

# ***Japanese space-based PNT system, QZSS*** **-Service, System, Applications-**

**IGNSS2018**

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**Satoshi Kogure**

QZSS Strategy Office,  
National Space Policy Secretariat  
Cabinet Office, Government of Japan



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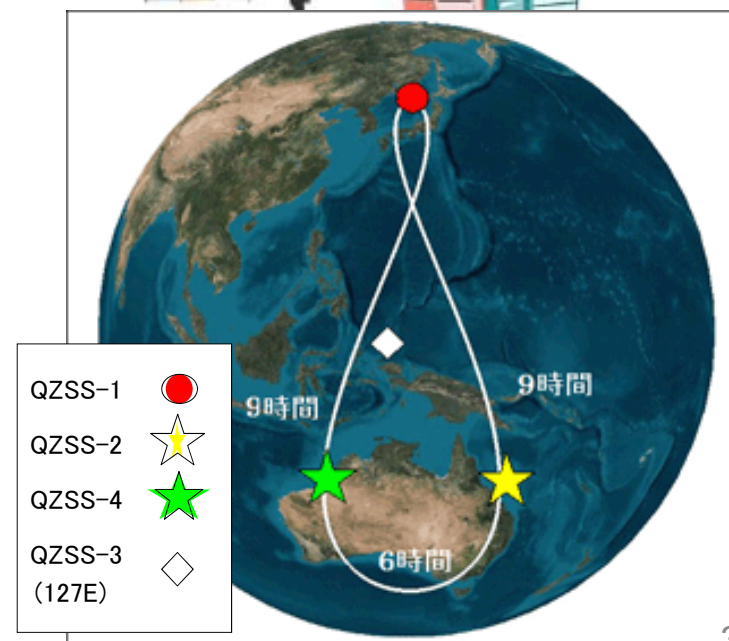
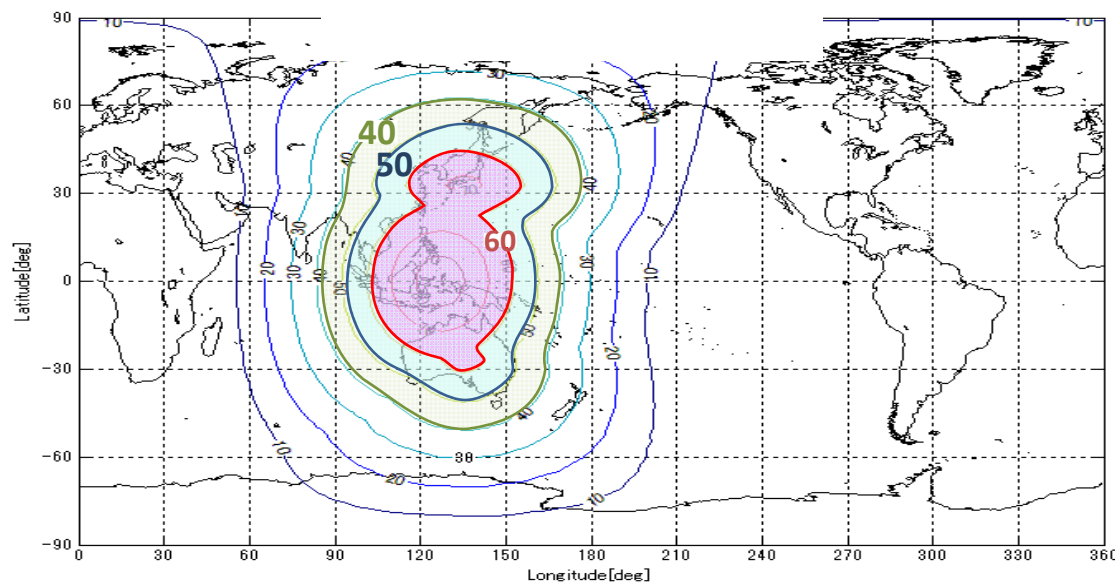
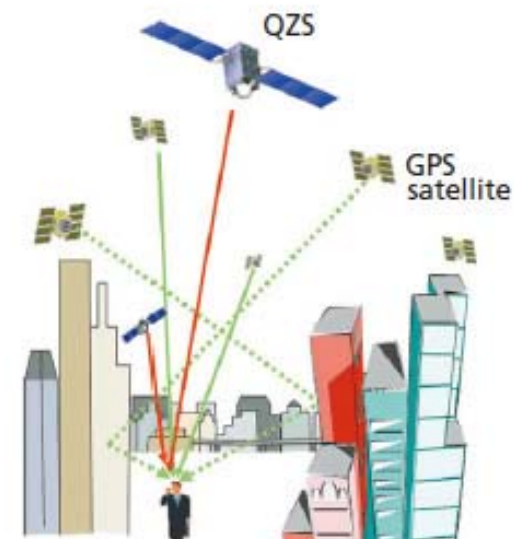


1. QZSS Overview
  - Services
  - System Architecture
  - Development Status
2. Some Applications
3. Summary

# QZSS Overview –Services–



- **Functional Capability:**
  - GPS Complementary
  - GNSS Augmentation
  - Messaging Service
- **Coverage:** Asia and Pacific region



# QZSS Overview –Services-



## Functional Capability 1 GPS Complementary

### **QZSS improves positioning availability time**

- Navigation signals L1-C/A, L1C, L2C, and L5 sent from high elevation will improve the time percentage of PNT availability.
- QZSS is the first L1C and L5 signals providers which has interoperability among other GNSSs
- SIS-URE: 2.6m (95%)

