Status Update on the Quasi-Zenith Satellite System

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Cabinet Office
National Space Policy Secretariat

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- **Current Status**
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1. QZSS Overview and Current Status

Launch of Satellite #4

提供：三菱重工/JAXA

Oct. 10, 2017 07:01:37 (JST) @ Tanegashima Space Center
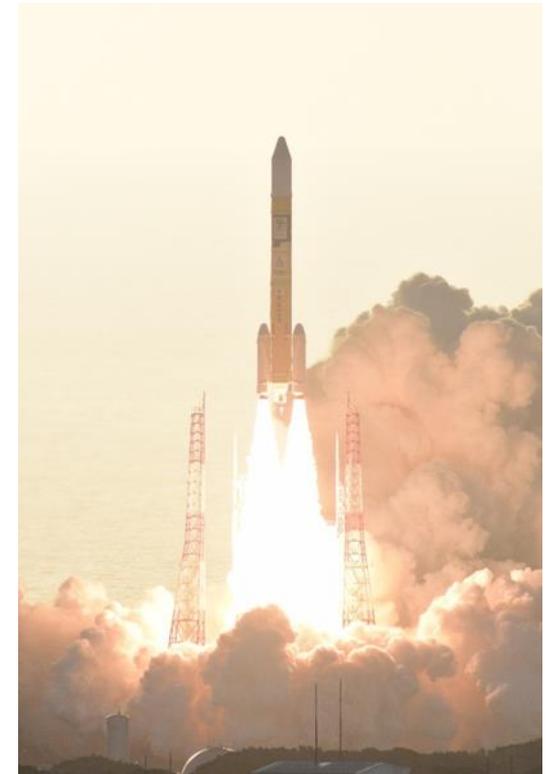
Current Status of QZSS

Three consecutive launches were successfully conducted for 4 constellation of QZSS.

©三菱重工/JAXA

| #2 satellite: Jun. 1, 2017 09:17:46(JST)	#3 satellite: Aug. 19, 2017 14:29:00(JST)	#4 satellite: Oct. 10, 2017 07:01:37 (JST)

QZSS Overview - System

- ## *Constellation:*

  - 1 GEO Satellite (127 deg. East)

  - 3 QZO Satellite

    - *First QZSS satellite "MICHIBIKI" launched in 2010.*

- ## *Ground System*

  - 2 Master Control Stations

  - 7 Satellite Control Stations

  - Over 30 Monitor Stations around the world

準天頂軌道
Quasi-zenith orbit

Equator
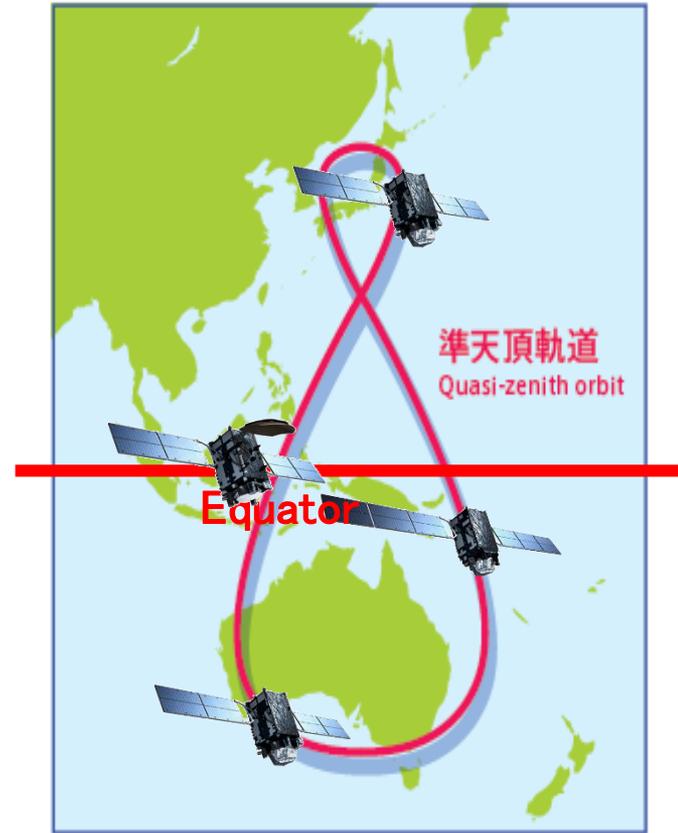
QZSS Control Center, Hitachi-Ohta,
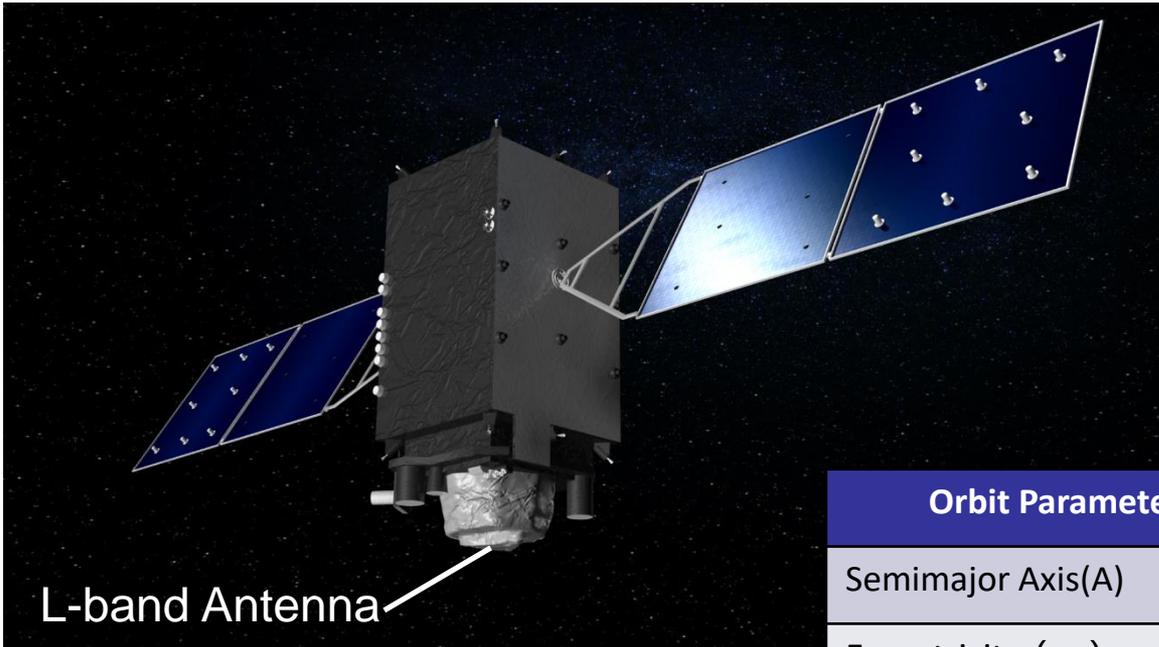
Master Control Stations

Sat Control Stations

Monitor Stations

QZSS Overview - System
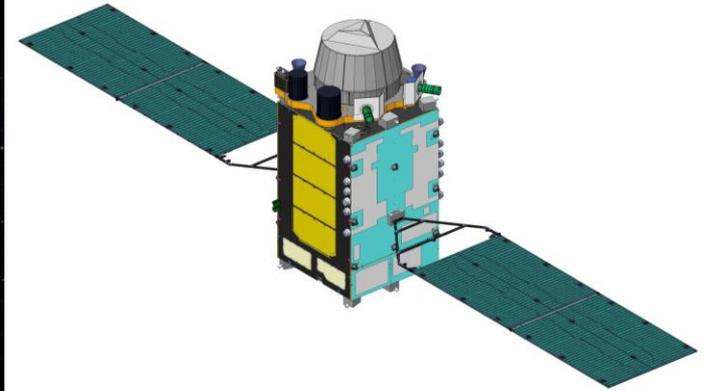
QZSS Satellite (#2 and #4)

