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National Space Policy Secretariat

Latest QZSS status

February 14, 2024

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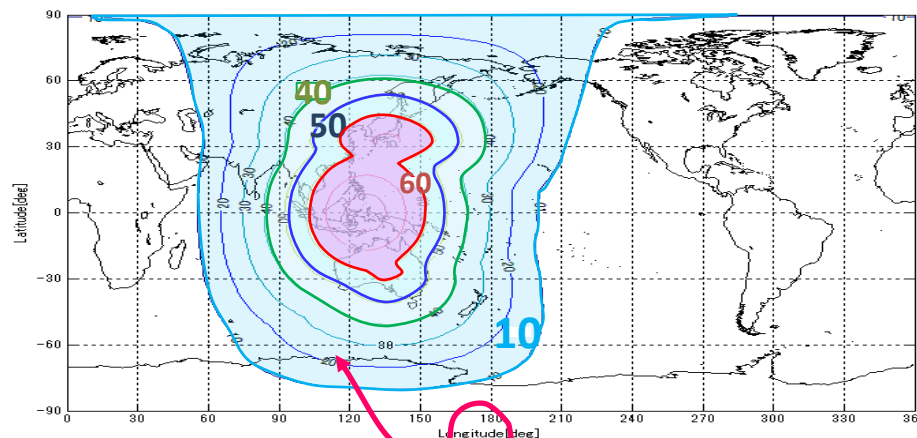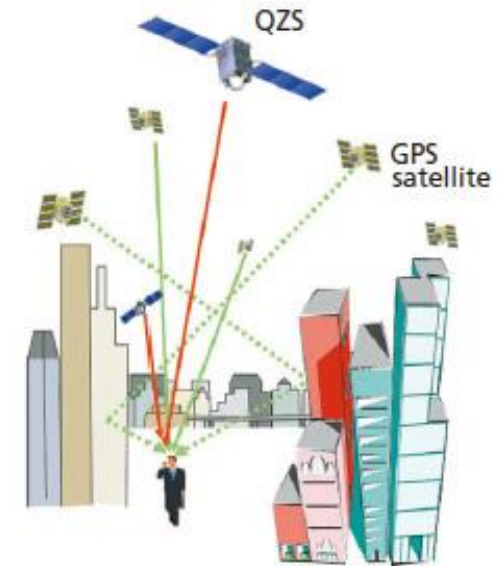
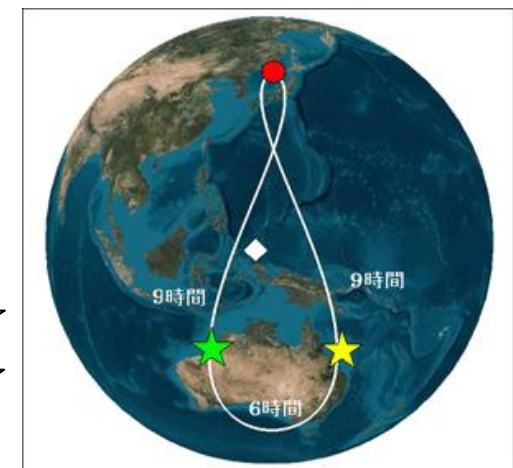# QZSS Overview -Current Services-

- **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

One or more QZSS SVs over 10 degrees elevation angle
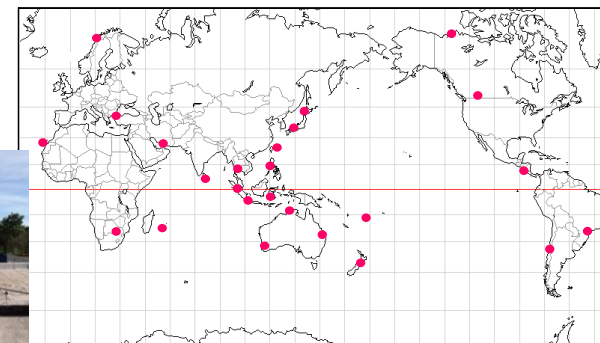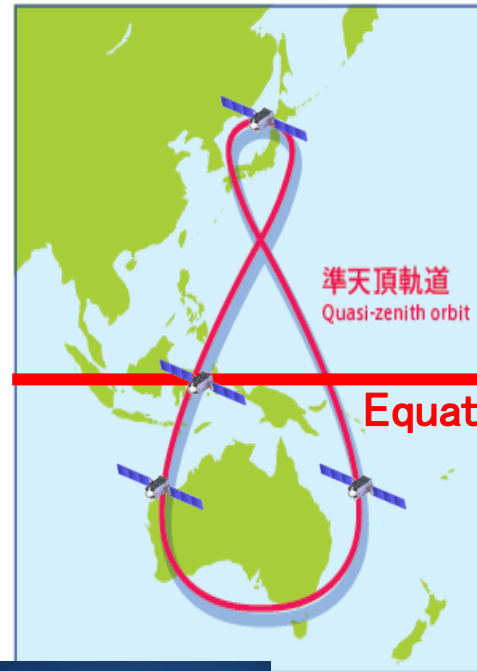
QZSS Overview -System-