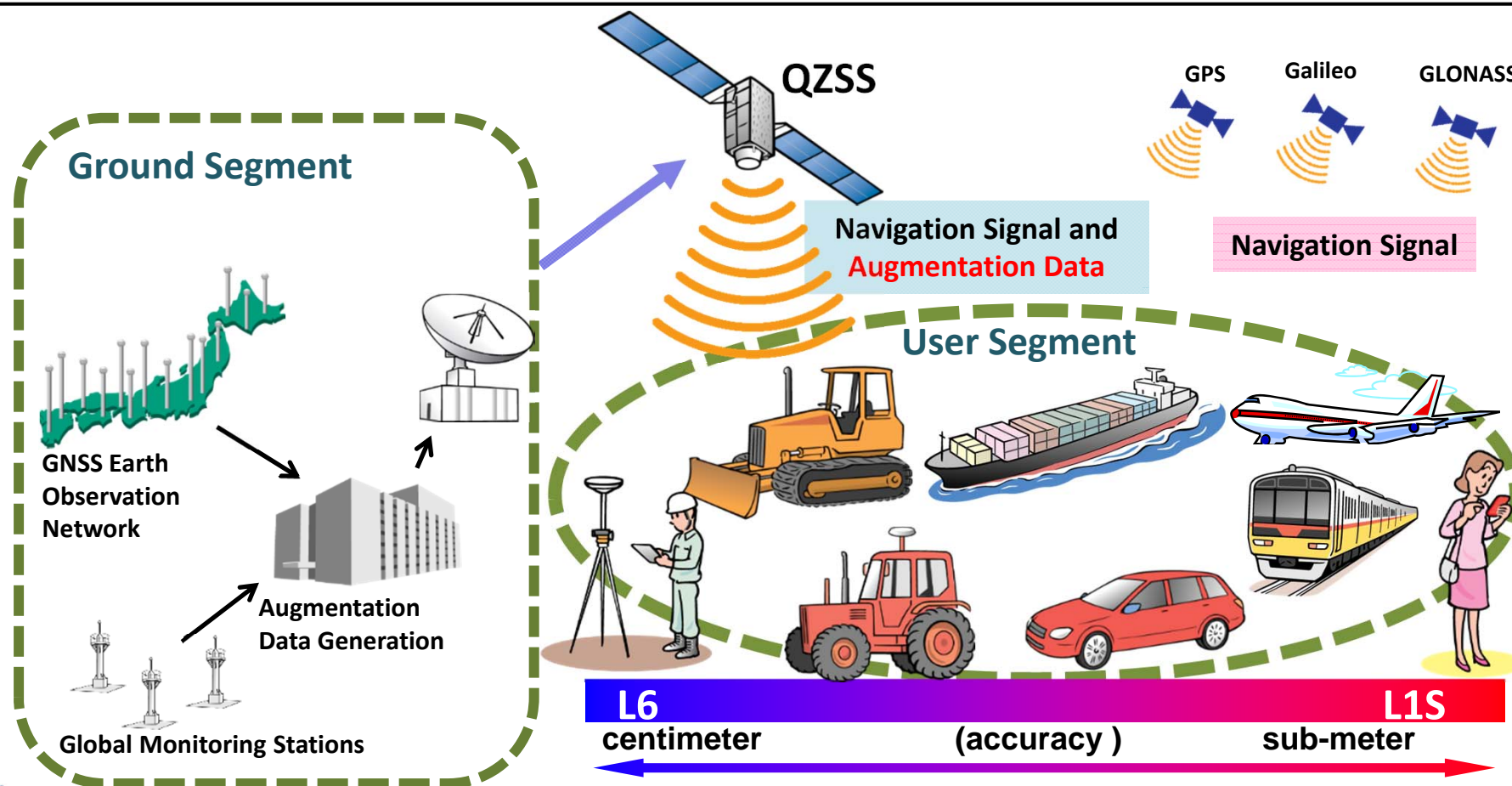


# QZSS Overview –Services-



## Functional Capability 2 GNSS Augmentation

QZSS improves **positioning accuracy and reliability**



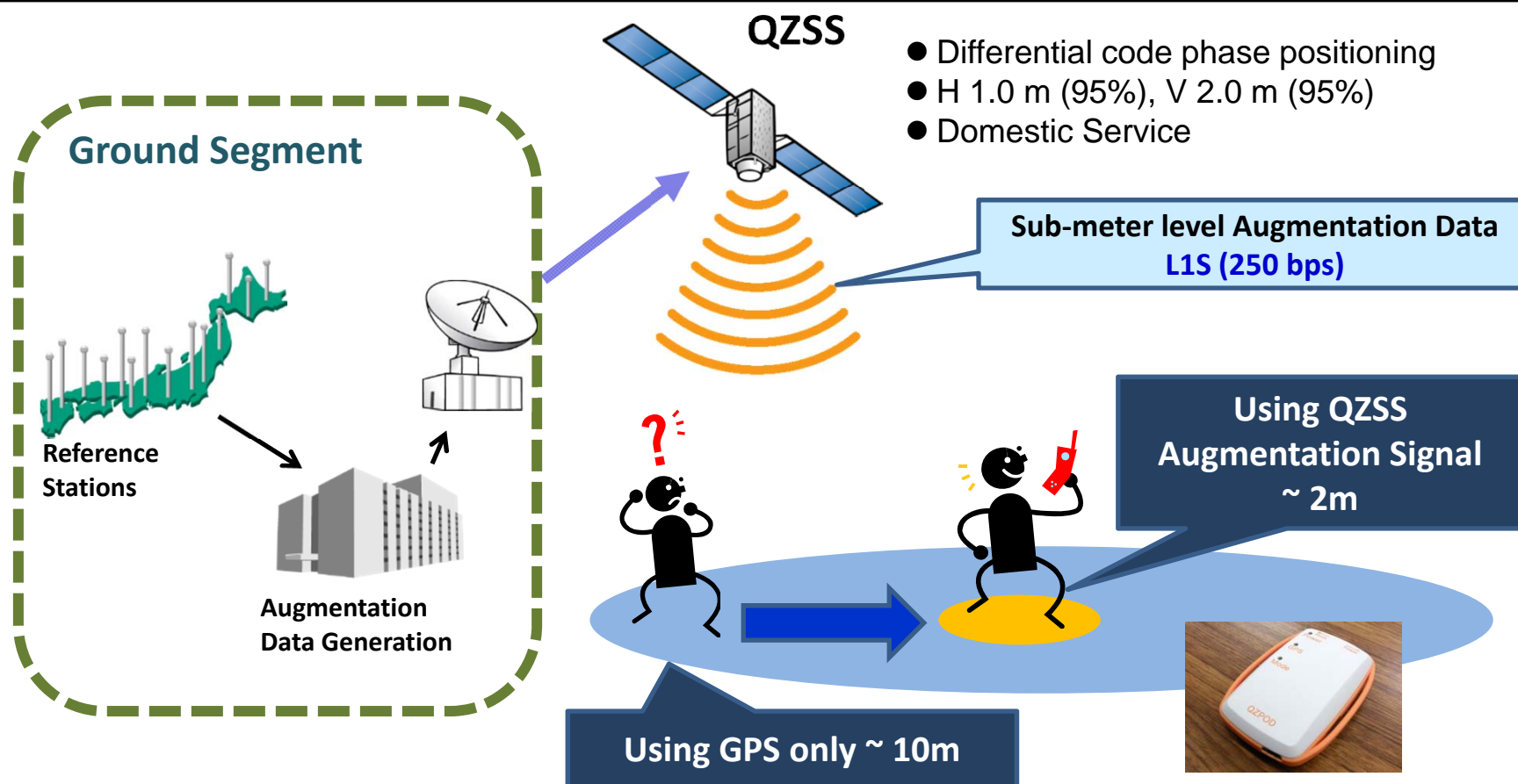


# QZSS Overview –Services-



## Functional Capability 2 GNSS Augmentation

### Sub-meter Level Augmentation Service: SLAS

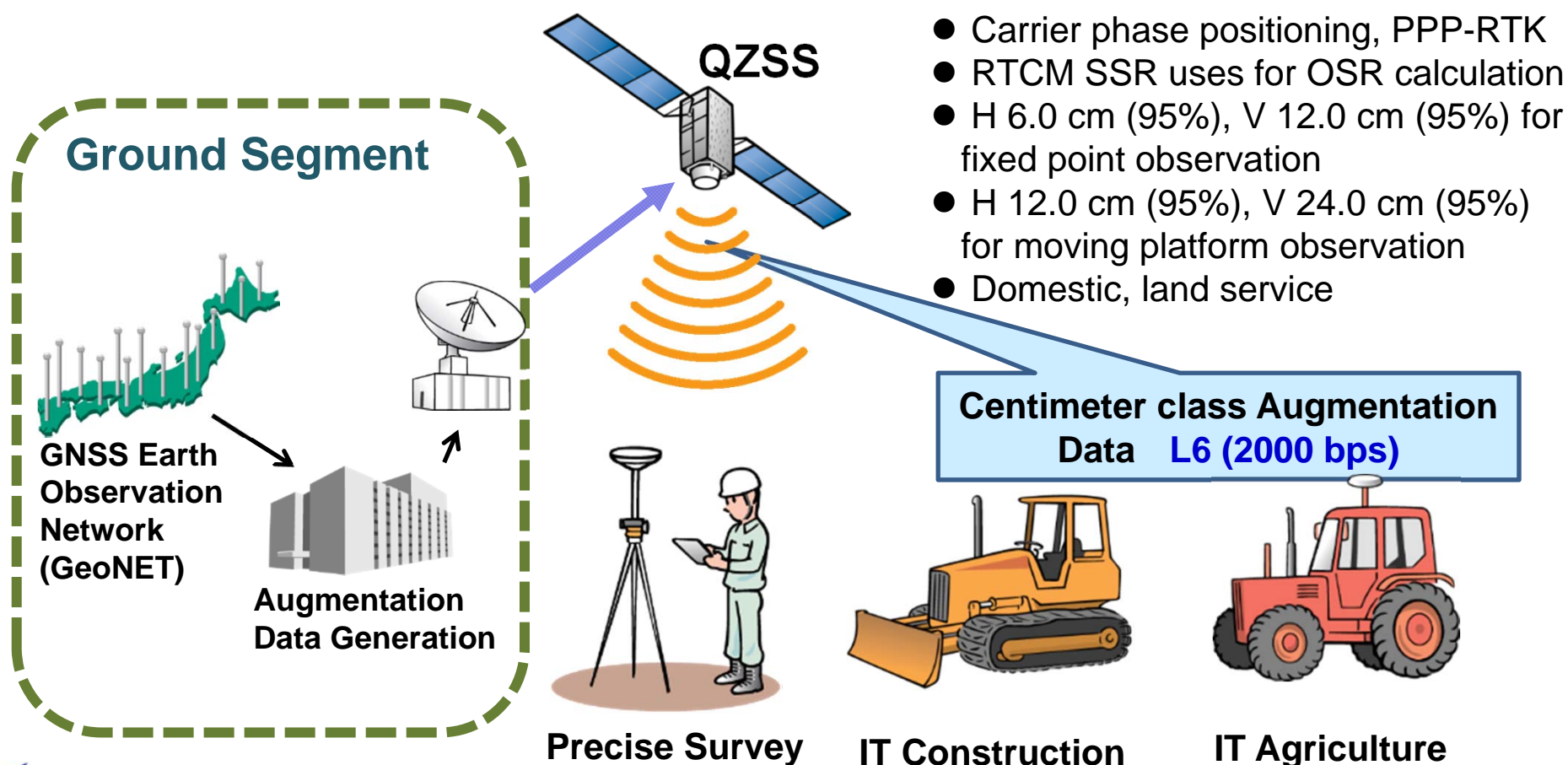


# QZSS Overview –Services-



## Functional Capability 2 GNSS Augmentation

### Centimeter Level Augmentation Service: CLAS

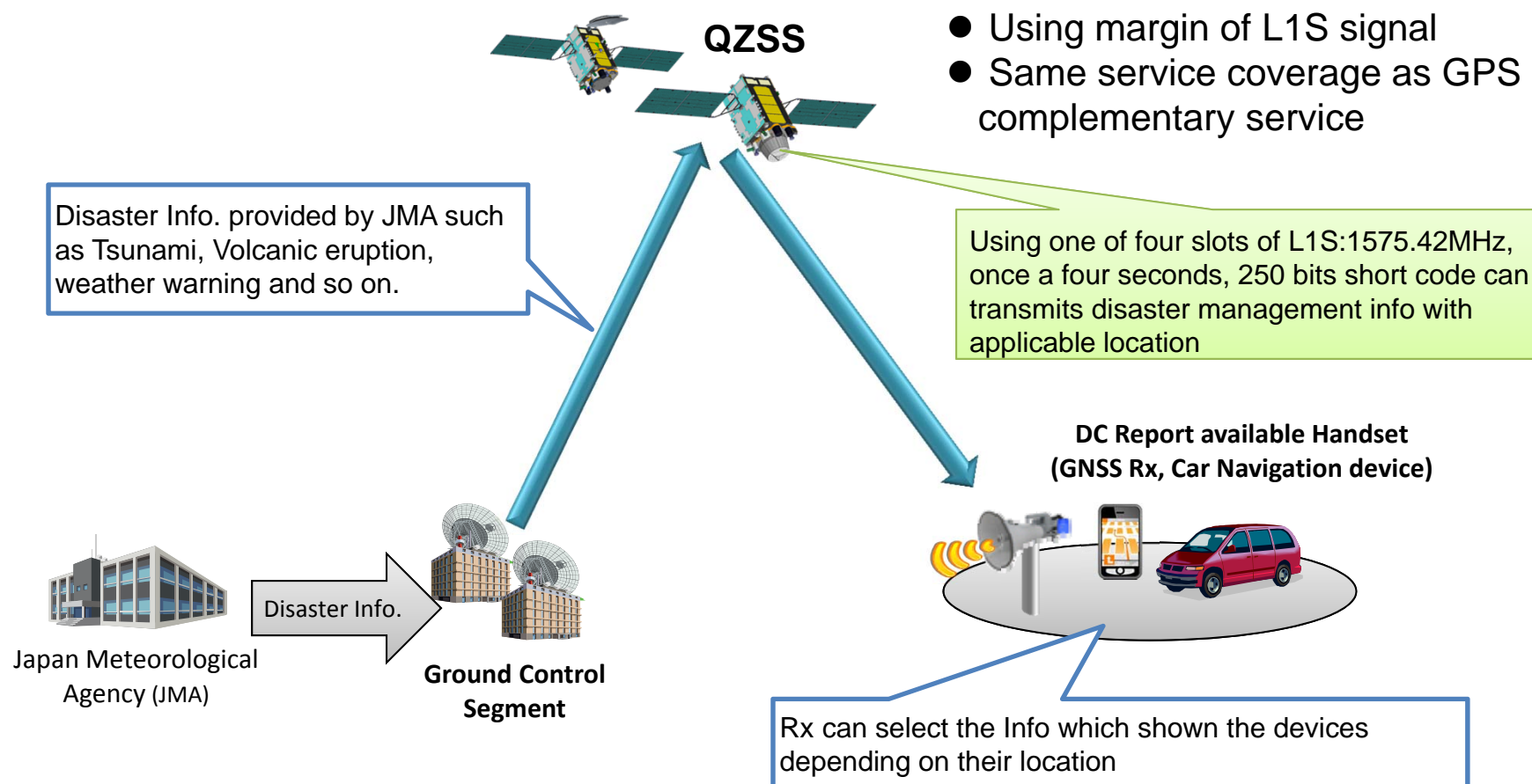