L-band Antenna

Launch Vehicle : H-IIA
Mass Dry/Launch : 1.6t/4.0t
Lifetime : 15years+

Orbit Parameter	Nominal Allocation
Semimajor Axis(A)	42164km
Eccentricity（e）	0.075
Inclination (i)	41 degree
Argument of Perigee(w)	270 degree
RAAN(Ω)	Block I_Q: 117 degree Block II_Q: 117±130 degree
Central Longitude (λ)	136 degree

RAAN: Right Ascension of the Ascending Node

QZSS Overview - System

QZSS Satellite (#3 GEO)

S-band Antenna

Launch Vehicle : H-ⅡA
Mass Dry/Launch : 1.8t/4.7t
Lifetime : 15years+
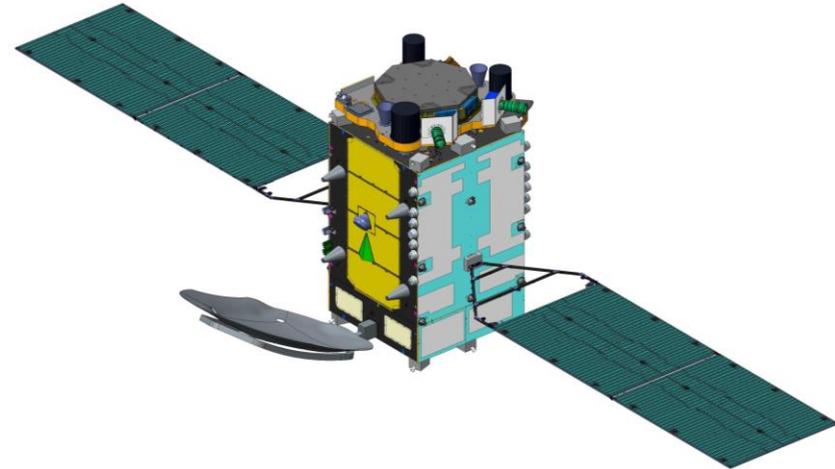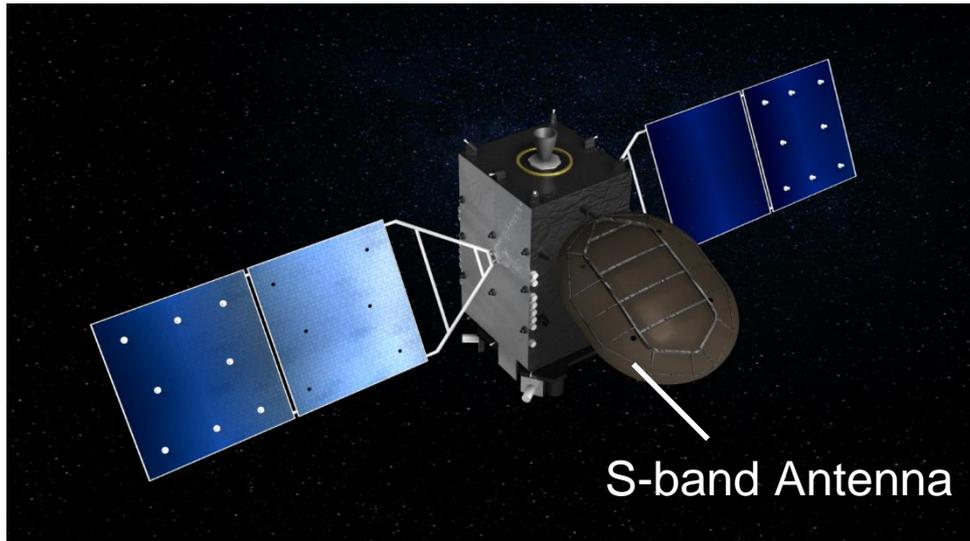

Orbit Parameter	Nominal Allocation
Longitude	E 127
Latitude	0

- Additional S-band antenna for two-way communication for emergency safety report (Q-ANPI service).
- L1b signal for SBAS service.

QZSS Overview -System-

QZSS Master Ground Station

http://www.mlit.go.jp/koku/15_bf_000367.html

QZSS Control Center, Kobe

- ✓ Two-Ground Station (Control Center) are available with site diversity.
- ✓ Hitachi-Ota station is main operation site and Kobe is a redundant site.

QZSS Control Center, Hitachi-Ohta,

http://www.mlit.go.jp/koku/15_bf_000367.html

QZSS TTC Stations

Hitachi Ota
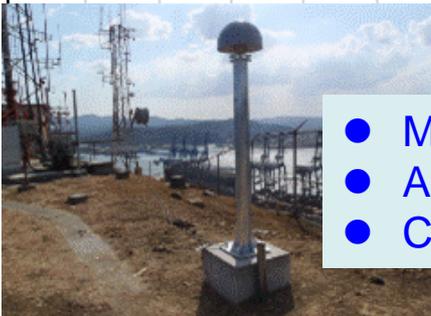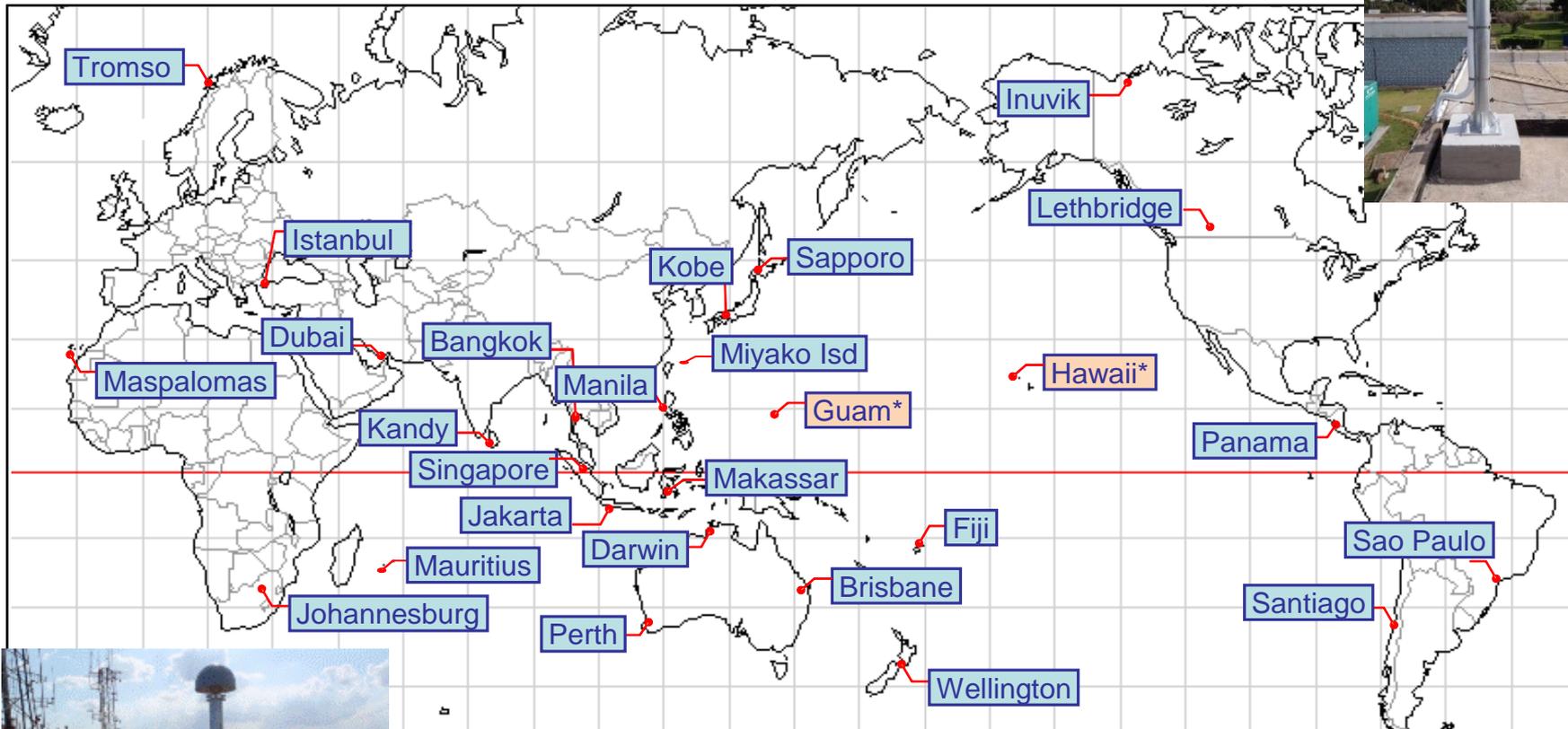
Kobe

Kume Is.