- **Constellation:**
  - ☐ 1 GEO Satellite, 127E
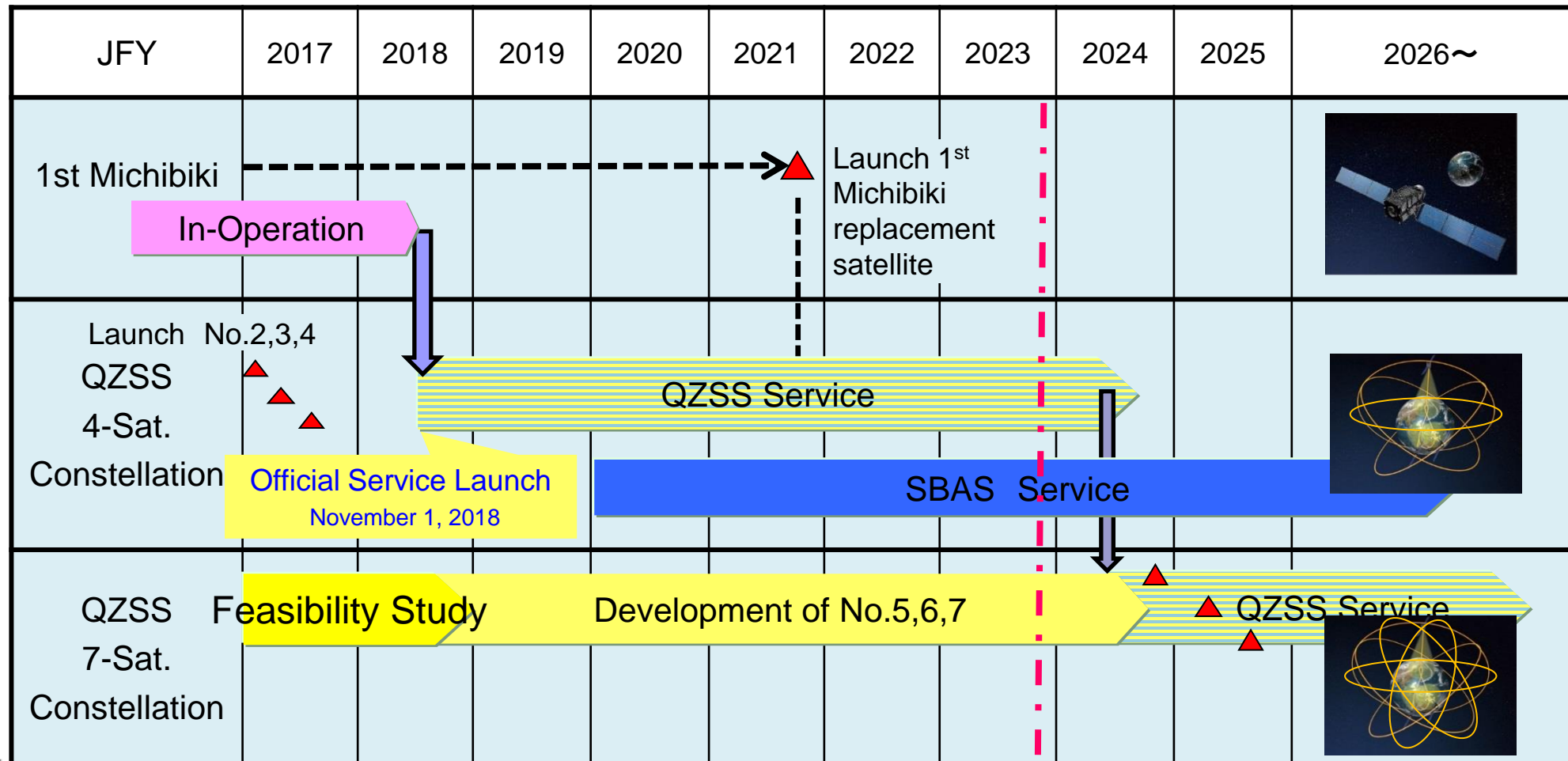 - ☐ 3 QZO Satellite (IGSO)
- **Ground System**
  - ☐ 2 Master Control Stations
    - Hitachi-Ota and Kobe
  - ☐ 7 Satellite TTC Stations
    - Located south-western islands
  - ☐ Over 30 Monitor Stations around the world

準天頂軌道
Quasi-zenith orbit

Equator

QZS-1R

QZS-2, 4

QZS-3

QZSS Control Center, Hitachi-Ohta,

QZSS Development Plan

- Development of 3 additional satellites are on-going.
- The launches for them are scheduled for JFY2024 to 2025 on the formal plan.