# QZSS Overview –Services-



## Functional Capability 3 Messaging Services

### Satellite Report for Disaster and Crisis Management (DC Report)





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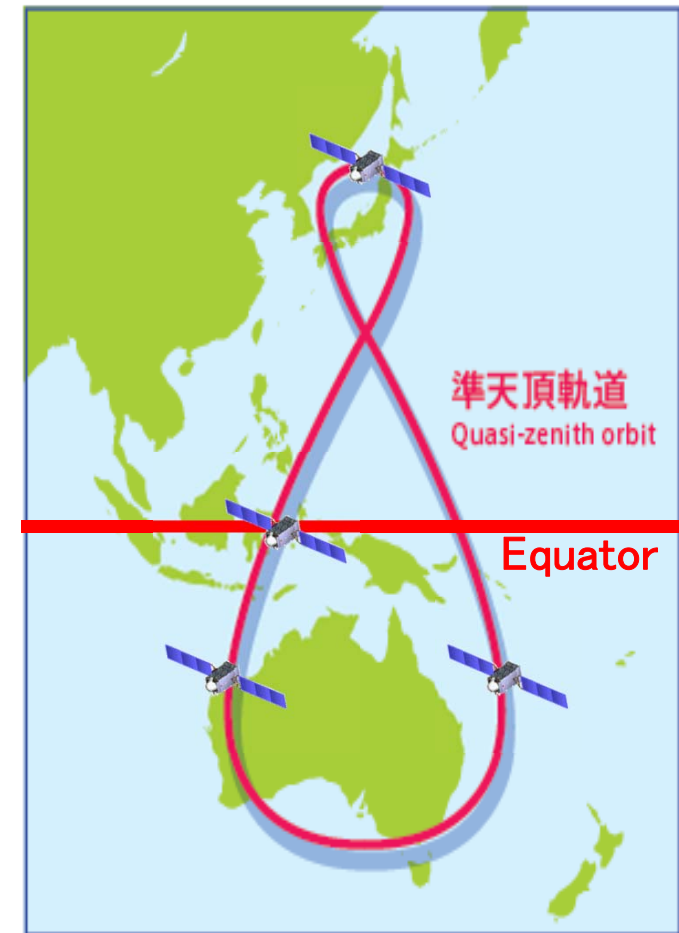


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# QZSS Overview -System-



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



# QZSS Overview -System-



QZS-1



QZS-2, 4



QZS-3



# QZSS Overview -System-



## QZSS Master Ground Station

[http://www.mlit.go.jp/koku/15\\_bf\\_000367.html](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,