Tanegashima Is.

Okinawa Is.

Ishigaki Is.

Miyako Is.
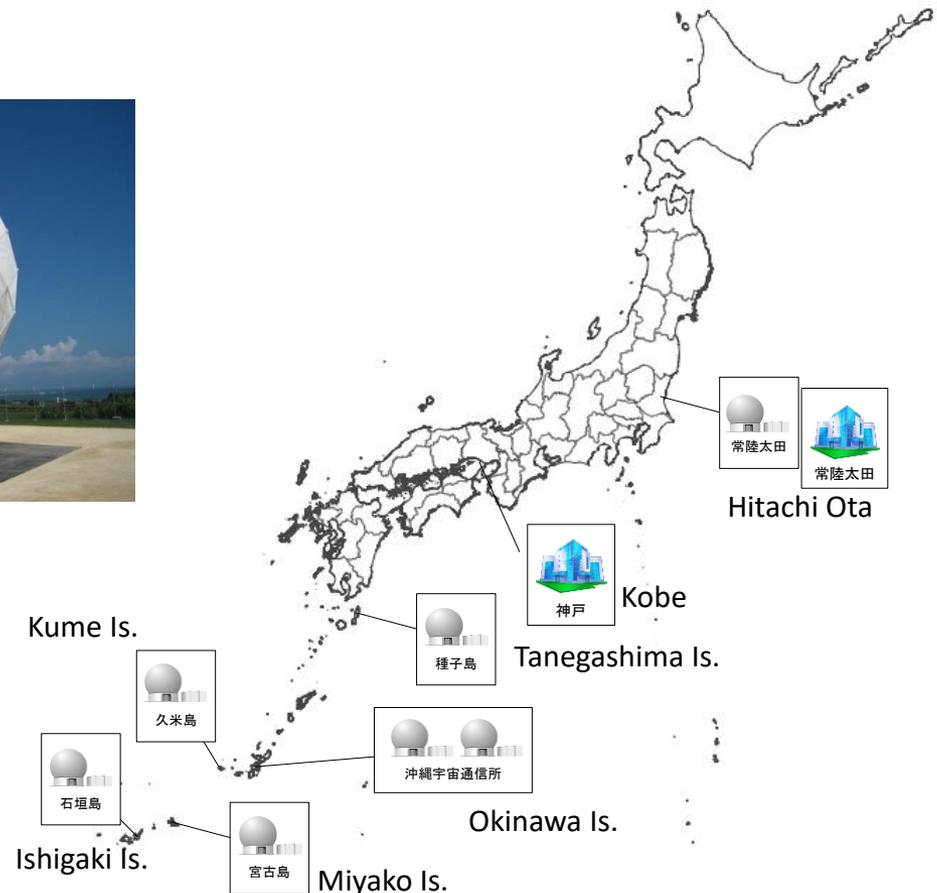
- 7 TTC (Telemetry, Tracking, and Command) stations: Most are at the southern part of Japan for satellite continuous visibility.
- All TTC stations were built and set operational by the end of 2016.

QZSS Overview -System-

QZSS Monitor Stations Distribution

Map of QZSS Monitor Stations Distribution with the following sites labeled:
Tromso, Inuvik, Istanbul, Lethbridge, Kobe, Sapporo, Dubai, Bangkok, Miyako Isd, Hawaii*, Maspalomas, Manila, Guam*, Kandy, Panama, Singapore, Makassar, Jakarta, Fiji, Mauritius, Darwin, Sao Paulo, Johannesburg, Brisbane, Santiago, Perth, Wellington

- More than 20 monitor stations for POD of both QZSS and GPS satellites
- Additional 10 domestic stations for SLAS (totally 13 sites)
- CLAS uses GEONET, Japanese CORS more than 1200 stations

:Monitor Site

:Monitor Site for independent monitoring use only

QZSS Overview -Services-

- **Coverage:** Asia and Pacific region
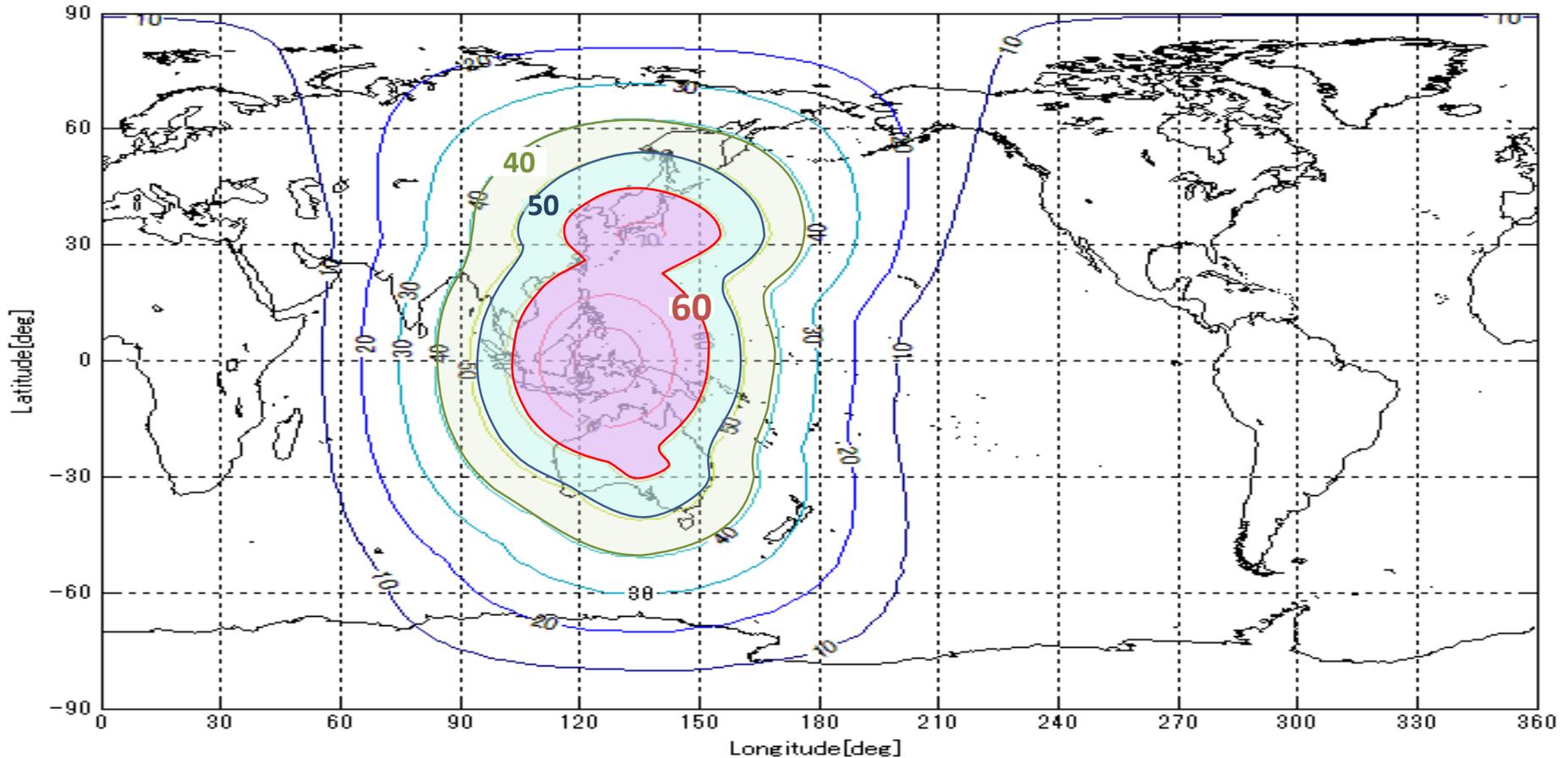
Minimum Largest Elevation Angle Contour in the QZSS 4SV Constellation

