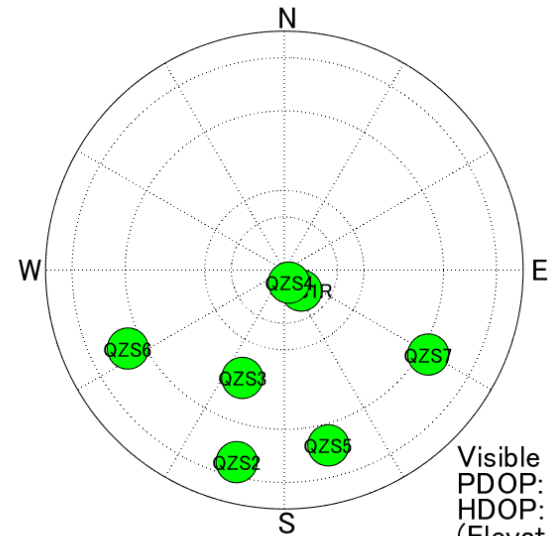
2. Future Expansion to 7SV constellation



Visibility at Tokyo



GNSS Sky Plot at Tokyo /Time(UTC) = 2025:09:01:00:00:00

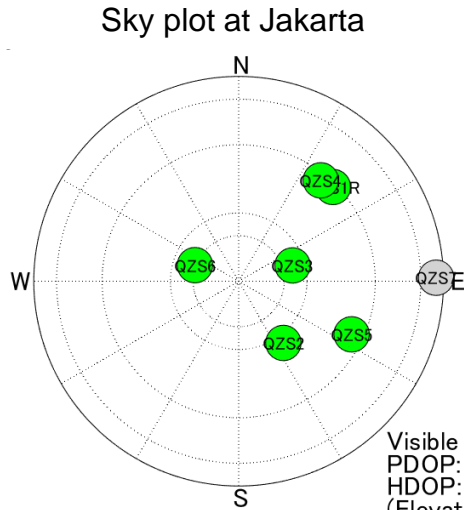


Visible Sat Number: 7
PDOP: 3.29
HDOP: 2.27 VDOP: 2.38
(Elevation Mask: 10 deg)

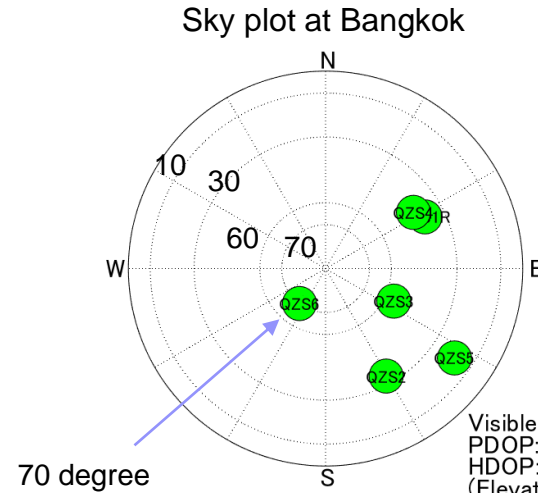
2. Future Expansion to 7SV constellation



■ Visibility at other Asian cities

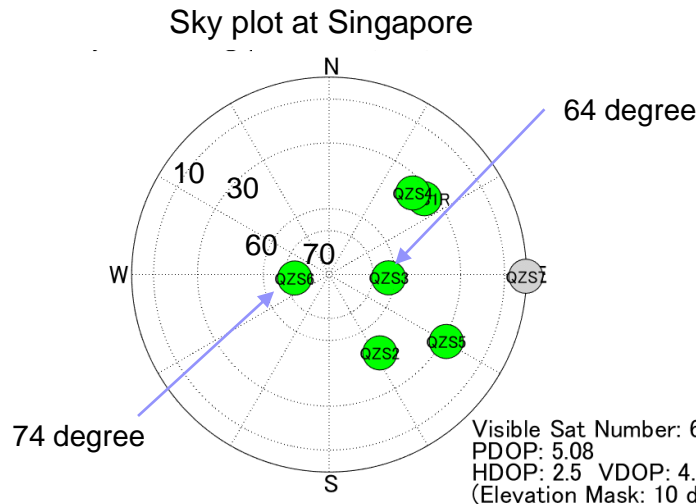


Visible Sat Number: 6
PDOP: 5.06
HDOP: 2.4 VDOP: 4.45
(Elevation Mask: 10 deg)