JFY	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026~
1st Michibiki		In-Operation			▲	Launch 1st Michibiki replacement satellite				
QZSS 4-Sat. Constellation	Launch No.2,3,4 ▲▲▲	Official Service Launch November 1, 2018		QZSS Service			SBAS Service			
QZSS 7-Sat. Constellation	Feasibility Study		Development of No.5,6,7					▲ ▲ ▲ QZSS Service		

Today

7 Satellites Constellation of QZSS

■ Additional services start around 2024-2025

- ☐ PNT service
  - ■ Users obtain PVT solution with using ranging signals provided by 7 SV constellations.
  - ■ Target accuracy is 1-meter horizontal error (95 percentile).
  - ■ Navigation Message Authentication(NMA) will be added to LNAV, CNAV, CNAV2 messages.
- ☐ MADOCA-PPP service
  - ■ Covering major part of eastern hemisphere and providing PPP error corrections on L6 signal.
- ☐ Early/Emergency Warning Satellite Service (EWSS)
  - ■ Four out of seven SVs will transmit 122 bits common EWS message on L1S signal.
  - ■ Common EWS message is developed under collaboration with EC, Cabinet office, and ISRO under ICG framework and <u>CAMF(Common Alert Message Format) has been published since January 2024 by EC.</u>
  - ■ Additional bits on QZSS EWS can be available for regional unique information sharing.

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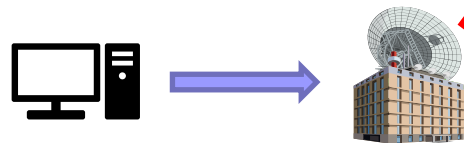National Space Policy Secretariat

Practical PPP correction service in Asia Pacific region

- Test live 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, QZSS will provide the ionospheric correction data for some areas from 2024 as an experiment for future practical operation.
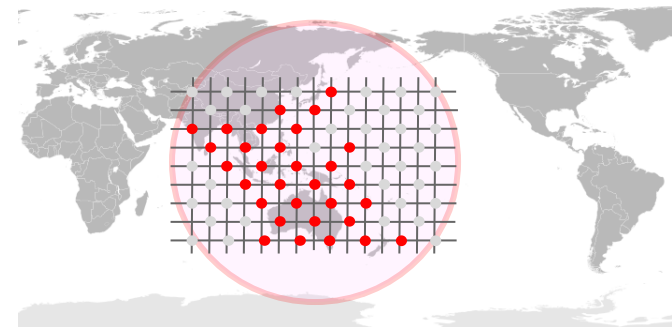
■ **Global PPP**

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

■ **Fast PPP with ionospheric correction**

Ionospheric correction data will be provided via L6D signal on QZS 6-7, with using regional/nation CORS observation data.

	QZS#1-5 L6D: CLAS	QZS#1-7 L6E: PPP corr.	QZS#6 and #7 L6D: Fast-PPP Ex
SV orbit error	✔	✔	
Clock error	✔	✔	
Code /phase Bias	✔	✔	
Ionospheric delay	✔		✔
Tropospheric delay	✔		

Fast PPP coverage will be depending on the partnership of regional/nation CORS operators.

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- **PS-QZSS 003 was published on Mar. 17, 2022**
  - ☐ Adding MADOCA-PPP service to the existing services
    - Defines augmented constellations and signals
      - ☐ QZSS, GPS, Galileo and Glonass
    - Service area
      - ☐ At least one QZS is visible more than 10 degrees elevation angle
      - ☐ Error corrections for more than 20 satellites over 10 degrees elevation angle are available in the service area.
    - Minimum performance level
      - ☐ Positioning Accuracy
        - Horizontal: 30cm (95%)
        - Vertical: 50cm (95%)
      - ☐ Convergence time
        - 1800 sec
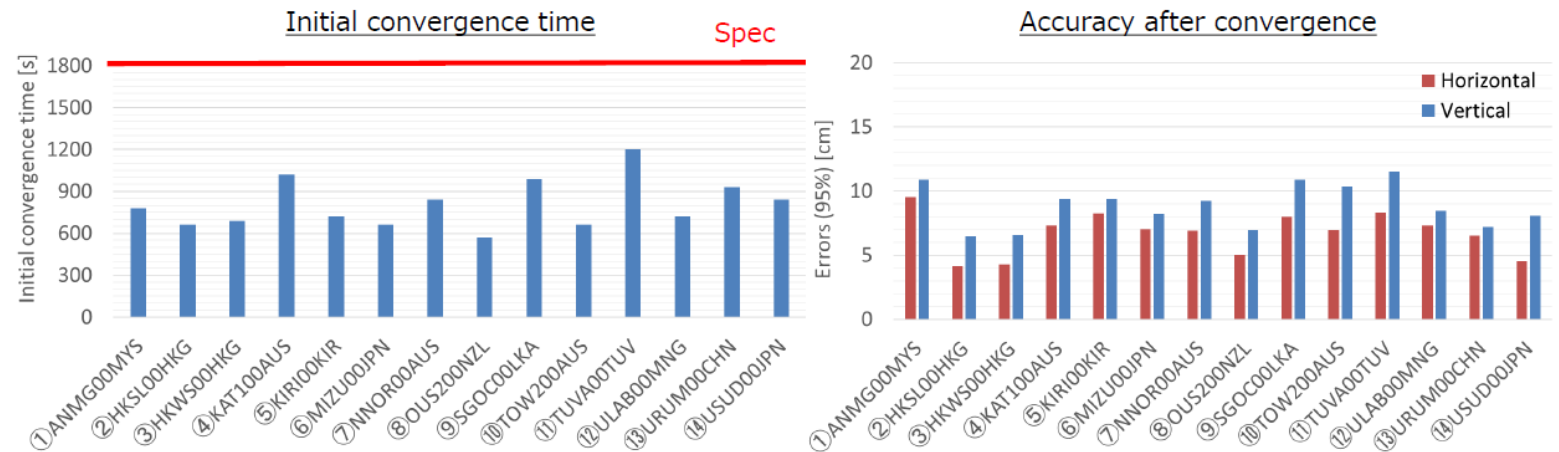   - 600 sec   (target value for initial convergence time with ionospheric correction)