QZSS Overview -Services-

- ***Functional Capability:***

  1. GPS Complementary

  2. GNSS Augmentation

  3. Messaging Service

QZSS improves positioning availability time

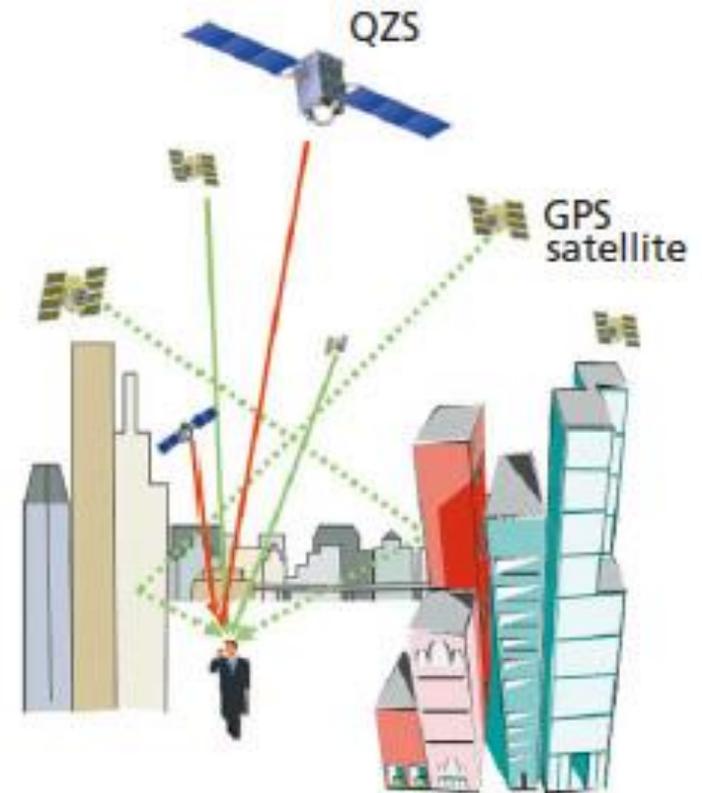Navigation signals L1-C/A, L1C, L2C, and L5 sent from high elevation will improve the time percentage of positioning availability.
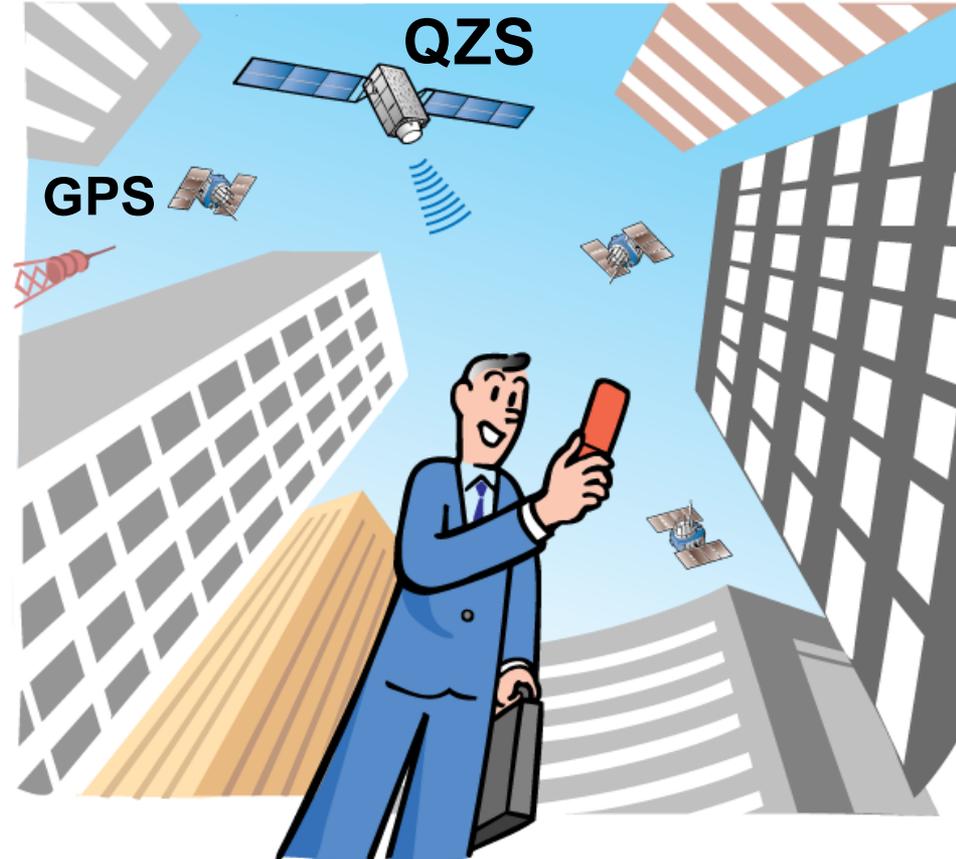
Functional Capability 2 **GNSS Augmentation**

Sub-meter Class Augmentation

QZSS

Ground Segment

GNSS Earth Observation Network

Global Monitoring Stations

Augmentation Data Generation

Sub-meter class Augmentation Data **L1S (250 bps)**

Using QZSS Augmentation Signal ~ 2m

Using GPS only ~ 10m
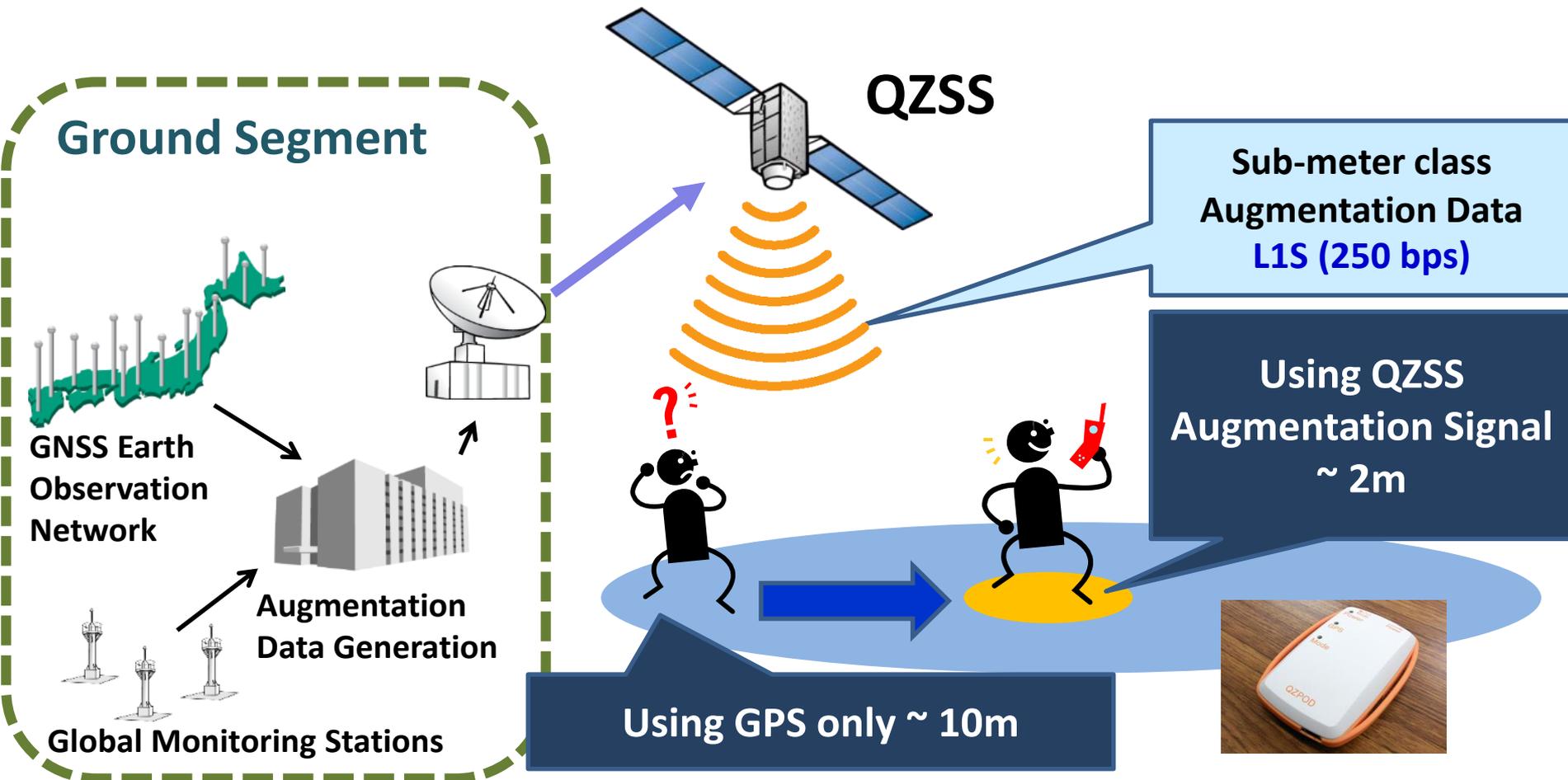
Experiment of "DFMC (Dual Frequency Multi-Constellation) SBAS" will be explained in NEXT presentation