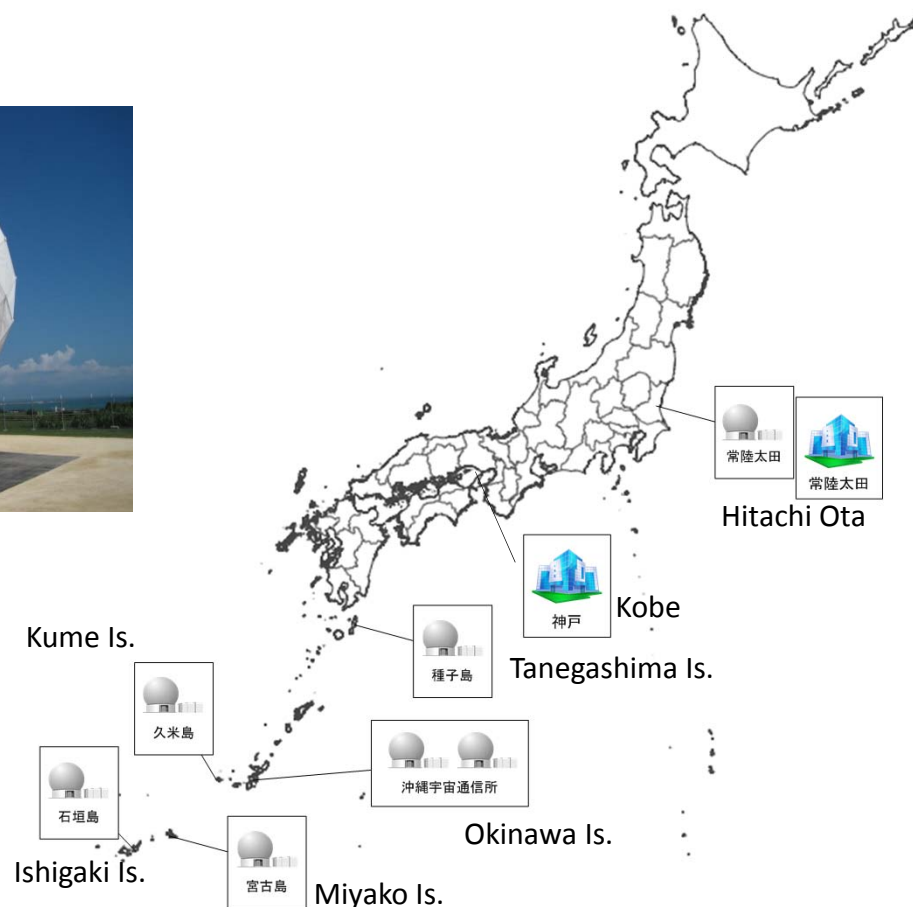
[http://www.mlit.go.jp/koku/15\\_bf\\_000367.html](http://www.mlit.go.jp/koku/15_bf_000367.html)



# QZSS Overview -System-



## QZSS TTC Stations



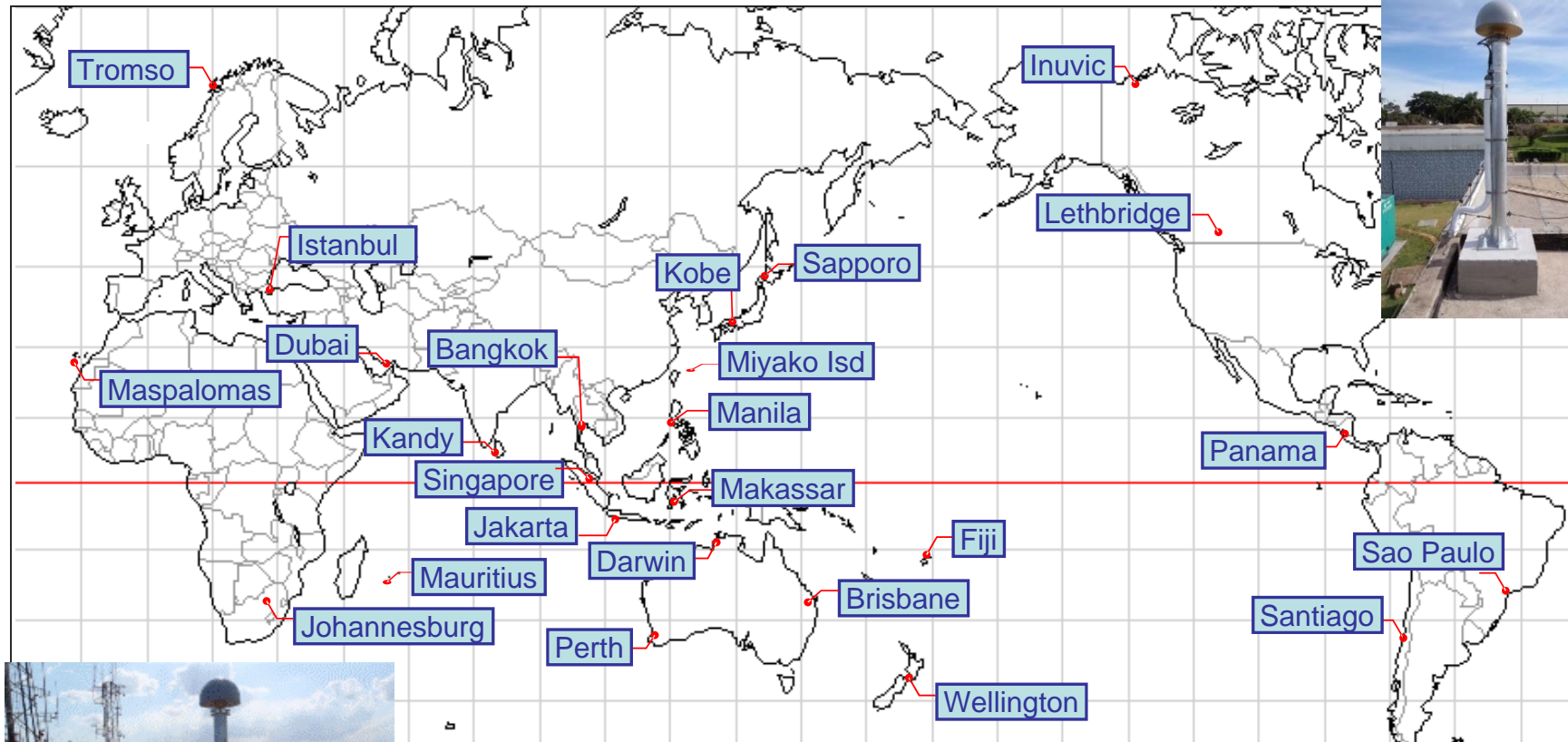
- 7 TTC (Telemetry, Tracking, and Command) stations: Most are at the southern part of Japan for satellite continuous visibility.
- All TTC stations were built and set operational by the end of 2016.