± 60 latitude and 70E to 200E longitude

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

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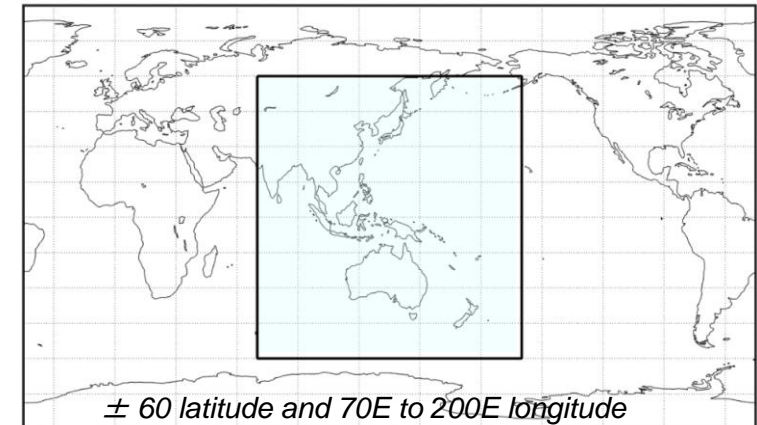
Practical PPP correction service in Asia Pacific region

- **IS-QZSS-MDC 002 was published in November, 2023**
  - ☐ Defining L6E channel properties and data format
  - ☐ RF specifications are same as CLAS(L6D)
    - Same receiver H/W can be available for tracking and decoding MADOCA-PPP error corrections
  - ☐ Data format is changed from the existing experimental signal on L6E and Compact-SSR format, same as CLAS, is adopted.
    - Updated error corrections will be provided from the beginning of October 2022.
  - ☐ The definition and data format for wide area ionospheric corrections has been added.
- Test evaluation result, Service Performance Report MADOCA-PPP, was also posted QZSS web site.
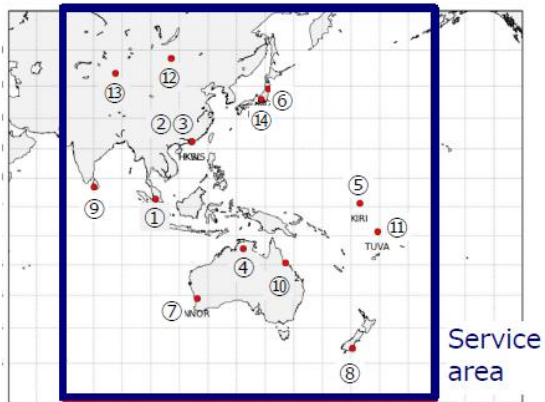
[Evaluation Period]: Dec. 1 to Dec. 31,

[Evaluation Period]: Dec. 1 to Dec. 31, 2022 Source; M. Kishimoto, "Latest Status of QZSS", ION GNSS+ 2023
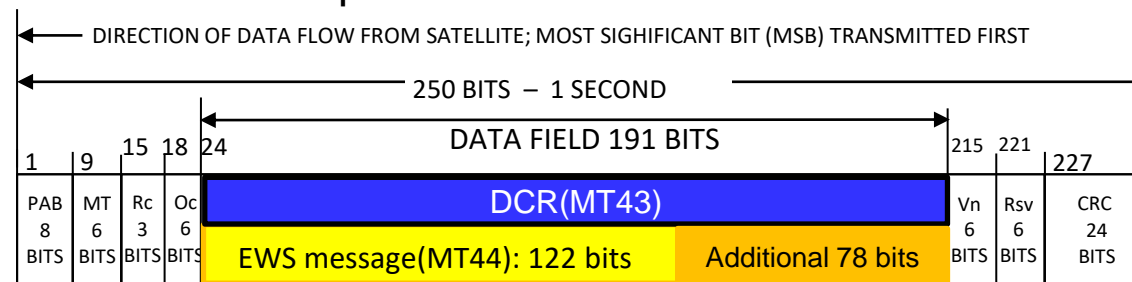
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https://qzss.go.jp/en/technical/ps-is-qzss/ps-is-qzss.html

Overview of QZSS EWSS

- **"Satellite Report for Disaster and Crisis Management" service (DCReport) is being provided with using L1S signal.**
  - ☐ Same RF property as L1 SBAS, 1575.42MHz, BPSK(1), 500sps(250bps)
  - ☐ 1 of 4 slots (every 4seconds) sharing with SLAS service (2 of 4 slots in 4 seconds)
  - ☐ MT43 is defined the information issued by Japan Meteorological Agency such as the earthquake, typhoon, tsunami, volcanic eruption and so on, in IS-QZSS-DCR-010.
  - ☐ MT44 will be extended for EWS.
    - Common EWS message with 122 bits and additional 78 bits
    - Common EWS includes disaster type, target area, and alert, guidance information.
    - Target area for an alert msg. is defined by ellipse and its radius is adjustable.
    - MT44 interface for oversea users is under development.