Centimeter Class Augmentation

QZSS

Ground Segment

GNSS Earth Observation Network

Augmentation Data Generation

Global Monitoring Stations

Centimeter class Augmentation Data L6 (2000 bps)

Precise Survey
Real-time Users

IT Construction
(cm level accuracy)

IT Agriculture
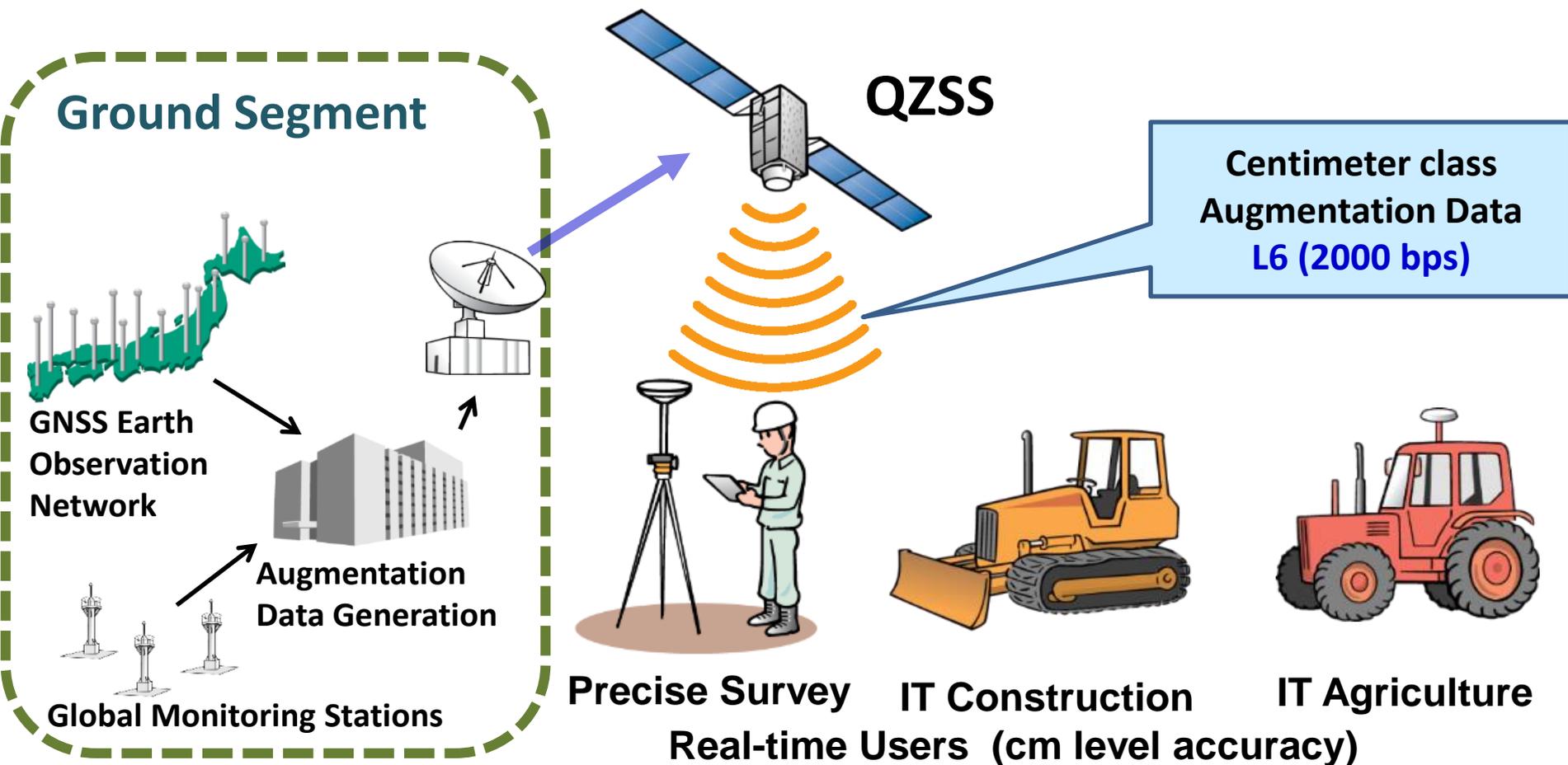
CLAS (L6D) and MADOCA (L6E) have begun broadcasting as trial services.

Functional Capability 3 **Messaging Services**

Satellite Report for Disaster and Crisis Management (DC Report)

QZSS

- Using margin of L1S signal
- Same service coverage as GPS complementary service

Disaster Info. provided by JMA such as Tsunami, Volcanic eruption, weather warning and so on.