# QZSS Overview -System-



## QZSS Monitor Stations Distribution



- 25 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

# QZSS Overview -System-



## Positioning Signals of QZSS

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)	SBAS (L1) 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(MADOCA)	PPP, PPP-AR (Carrier Phase Positioning)	-	✓	✓



# Experiments using QZSS

## Precise Point Positioning (PPP)

- A precise positioning methodology obtaining absolute location with deci-meter level
- Resolving Integer ambiguity of carrier phase is called “PPP-AR” which can reach a couple of cm. level solution

### CLAS on L6D channel

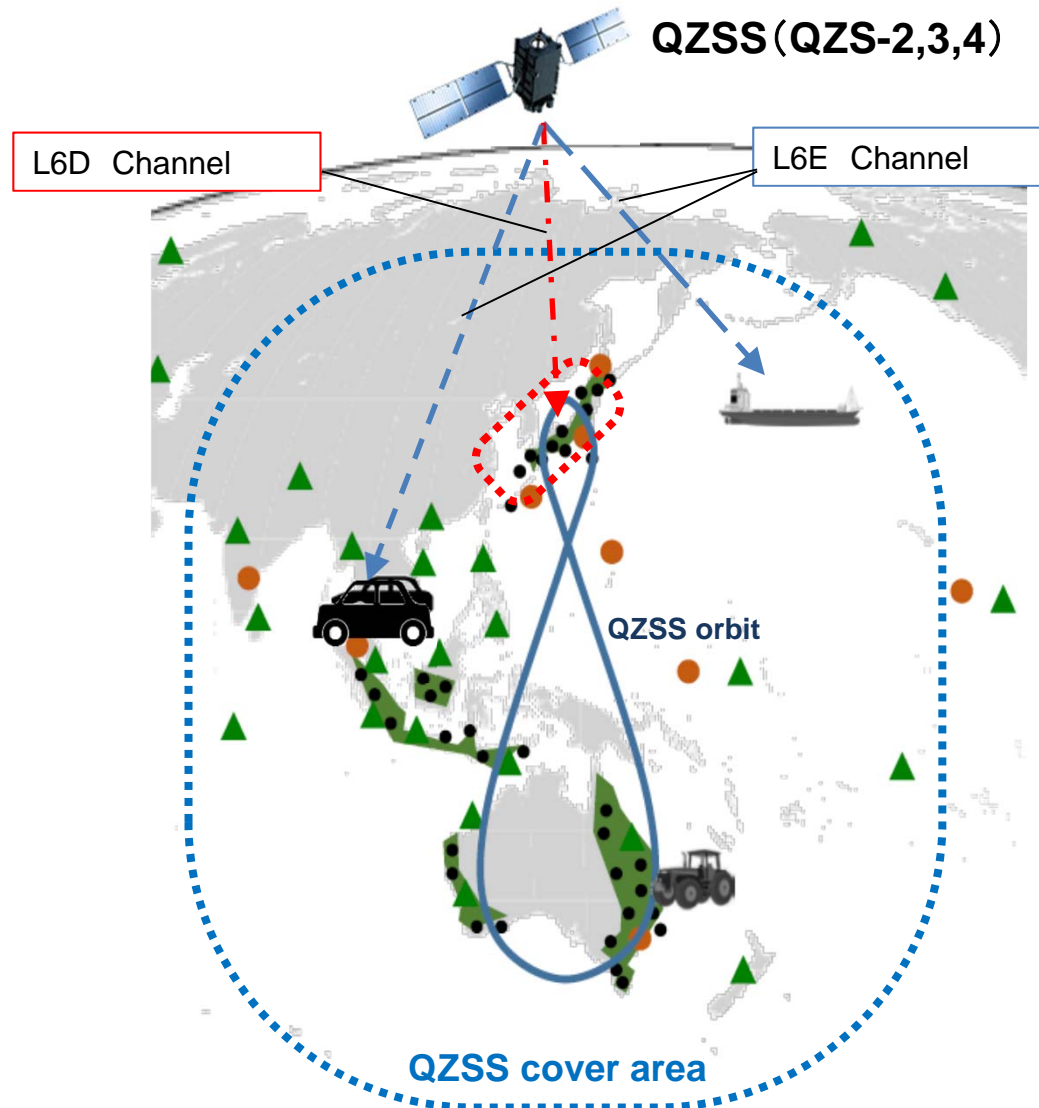
- Provides following error corrections;
  - SV orbit
  - SV clock
  - SV code/phase bias
  - Iono. delay
  - Tropo. Delay
- GPS, QZSS and Galileo
- Operational service

### MADOCA on L6E channel

- Provides following error corrections;
  - SV orbit
  - SV clock
  - SV code/phase bias
- GPS, QZSS and Glonass at present, (GAL and BDS in future)
- Positioning Technology Validation service (Experimental)

- long convergence time (30-40 minutes)
- Global coverage with global ref. network

# Centi-meter Level Augmentation Service by using L6D(D1) and L6E(D2)



: region

- CLAS (Centimeter Level Augmentation Service) will be provided by using L6(D1) signal.
- Dense GNSS monitoring network in the region is necessary.
- CLAS for Japan will be started in 2018. Other region is under consideration.

: region

- Experimental Augmentation service with MADOCA (Multi-GNSS Advanced Demonstration tool for Orbit and Clock Analysis) will be provided by using L6(D2) signal.
- Global GNSS monitoring network is necessary.
- MADOCA Augmentation service will be started in 2018 as Positioning Technology Validation Service



# DFMC SBAS Experiment

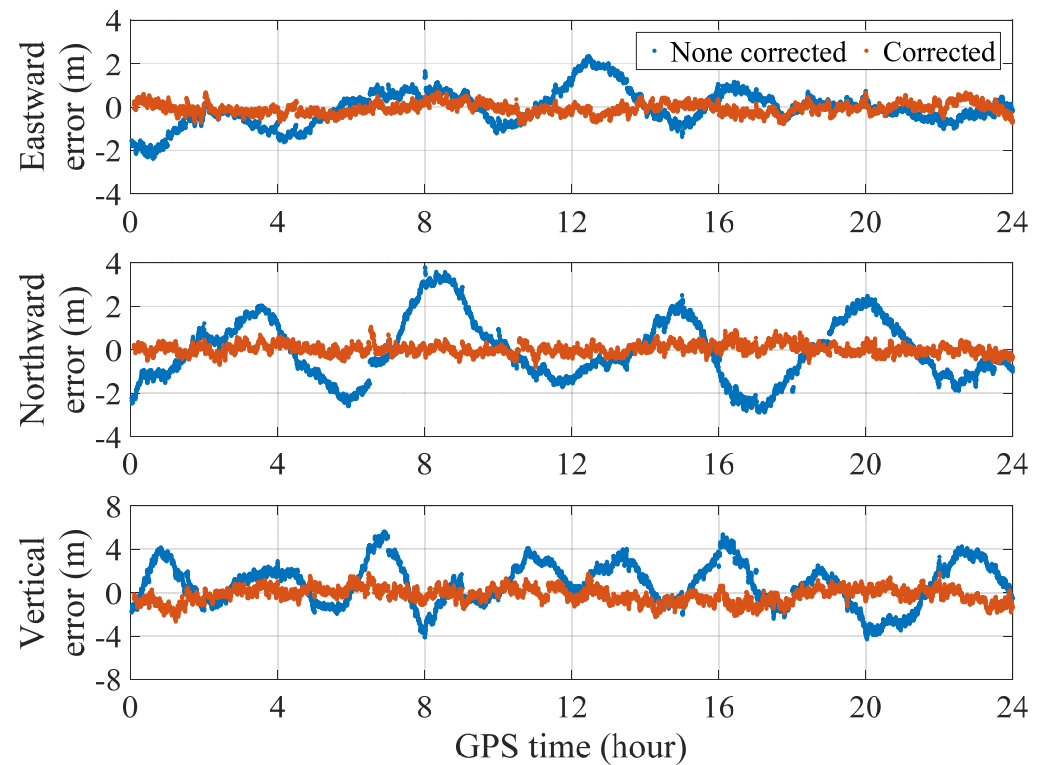
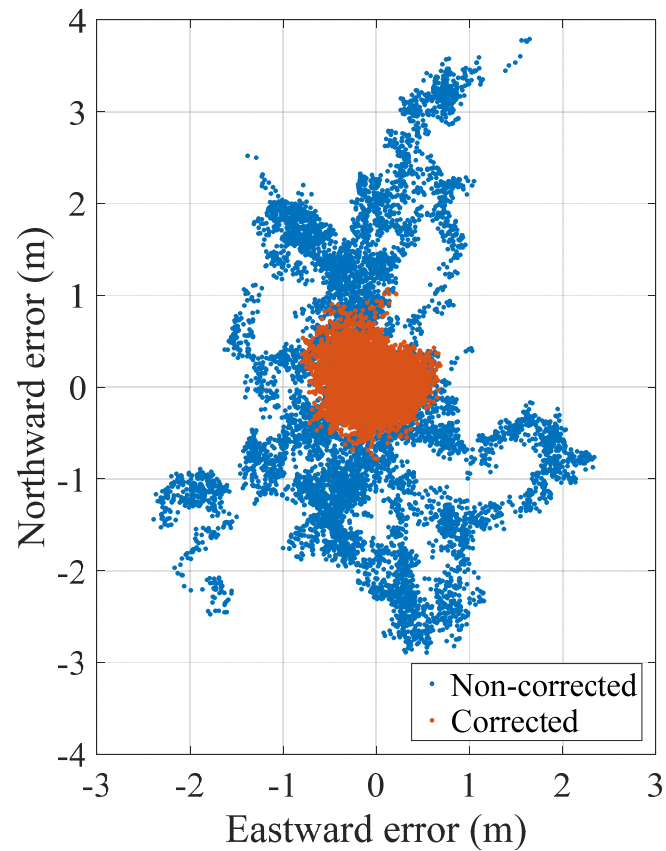
- **DFMC (Dual-Frequency Multi-Constellation) SBAS**
  - International standard augmentation system primarily for aviation.
    - *Using L5 SBAS signal.*
    - *Following L1 single frequency single constellation SBAS.*
  - Eliminates ionospheric effects dramatically.
    - *Vertical guidance service everywhere in the coverage.*
- **ENRI is now conducting DFMC SBAS Experiment**
  - Electronic Navigation Research Institute, MPAT in Tokyo, Japan.
  - The World First L5 SBAS experiment with real L5 signal from the space.
    - *Using QZSS L5S signal transmitted from GEO (QZS-3) and IGSO (QZS-2/4).*
  - Prototype DFMC SBAS for experiments has been developed.
    - *GPS/GLONASS-capable dual frequency SBAS.*
      - ◆ Galileo extension by this year.
    - *Compliant with L5 DFMC SBAS ICD.*
  - Began the initial test on 22 Aug. using L5S signal (PRN 196) of QZS-2 IGSO.
    - *Expects participation to this experiments! Contact: <sakai@mpat.go.jp>*