PAB: Preamble
MT: Message type
Rc: Report Classification
Oc: Organization Code
Vn: Version Number
Rsv: Reserved
CRC: Cyclic Redundancy Check

DIRECTION OF DATA FLOW FROM SATELLITE; MOST SIGHIFICANT BIT (MSB) TRANSMITTED FIRST

250 BITS － 1 SECOND

DATA FIELD 191 BITS

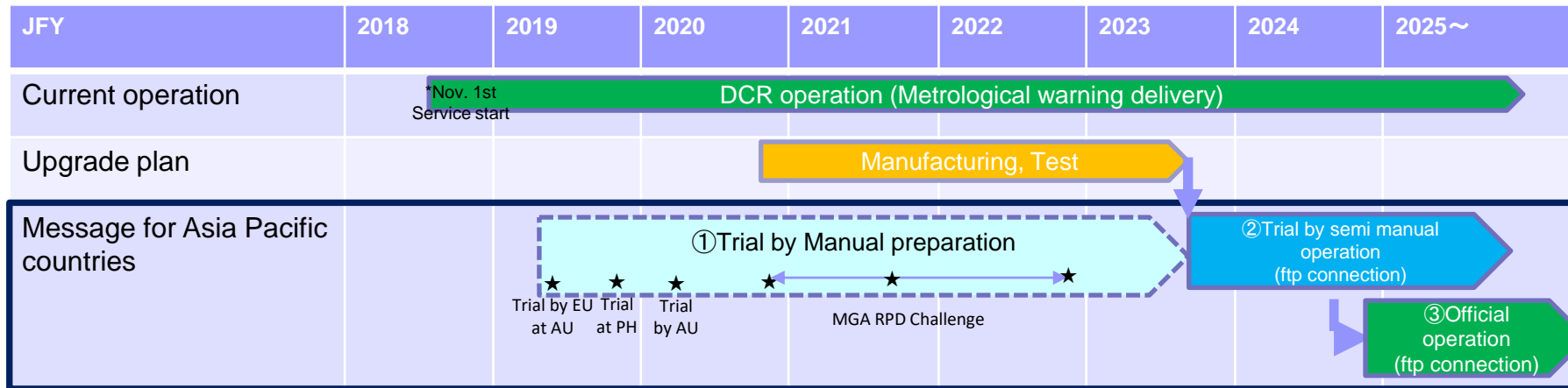| 1	9	15	18	24		215	221	227
PAB 8 BITS	MT 6 BITS	Rc 3 BITS	Oc 6 BITS	DCR(MT43)		Vn 6 BITS	Rsv 6 BITS	CRC 24 BITS
				EWS message(MT44): 122 bits	Additional 78 bits			

Report category : 1 Maximum priority, 2 Priority, 3 Regular, 7 Training/Test

Message type : 43, 44(DC report), 47～50 (SLAS), etc.

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QZSS EWSS for Asia Pacific region

■ Ground control segment upgrade is on-going, official operation will start from JFY2025.

JFY	2018	2019	2020	2021	2022	2023	2024	2025～
Current operation	*Nov. 1st Service start	DCR operation (Metrological warning delivery)						
Upgrade plan				Manufacturing, Test				
Message for Asia Pacific countries		①Trial by Manual preparation					②Trial by semi manual operation (ftp connection)	③Official operation (ftp connection)

Trial by EU at AU   Trial at PH   Trial by AU   MGA RPD Challenge

■ Step by step approach to practical operation

① **Trial by Manual preparation**

Message is received by e-mail and prepared by manual.