Using one of four slots of L1S:1575.42MHz, once a four seconds, 250 bits short code can transmits disaster management info with applicable location
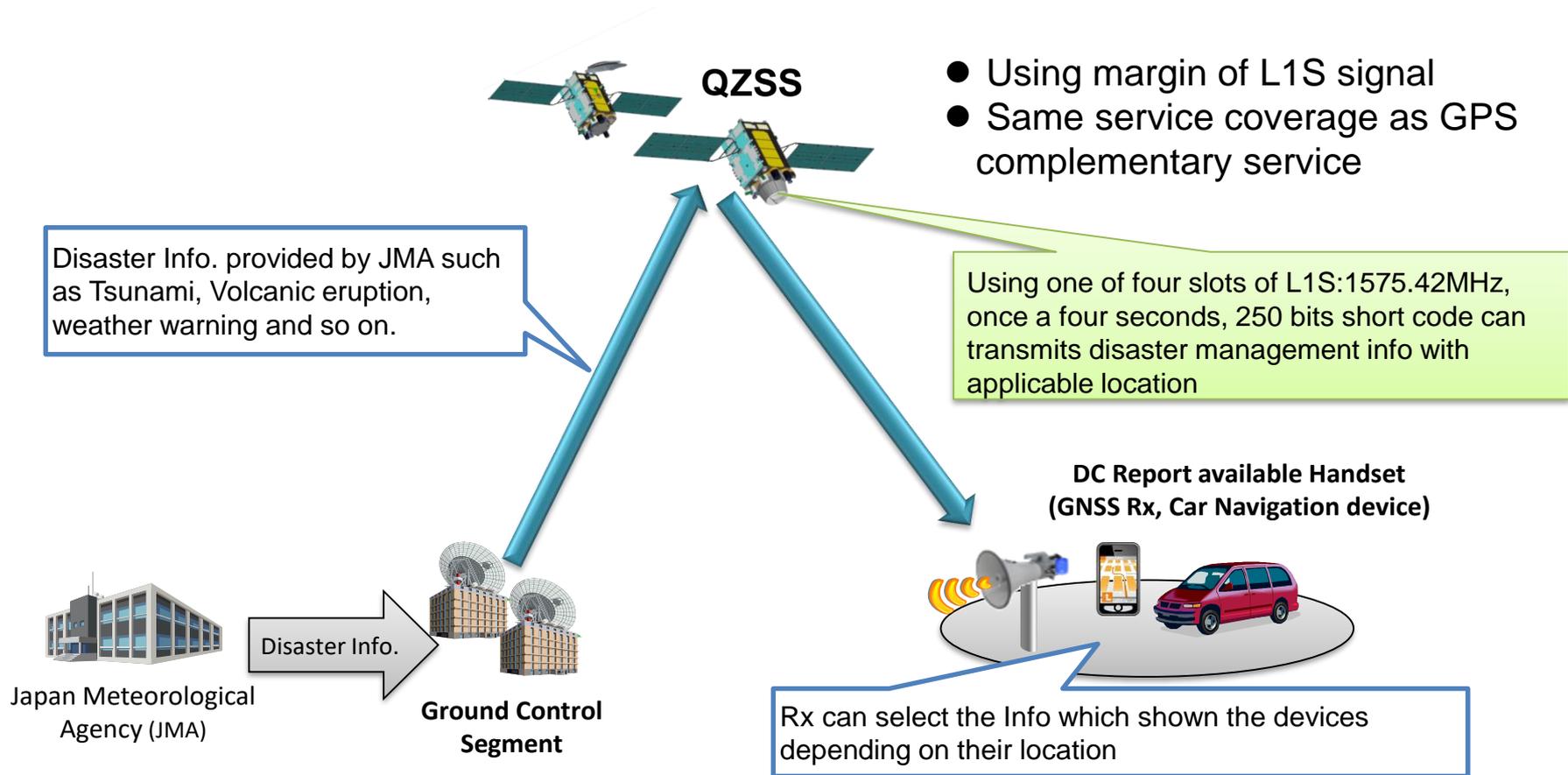
DC Report available Handset (GNSS Rx, Car Navigation device)

Disaster Info.

Japan Meteorological Agency (JMA)

Ground Control Segment

Rx can select the Info which shown the devices depending on their location

A Demonstration of DC Report was conducted during the emergency evacuation training on the World *Tsunami* Awareness Day

SBAS Configuration(After FY2023)

Draft Plan for QZSS 7constellation

JCAB

SBAS Equipment

SBAS Operation

Hitachi-Ota

Technical Management Center

Part of JCAB
- Generate for SBAS message
- Monitoring and Operation for SBAS service

CAO   QZSS

Master Control Station

Hitachi-Ota MCS

Kobe MCS

QZS3(GEO)

QZS / Additional GEOs

Additional sites

Uplink Stations

Additional sites

Monitor Stations

SBAS Signal

GPS

GPS Signal

SBAS service segment

JCAB's service for aviation

service for non-aviation

CAO; Cabinet Office
QZS; Quasi-Zenith Satellite
QZSS; Quasi-Zenith Satellite System

DFMC-SBAS Test-bed (from Aug 2017)

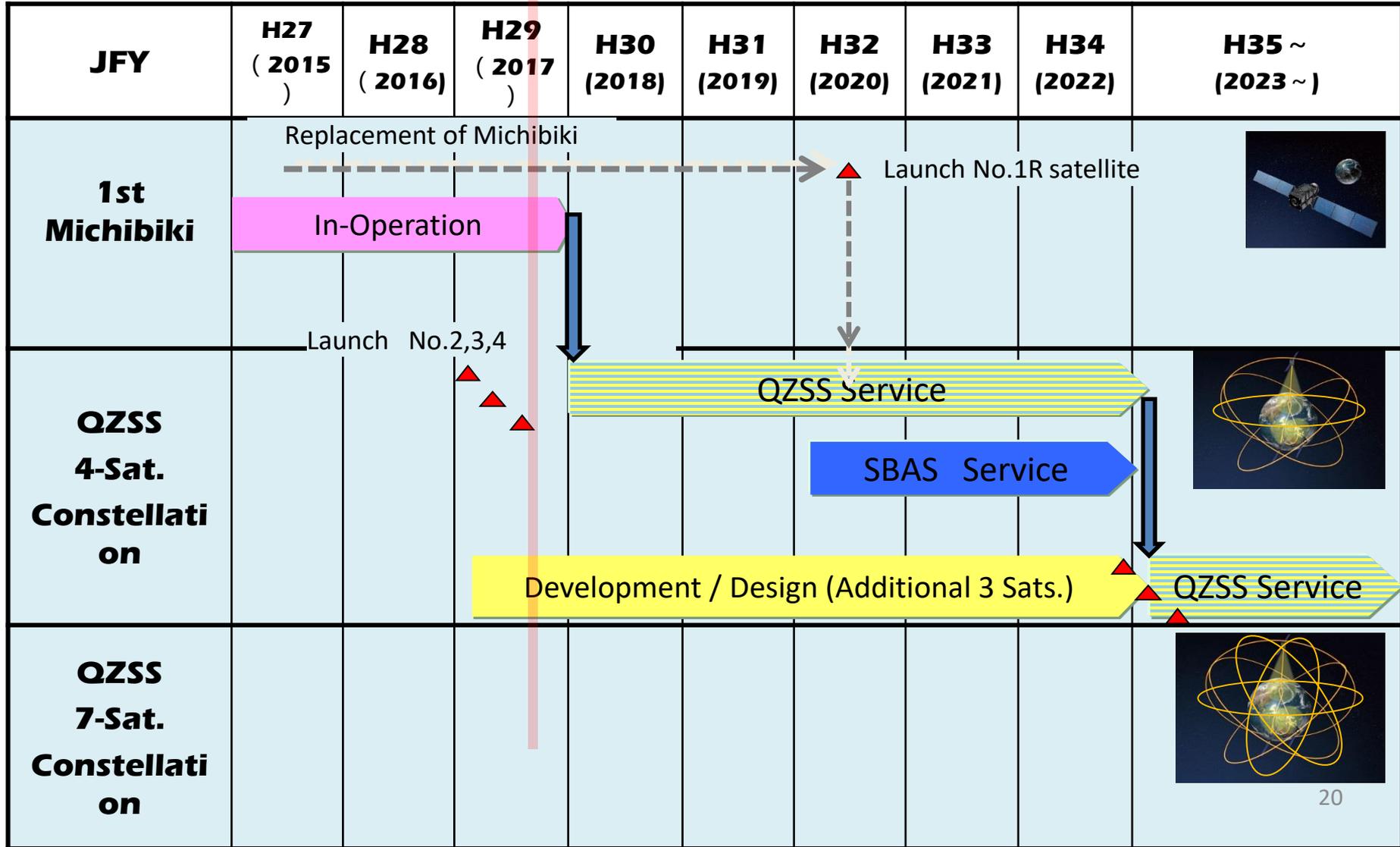*ENRI began demonstration of DFMC-SBAS*
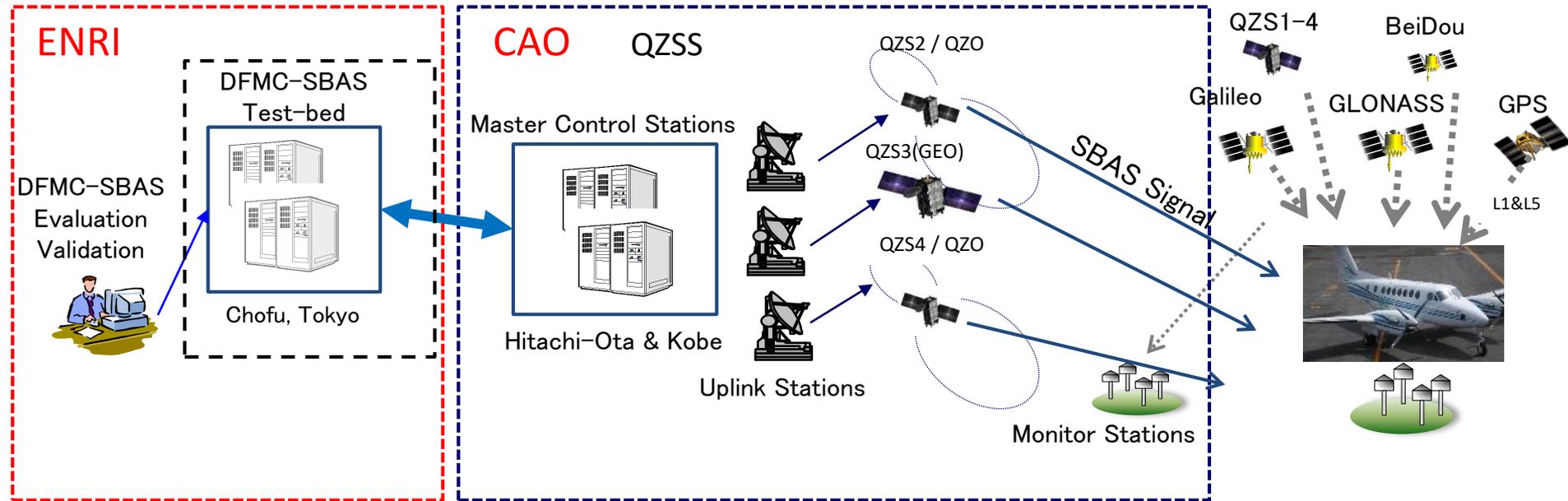
Investigate to implementation of DFMC-SBAS with QZSS 7 constellation