# DFMC experiment result snapshot at Wakayama

SLIDE 19



# QZSS Overview -System-



## Interface Documents

The screenshot shows a web browser window with the URL <http://qzss.go.jp/en/technical/ps-is-qzss/ps-is-qzss.html>. The page title is "Performance Standard (PS-QZSS) and Interface Specification (IS-QZSS)". Below the title are social media sharing buttons for "いいね!" (Like) and "Tweet". A table lists the documents available:

	Performance Standard	Interface Specification
Satellite Positioning, Navigation and Timing Service	PS-QZSS-001	IS-QZSS-PNT-001 (March 28, 2017 / PDF: 3748KB)
Sub-meter Level Augmentation Service (SLAS)		IS-QZSS-L1S-001 (March 28, 2017 / PDF: 709KB)
		IS-QZSS-L6-001

Performance Standard (PS-QZSS) and Interface Specification (IS-QZSS) are available in our website  
<http://qzss.go.jp/en/technical/ps-is-qzss/ps-is-qzss.html>



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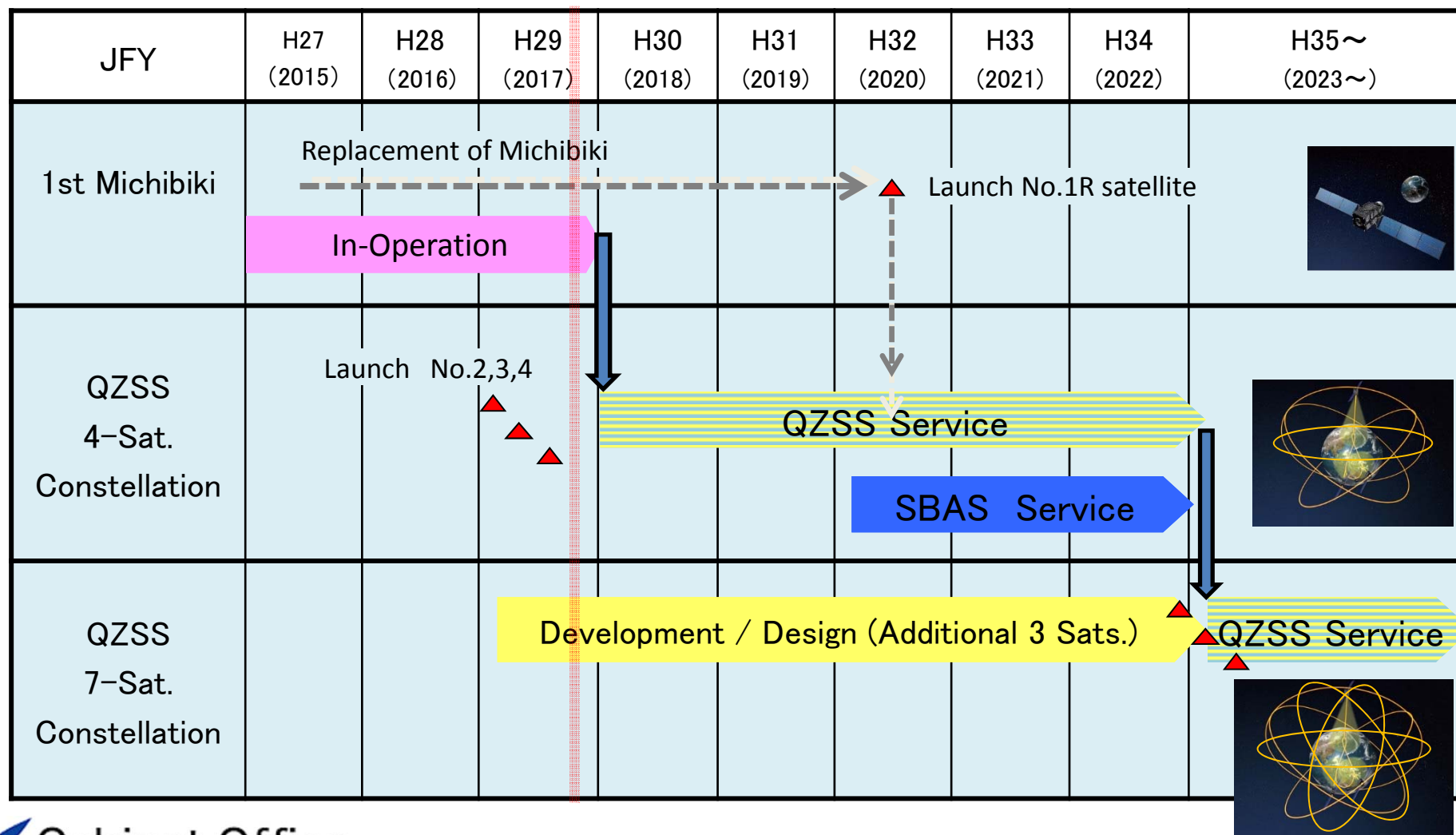
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# QZSS Overview –Development Status–



## QZSS Program Schedule (latest)



# QZSS Overview –Development Status–



Three consecutive launches and preparing service-in!