② **Trial by semi manual operation**

Message is received by ftp and prepared by system. The message will be broadcasted within 2mins(e.g.).
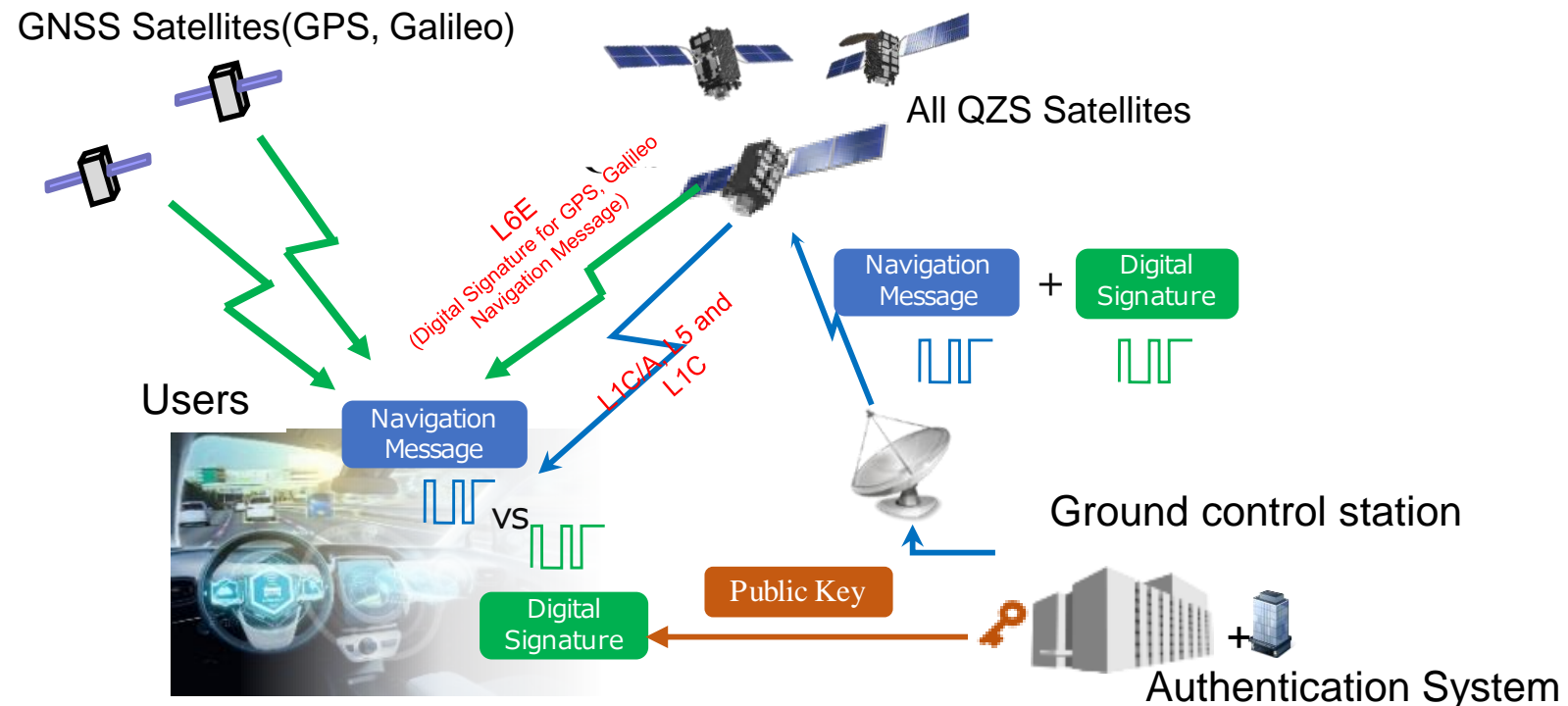
③ **Official operation**

After modifications extracted through the above Trial operation, official operation will start form JFY 2025. (with ftp I/F and within 2 min alert broadcasting from user's alert issue.
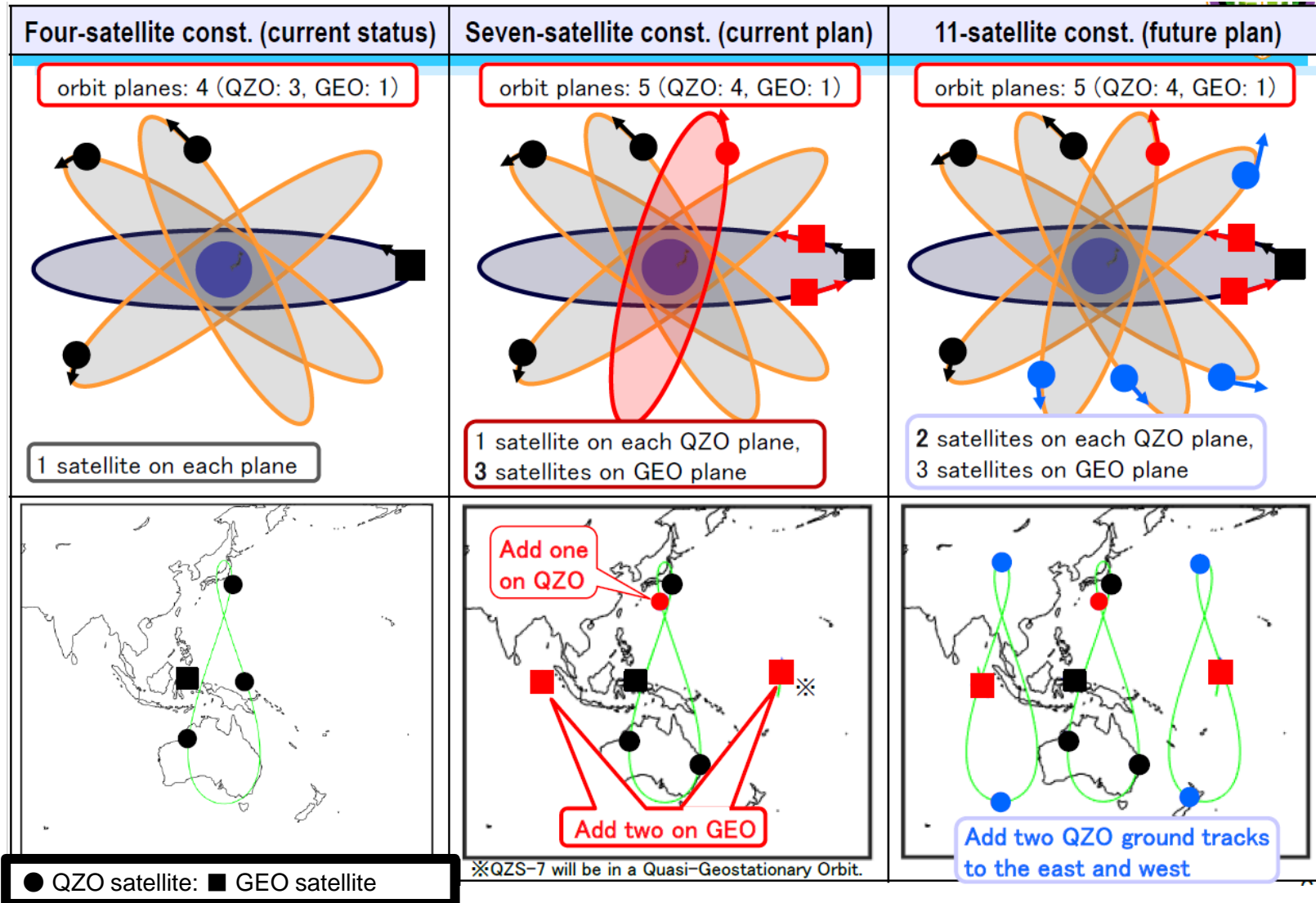