70 degree

Visible Sat Number: 6
PDOP: 5.15
HDOP: 2.92 VDOP: 4.25
(Elevation Mask: 10 deg)



64 degree

74 degree

Visible Sat Number: 6
PDOP: 5.08
HDOP: 2.5 VDOP: 4.42
(Elevation Mask: 10 deg)

2. Future Expansion to 7SV constellation

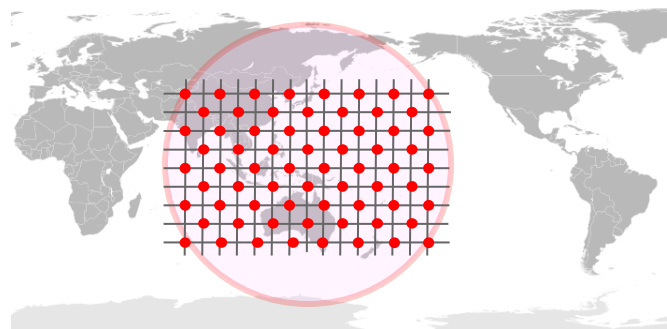
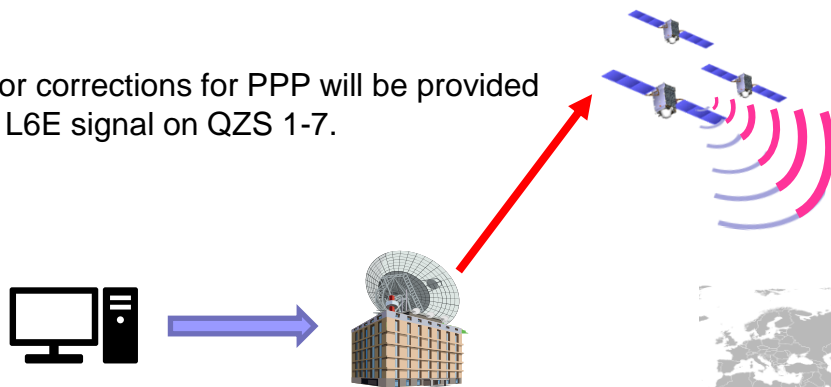
Practical PPP correction service in Asia Pacific region



- Experimental augmentation signal of MADOCA-PPP is now available for Asia-Pacific region.
- Operational service will start no later than 2024.
- For reduction of initial convergence period in PPP, QZS will provide the ionospheric correction data for some areas from 2024 as an experiment for future practical operation.

Error corrections for PPP will be provided via L6E signal on QZS 1-7.

Ionospheric correction data will be provided via L6D signal on QZS 5-7.



	QZS#1-4 L6D: CLAS	QZS#1-7 L6E: PPP corr.	QZS#5-7 L6D: Fast-PPP Ex
SV orbit error	✓	✓	
Clock error	✓	✓	
Code /phase Bias	✓	✓	
Ionospheric delay	✓		✓
Tropospheric delay	✓		

Fast PPP convergence time can be achieved with QZSS wide area ionospheric correction.

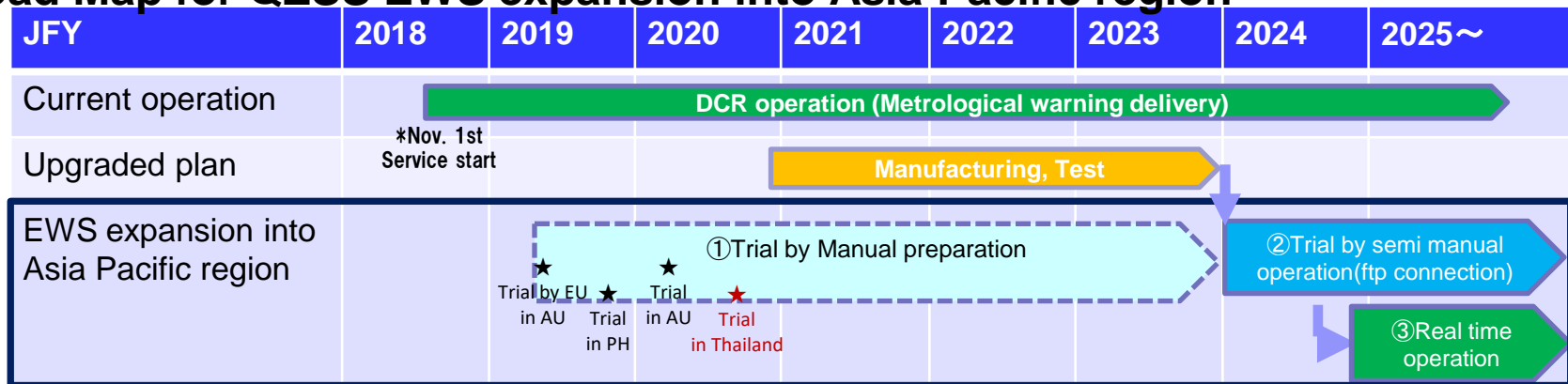
2. Future Expansion to 7SV constellation Early Warning Service (EWS)