#2 satellite: Jun. 1, 2017  
00:17:46(UCT)



#3 satellite: Aug. 19, 2017  
05:29:00(UTC)



©三菱重工/JAXA

#4 satellite: Oct. 9, 2017  
22:01:37 (UTC)



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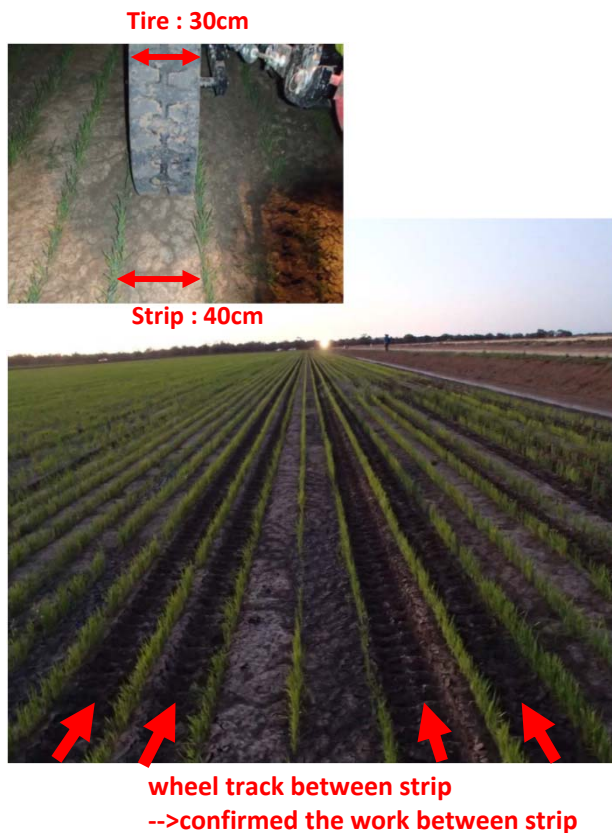
1. QZSS Overview
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# App Examples: (1) Smart-agriculture by utilizing QZS

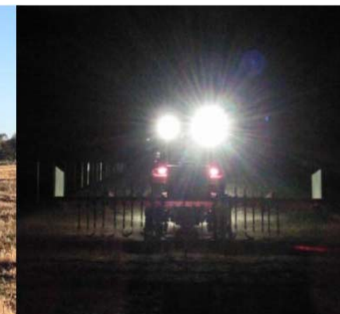
- ◆ Demonstration to show cm-class control by using position correction information supplied by QZS.
- ◆ No need for reference point. (Refers at the first launching. Used station 400km away from the site at this demonstration. Could be operated with only QZS signal.)



±5cm class precision was demonstrated in weeding and fertilization with unmanned tractor



weeding (day)

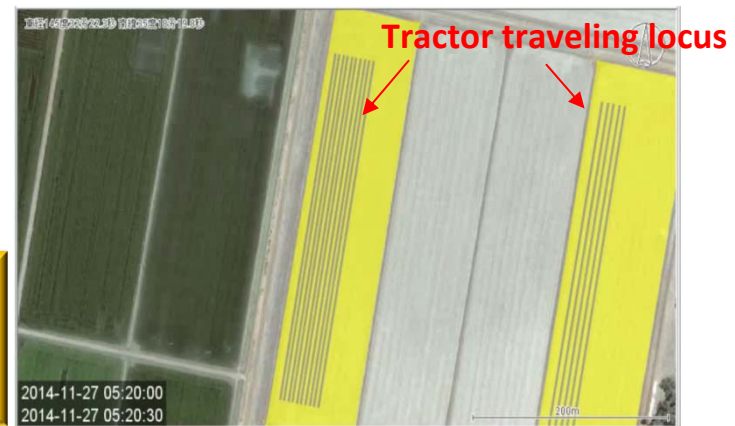


weeding (night)