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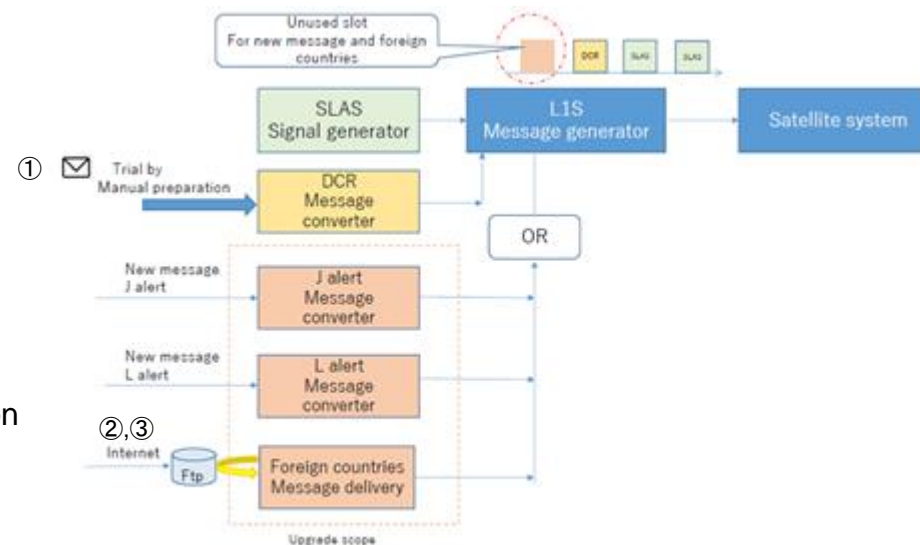
QZSS QZNMA Service

- QZSS navigation message authentication (QZNMA) service will be lunched in 2024. Navigation messages in the following signals are authenticated with using ECDSA (P-256).
  - ➢ QZSS signals (L1C/A, L1C, L5) are protected by self-authentication
  - ➢ GNSS signal (GPS: L1C/A, L1C, L5, Galileo:E1b, E5a) are protected by cross-authentication (L6E)
- The Interface Specification (IS-QZSS-SAS-001)(draft-002) is now available on our website.
- Test Transmission started from the end of July 2023.

QZSS Constellation Expansion Plan

Four-satellite const. (current status)	Seven-satellite const. (current plan)	11-satellite const. (future plan)
orbit planes: 4 (QZO: 3, GEO: 1)	orbit planes: 5 (QZO: 4, GEO: 1)	orbit planes: 5 (QZO: 4, GEO: 1)

1 satellite on each plane

1 satellite on each QZO plane,
3 satellites on GEO plane

2 satellites on each QZO plane,
3 satellites on GEO plane

Add one on QZO

Add two on GEO

※QZS-7 will be in a Quasi-Geostationary Orbit.

Add two QZO ground tracks to the east and west

● QZO satellite: ■ GEO satellite

■ **Three Advantage of 11SV constellation**

1. Higher and more stable accuracy
2. More resilient and robust system
3. Wider service coverage

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Asia-Oceania Collaborations with QZSS

Vietnam for MADOCA-PPP

Signed the LoI with VNSC to conduct demonstration of MADOCA-PPP.

Bangladesh for EWSS

Planning for seminars and promotions with local disaster prevention organization (MDMR, etc) in JFY2023

Nepal for EWSS

Planning for seminars and promotions with local organizations (MOHA, etc) in JFY2023

Thailand for EWSS/MADOCA-PPP

EWSS) Performed demonstration with GISTDA for forest fires in JFY2022. Planning second demonstration in March 2024.   MADOCA-PPP) Under evaluating positioning performance with GISTDA.