- QZSS L1S signal is sharing 250 bps data stream with SLAS and Disaster and Crisis Report service.
- DCR service is currently providing weather information generated by JMA for Japanese domestic users.
- Common EWS format is being investigated in collaboration with EC and India.
- QZSS ground segment will be upgraded to support EWS in 2024-2025.

Signal	Service Name	Center freq.	Modulation	Bit Rate
L1S	Sub-meter Level Augmentation Service (SLAS)	1575.42MHz	BPSK	250bps
	DC Report Service			

Road Map for QZSS EWS expansion into Asia Pacific region



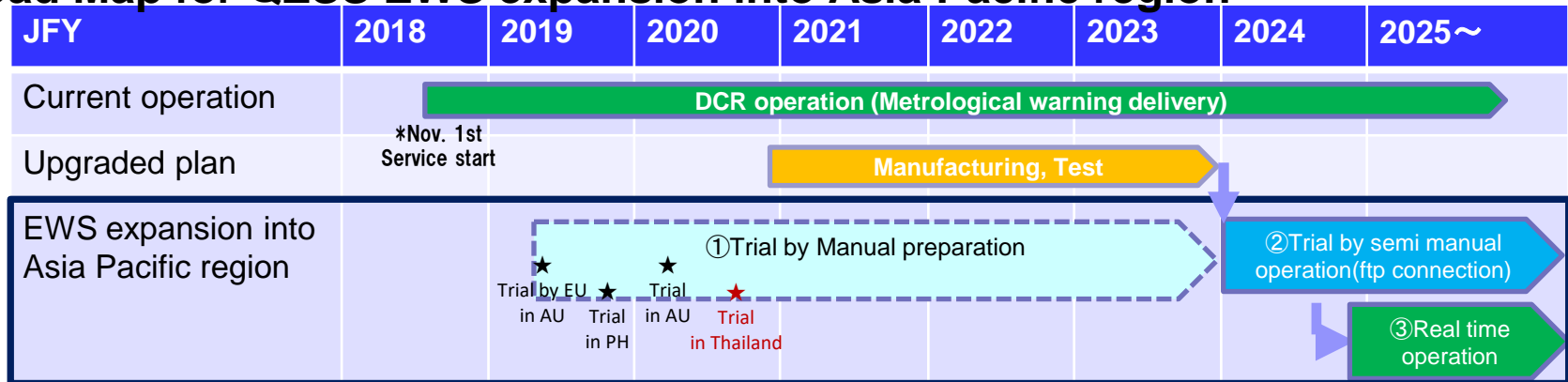
2. Future Expansion to 7SV constellation Early Warning Service (EWS)



- QZSS L1S signal is sharing 250 bps data stream with SLAS and Disaster and Challenges to be solved in advance of practical operation;
- Due to narrow bandwidth of satellite transmission through QZSS L1S, effective way to share it among stakeholders in the region, some prioritization scheme will be required.

Signal	Service Name	Center freq.	Modulation	Bit Rate
L1S	Sub-meter Level Augmentation Service (SLAS)	1575.42MHz	BPSK	250bps
	DC Report Service			

Road Map for QZSS EWS expansion into Asia Pacific region



IS-QZSS-PNT update



- Update the interface specification for PNT
 - New PRN codes were assigned for QZS-5, 6, and 7.
 - Change L1C/A to L1C/B after QZS-1R satellite.
 - Due to the interference mitigation into GPS C/A, QZSS will transmit L1C/A or L1 C/B signal within the agreed interference level.
 - L1 C/B has BOC(1,1) wave form instead of BPSK(1) for L1 C/A, with same PRN code family and data format, LNAV.