ENRI ; Electronic Navigation Research Institute

QZSS Overview –Development Plan-

QZSS Program Schedule (latest)

JFY	H27 (2015)	H28 (2016)	H29 (2017)	H30 (2018)	H31 (2019)	H32 (2020)	H33 (2021)	H34 (2022)	H35 ～ (2023～)
1st Michibiki	Replacement of Michibiki / In-Operation					▲ Launch No.1R satellite			
QZSS 4-Sat. Constellation	Launch No.2,3,4 ▲▲▲			QZSS Service		SBAS Service		Development / Design (Additional 3 Sats.) ▲	QZSS Service ▲▲
QZSS 7-Sat. Constellation									

Upgrade Plan For Next Generation QZSS

■Technical goals to improve accuracy, availability, integrity:

- Improving orbit and clock estimation accuracy by adding new observation data
- Improving availability by robust satellite system design
- Enhancing integrity by monitoring L-band signal on orbit
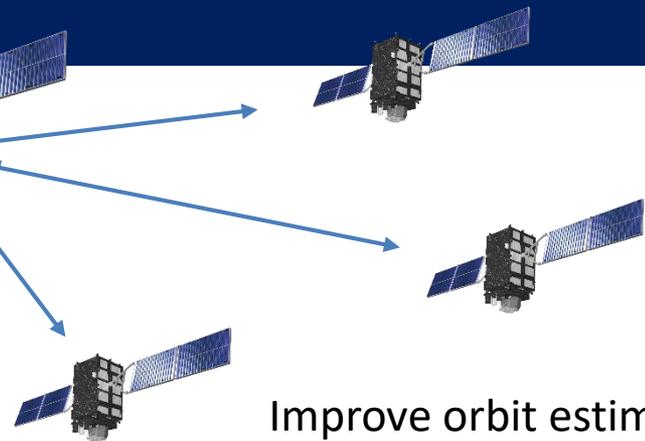
2-Key Technologies

Two-way Ranging (Ground - Satellite)	Inter Satellite Ranging

Cancel Errors below:
- Ionosphere
- Troposphere

Improve orbit estimation (especially along track) accuracy by reducing DOP

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 will be published on our web-site (http://qzss.go.jp/en/technical/qzssinfo/index.html).

➢ Current Status and Plan

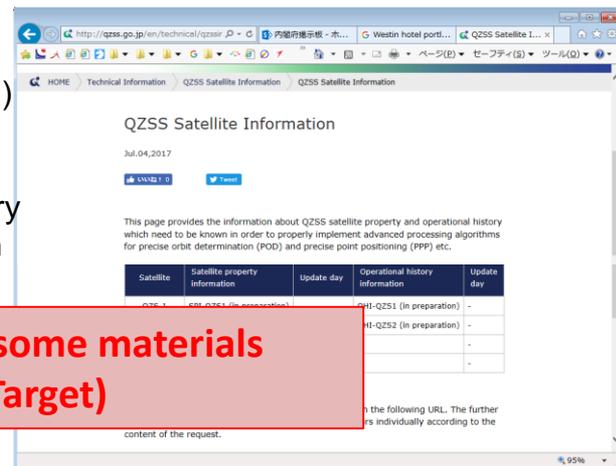| Satellite	SPI	OHI
QZS-1	Published(2017.10.6)	Published(2017.10.6)
QZS-2	Published(2017.7.4), Updated(2017.11.30)	December, 2017 (Target)
QZS-3	Published(2017.11.30)	March, 2018(Target)
QZS-4	Published(2017.11.30)	March, 2018(Target)

➢ Contents

■Satellite Property Information(SPI)
- Reference Frame
- Attitude Law
- Mass and Center of Mass
- Navigation Antenna Phase Center Corrections
- Geometry
  - Satellite dimension
- Optical Property
- Laser Retro Reflector Location
- Differential Code Bias
- Antenna Transmit Power

■Operational History Information(OHI)
- Attitude Change history
  - mode/start・end
- Orbit maintenance maneuver history
  - time/duration/delta-V/direction
- Estimated mass history

**Measuring Opt. characteristics of some materials
To be published in January ,2018(Target)**

QZSS Satellite Information

Jul.04,2017

This page provides the information about QZSS satellite property and operational history 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. Some Applications

App Examples: (1) Smart-agriculture by utilizing QZS

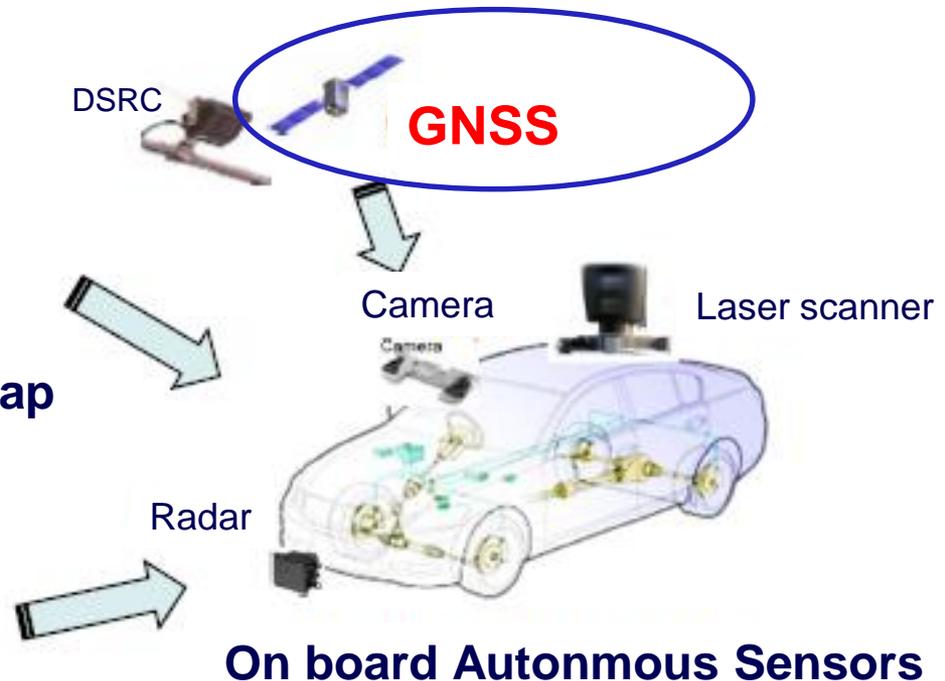EG453 Multi Robot Tractor with QZSS(CLAS)

App Examples: (2) Traffic

Autonomous Driving = Dynamic Map + relative sensors (IMU, vision sensor, radar, etc.) + absolute sensor (GNSS)

DSRC

GNSS

Camera

Laser scanner

High resolution digital map

Radar

On board Autonmous Sensors

Road, Trafic Information on the driving route

In this scinario, the role of GNSS is to detect where a vehicle is running.