Cambodia for EWSS

Planning for seminars and promotions with local organization (NCMD) in JFY2023

Malaysia for EWSS

Performed of seminars and promotions with local disaster prevention organization (NADMA, etc) in August, 2023

Philippines for EWSS/MADOCA-PPP

EWSS) Planning for seminars and promotions with local disaster prevention organization (OCD) in JFY2023
MADOCA-PPP) Signed the LoI with NAMRIA to conduct demonstration of MADOCA-PPP.

Indonesia for EWSS/MADOCA

EWSS) Planning for seminars and promotions with local disaster prevention organization (BNPB, University of Indonesia) in JFY2023
MADOCA-PPP) Signed the LoI with BIG and BRIN to conduct demonstration and seminars of MADOCA-PPP.

Fiji for EWSS

Performed demonstration with NDMO to evacuate residents and tourists from Tsunami in JFY2022.
Planning second demonstration in JFY2023.

Australia for EWSS

Performed demonstration with GA for forest fires in JFY2022. Planning second demonstration by mainly university in JFY2023.
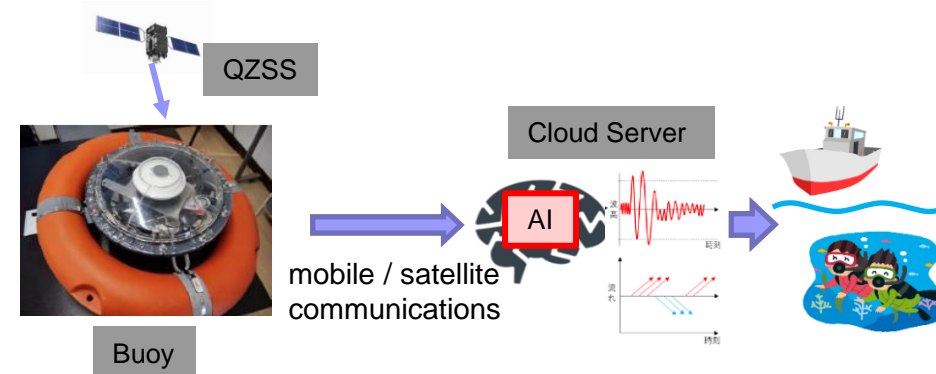
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QZSS Applications

Autonomous driving

QZSS compatible antenna (Built in shark fin)

(©Honda R&D Co., Ltd.)

QZSS compatible antenna (Built in shark fin)

(© Nissan Motor Co., Ltd.)

Buoy for real-time ocean tide monitoring

QZSS

Buoy

mobile / satellite communications

Cloud Server

AI

Wearable terminals

display the distance to the green

display the EWS message

Drones

Agricultural Drone

Logistics drone

GNSS Receiver and Chipset

CORE Corp. Cohac∞Ten+ (for CLAS,MADOCA) 150*210*55mm	Bizstation Corp. RWS.DC (for CLAS,MADOCA) 50*51.5*13.1mm	Magellan Systems Japan MJ-3021-GM4-QZS-EVK (for CLAS,MADOCA) 130*90*42 mm
Septentrio Mosaic-CLAS 31*31*4mm	u-blox ZED-F9P + **NEO-D9C** (for CLAS)	Magellan Systems Japan Digital ASIC** (for CLAS,MADOCA) Less than 30*40 mm

*   Additional android software for MADOCA-PPP
** to be available in the end of March 2023

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# QZSS Applications for Smart Cities

- **Planning and early construction phase**
  - ☐ Enough infrastructure has not established the area
  - ☐ MADOCA-PPP support effective drone survey, construction machine control and etc.…

- **Autonomous Mobility, Logistics**
  - ☐ GNSS is most important key technology for precise positioning and timing, QZSS can provide error corrections for autonomous mobility and logistics.
  - ☐ QZNMA can provide secure position and timing against emerging spoofing threats.

- **Precise Time Synchronization**
  - ☐ Sub nano-second time synchronization for finance applications, traffic control system and so on.
  - ☐ Using phased array antenna tracking a QZSS satellite can strengthen anti-jamming capability.

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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
- Future expansion to 7 satellite constellation
  - Three additional satellites will be launched in JFY2024 to JFY2025. QZSS will provide independent PNT capability for more reliable applications.
- 11 SV constellations will realize more stable, robust performance and wider service coverage.
- New services
  - QZNMA will provide message authentication capability to users, applying ECDSA (P-256).
  - MADOCA-PPP will become operational service no later than 2024 and also EWSS covering Asia Pacific region.
- Commercial devices and applications
  - Emerging new applications such as autonomous driving, drone operation with some commercial devices.
  - According to applications for the smart cities, QZMNA and time sync are most likely expected to strengthen resilience.
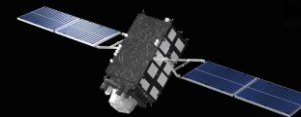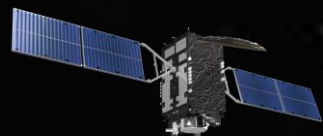
Thank you for your attention!

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

Question? ✉ kogure.satoshi@jaxa.jp