“IS-QZSS-PNT-004”

<https://qzss.go.jp/en/technical/ps-is-qzss/ps-is-qzss.html>

Available Receiver, chipset for QZSS use



MADOCA-PPP available

GNSS and MADOCA Receiver
L1, L2, E5b, L6
GPS, GLONASS, GALILEO, BEIDOU, QZSS
Size: W: 55 x B: 55 x D: 15

tblox

CLAS available

SLAS, EWS available



Dual-band GNSS market moving from insignificant to billions in less than 5 years

December 6, 2018 - By GPS World Staff 0 Comments Est. reading time: 2:30

Most of smart phone can track QZSS

Available Receiver, chipset for QZSS use



MADOCA-PPP available

GNSS and MADOCA Receiver
L1, L2, E5b, L6
GPS, GLONASS, GALILEO, BEIDOU, QZSS
Size: W: 55 x B: 55 x D: 15

CLAS available

SLAS, EWS available

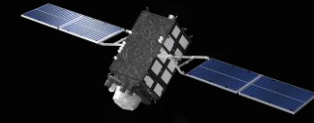
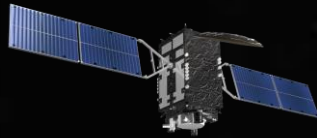
List of products that support the QZSS is shown;
<https://qzss.go.jp/en/usage/products/list.html>

Most of smart phone can track QZSS

Summary



- QZSS is Japanese regional navigation satellite system to improve not only GNSS availability but also accuracy and reliability
 - 4 satellite constellation: Three IGSO and one GEO satellites
- Cabinet Office has been providing PNT, augmentation and messaging services with good performances since Nov. 1, 2018.
 - The service performance has satisfied with the specifications.
 - CLAS performance is enhanced with increasing augmented satellite number.
- Future expansion to 7 satellite constellation
 - Started procurement process for additional 3 satellites around 2023
 - An IGSO, a GSO and a QGSO satellite will be added to the existing constellation
 - MADOCA-PPP will become operational service no later than 2024 and also EWS
- Latest launch, for QZS-1R, on Oct. 26, 2021, was completed successfully.



Thank you for your attention!