fertilization

【Site】  
Australia

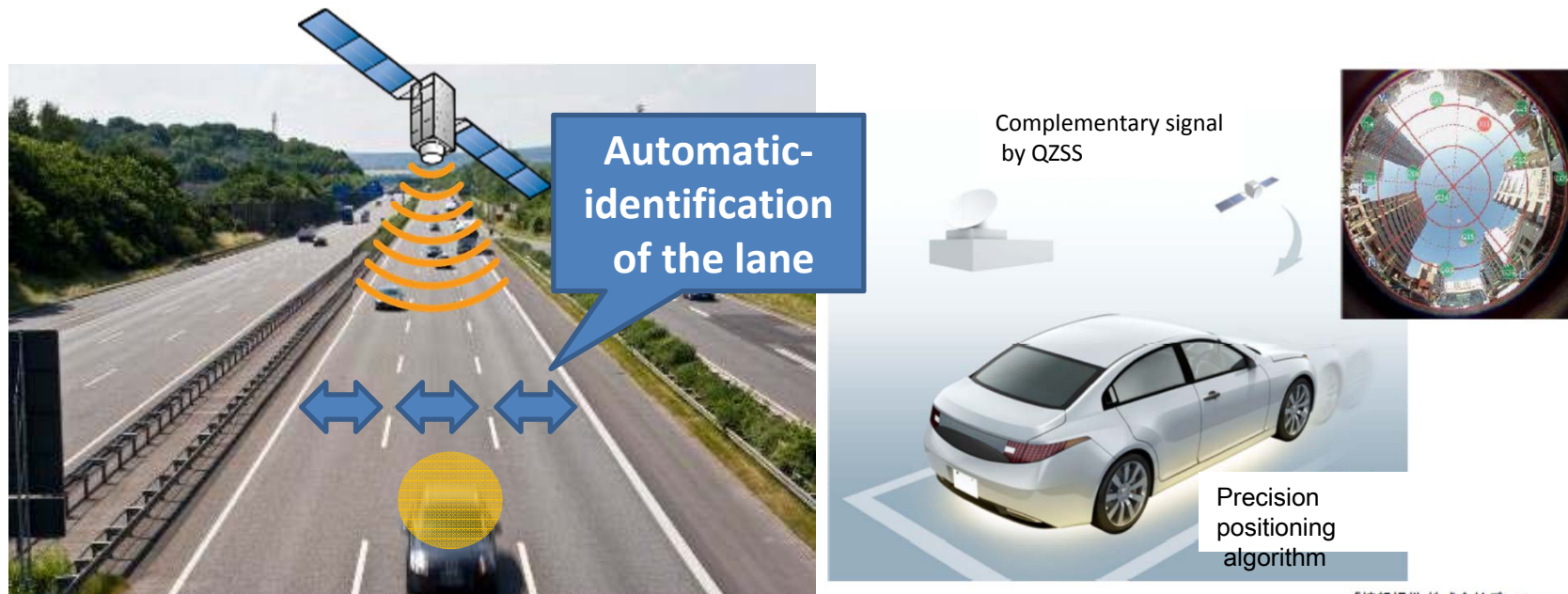


Example of GIS control monitor

## App Examples: (2) Traffic

### ➤ Discussing with ITS Japan(\*) 「QZS・Multi-GNSS Utilization Committee」 (GNSS=Global Navigation Satellite System)

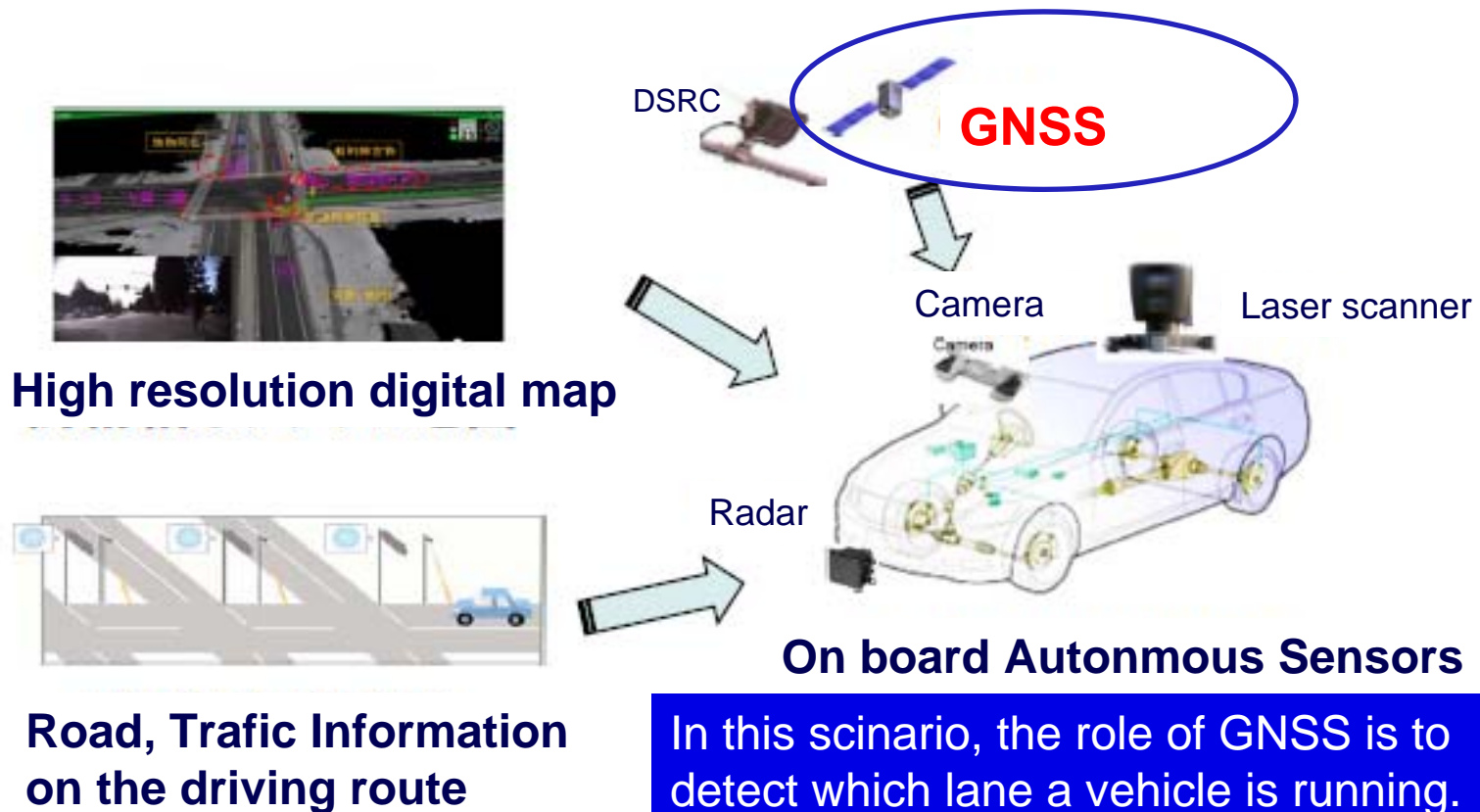
(\*)ITS Japan (Chairman : Shinichi Sasaki (Toyota Motor advisory and Senior Technical Executive)) : One of the private organization across the three regions (US, Europe and Asia) in ITS promotion, ITS Japan conducts various researches in ITS in support to realize ITS business.



「情報提供:株式会社デンソー」

## App Examples: (2) Traffic

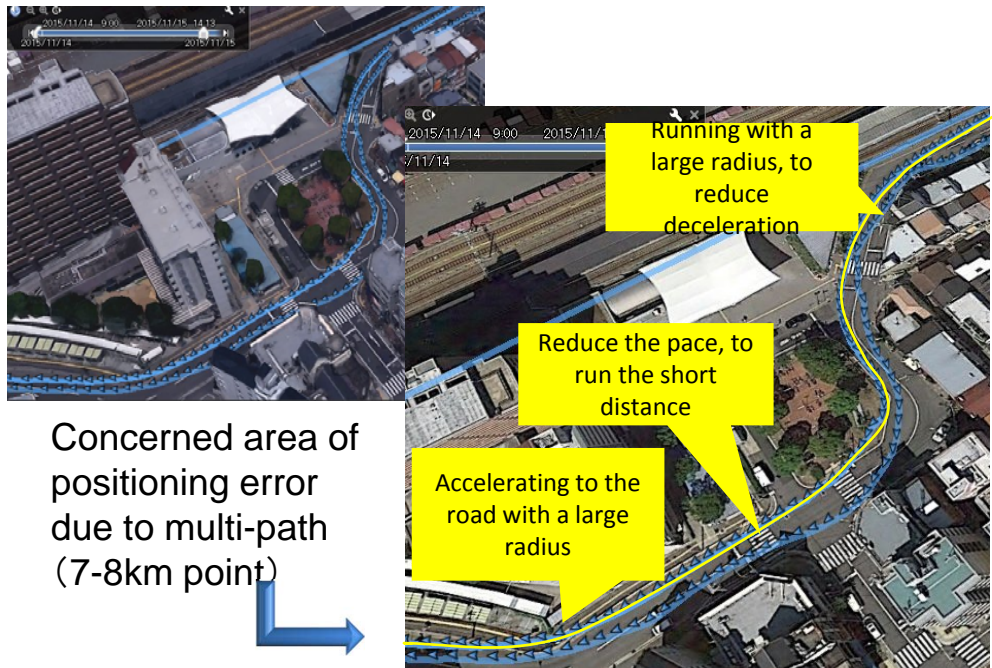
Autonomous Driving = Dynamic Map + relative sensors (IMU, vision sensor, radar, etc.) + absolute sensor (GNSS)



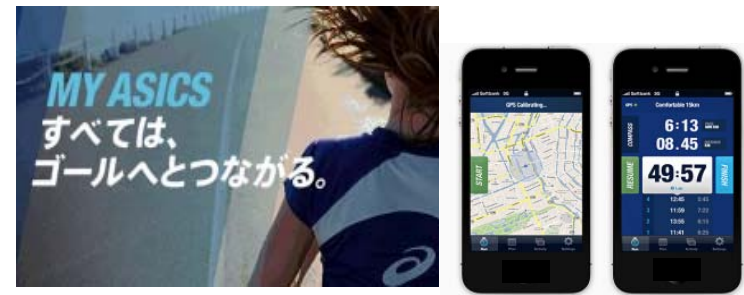


# App Examples: (3) Sports and Health

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



● Demonstration at Kobe Marathon (15<sup>th</sup> Nov. 2015)



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

● Application for smart-phone



# App Examples: (4) Road pricing

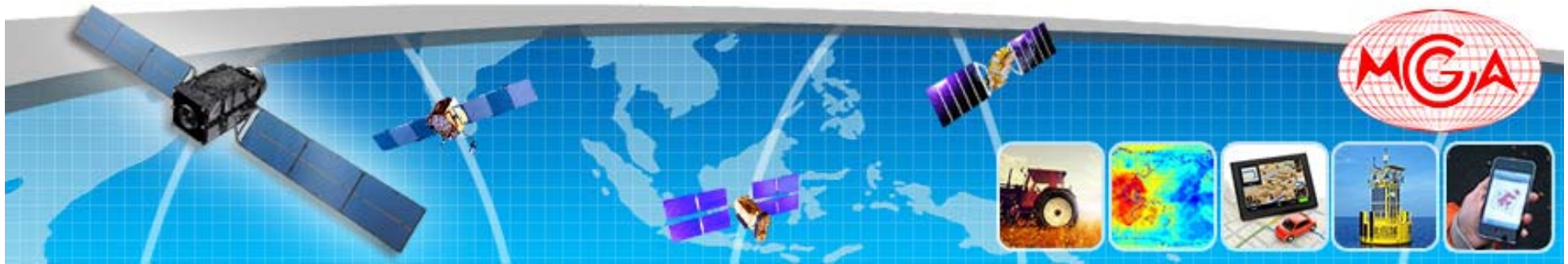
## GNSS-based road pricing system in Singapore



- ◆ 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](http://www.mhi.co.jp/products/detail/element_technology_supporting_its.html)



# 10<sup>th</sup> Multi-GNSS Asia (MGA) Conference



RMIT University  
Melbourne, Australia

23-25 October 2018




# Summary


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- 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 successfully conducted and four satellites have been ready on their orbits.
- 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.
- In Australia, following services are available;
  - GPS complimentary service, i.e. ranging signals from QZSS
  - Positioning technology verification, PPP (L6E) and DFMC (L5S)





Thank you for your attention.



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