Source: Japan Cabinet Office Strategic Innovation Program (SIP) Symposium 2014
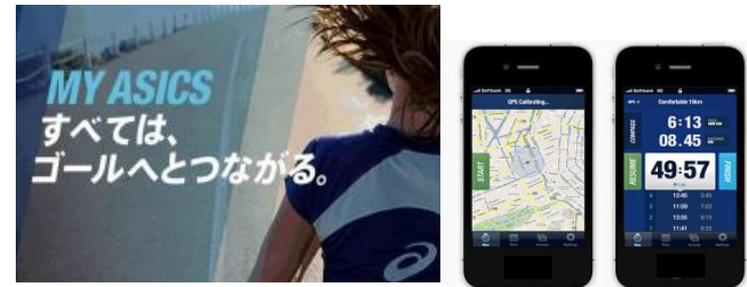
App Examples: (2) Traffic

App Examples: (3) Sports and Health

> Providing real-time (or after) coaching, pacing and course strategy, during marathon by tracking the running course with QZS.

Concerned area of positioning error due to multi-path （7-8km point）

Running with a large radius, to reduce deceleration

Reduce the pace, to run the short distance

Accelerating to the road with a large radius
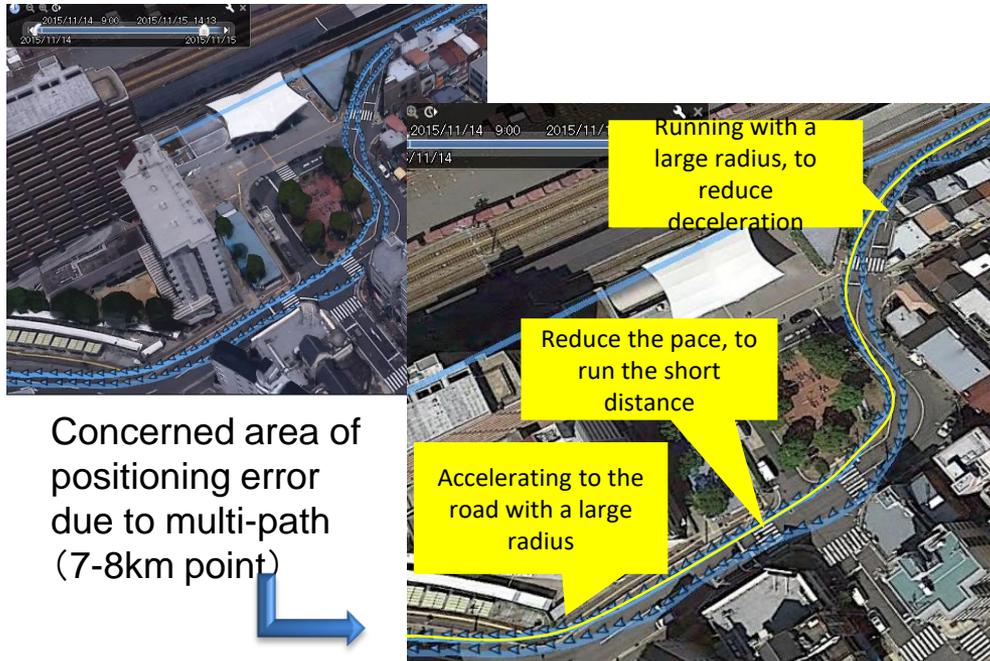
●Demonstration at Kobe Marathon（15th Nov. 2015）

"MY ASICS"
Pace-controlling training application focusing on running speed and distance

●Application for smart-phone

App Examples: (4) Road pricing

GNSS-based road pricing system in Singapore

◆ Collecting and analyzing each position of vehicles measured by GNSS including QZSS

◆ Relax traffic congestion through flexible pricing based on travel route and distance, with informing drivers of real-time road conditions.

Source:
http://www.mhi.co.jp/products/detail/element_technology_supporting_its.html

Summary

- QZSS is Japanese regional satellite navigation system to improve not only GNSS availability but also accuracy and reliability.
  - 4 satellite constellations, three IGSO satellites and one GEO satellite provides GPS compliment service, GNSS augmentation, and messaging service.
- Three consecutive launches have been successfully conducted. Operational Service will be provided in JFY 2018.
  - Precise positioning service can be utilized in many applications with Multiple GNSS as well as multi-sensors.
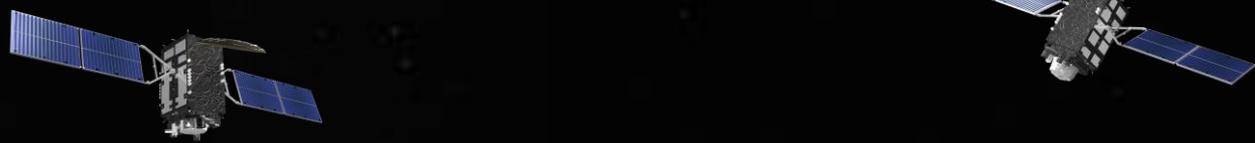
Thank you for your kind attention!
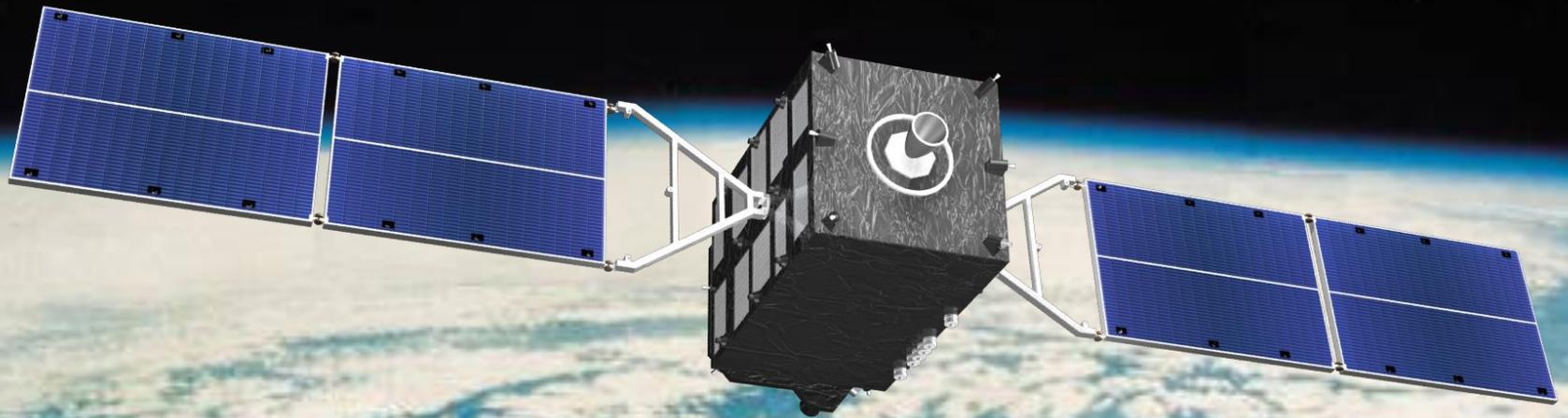
For more information, please visit our web site
http://qzss.go.jp/en/