For more information, please visit our web site

<https://qzss.go.jp/en/>

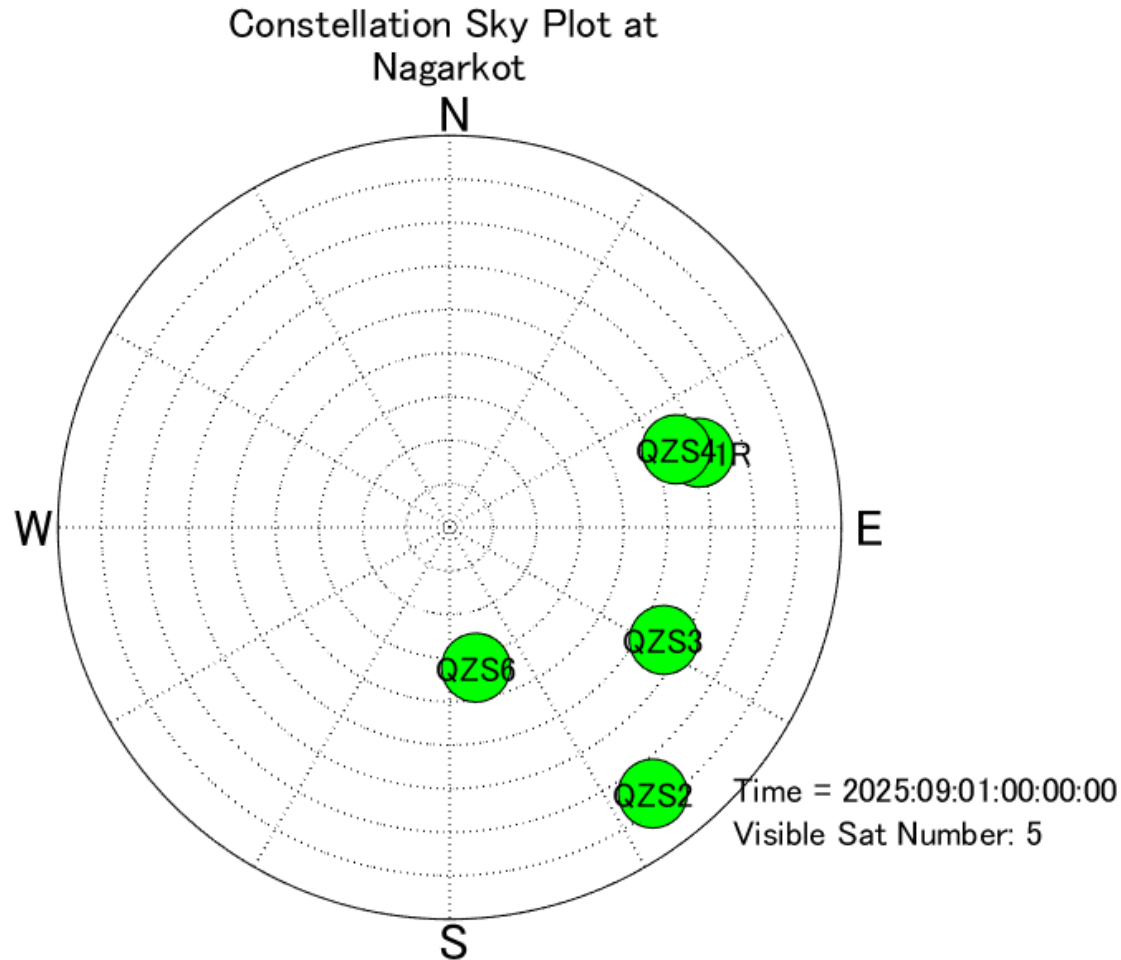


Question?  kogure.satoshi@jaxa.jp

2. QZSS 7SV Constellation Design



Visibility at Nagarkot, Nepal

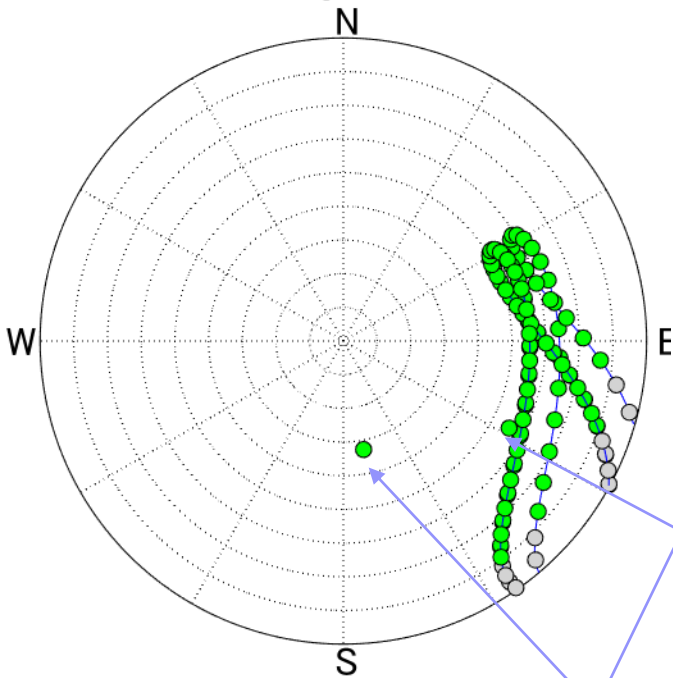


2. QZSS 7SV Constellation Design



Visibility in Nagarkot, Nepal

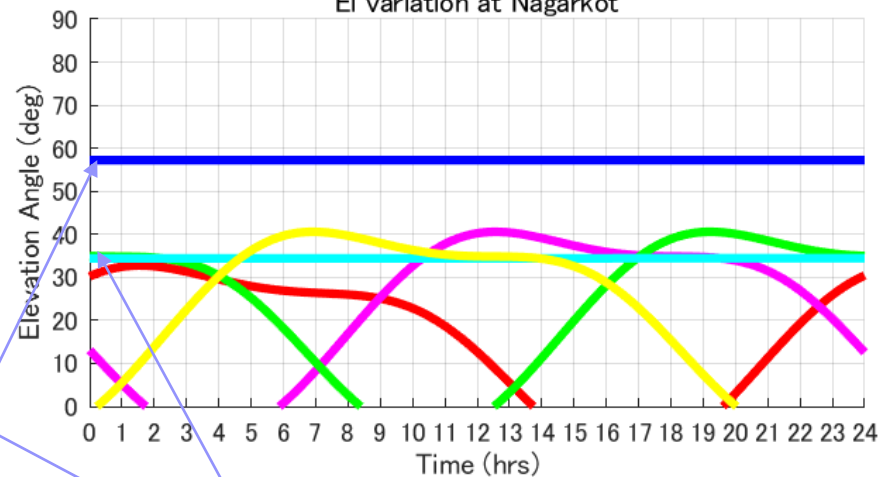
Constellation Sky Plot at Nagarkot



QZS-6 Elevation 57 deg

QZS-3 Elevation 34 deg

EI variation at Nagarkot



- QZS-1R
- QZS-2
- QZS-4
- QZS-3
- QZS-5
- QZS-6
- QZS-7