# *Introduction of the Quasi-Zenith Satellite System (QZSS)*

Satoshi KOGURE
Japan Aerospace Exploration Agency

UN COPUOS STSC
February 15, 2010@Vienna

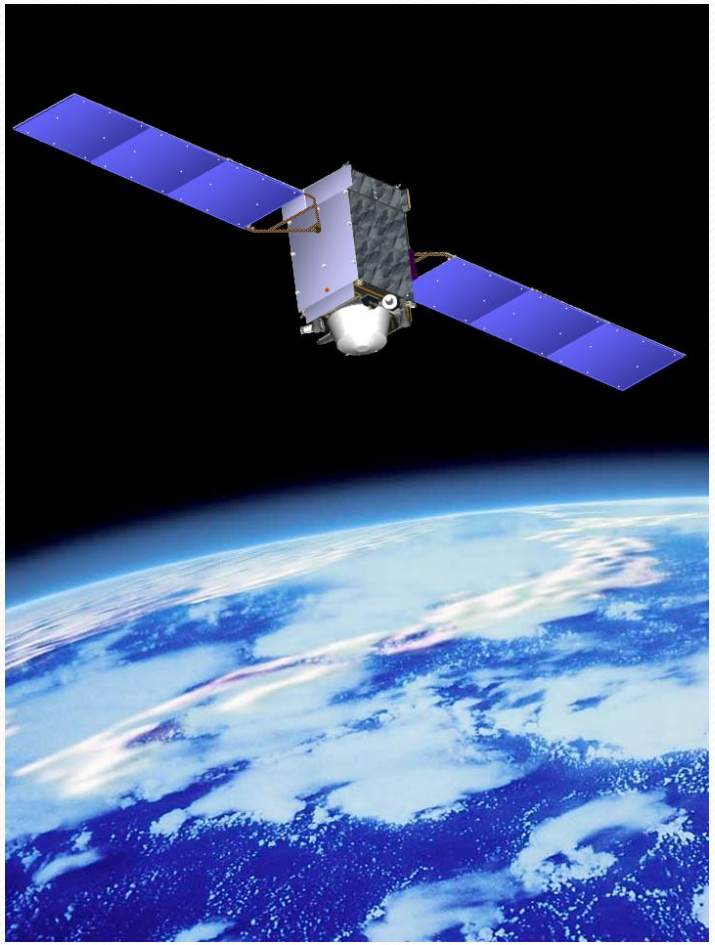
# Topics

- Overviews of the QZSS
- Development Status
- Multi-GNSS Demonstration Campaign
- Asia Oceania Regional Workshop on GNSS

# Quasi-Zenith Satellite System

## The QZSS

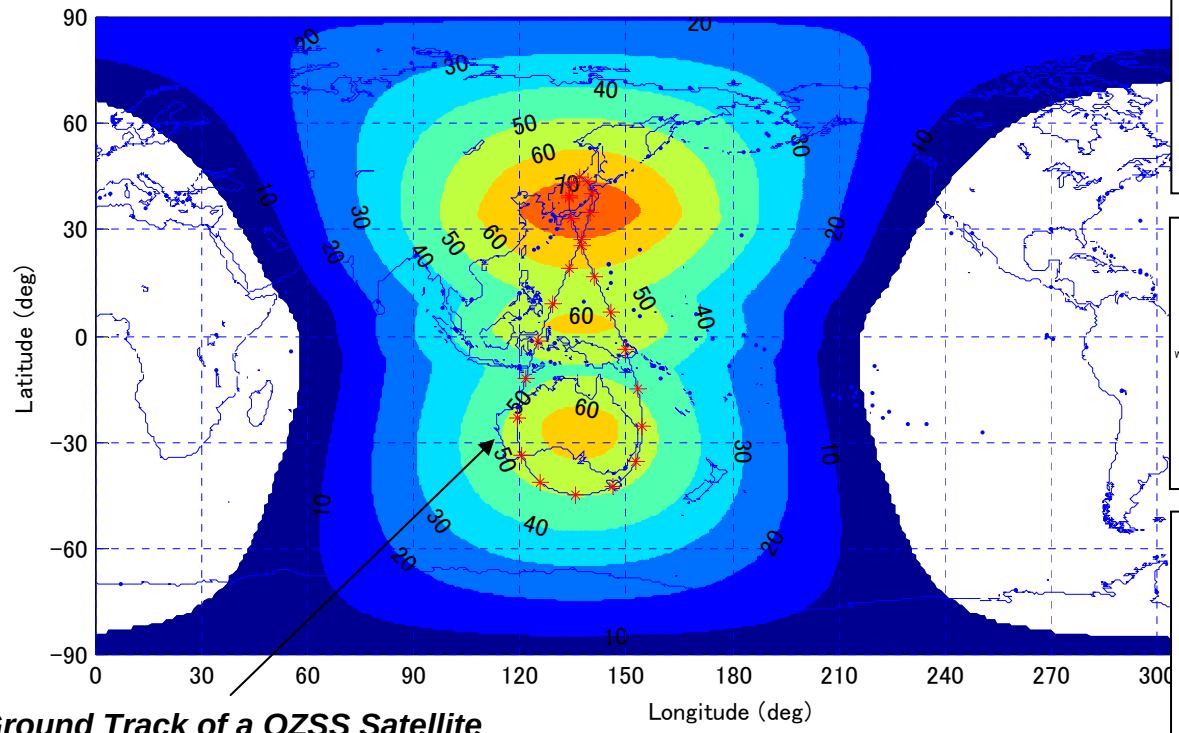
- *is a regional space-based PNT (Positioning, Navigation and Timing) system*
- *covers East Asia and Oceania region and transmits six civil PNT signals;*
  - *L1C/A, L1C on 1575.42 MHz, L2C on 1227.60 MHz and L5 on 1176.45 MHz*
  - *L1-SAIF on 1575.42 MHz*
  - *LEX on 1278.75MHz*
- *can provide seamless PNT services by combining usage with GPS.*
  - *Increasing coverage and availability of PNT services even in downtown and mountainous areas.*
- *can enhance GPS performance by transmitting error correction and integrity information.*
- *can accelerate the Modernization of GPS in Asia Oceania region.*
- *can be a suitable platform for Multi-GNSS augmentation.*



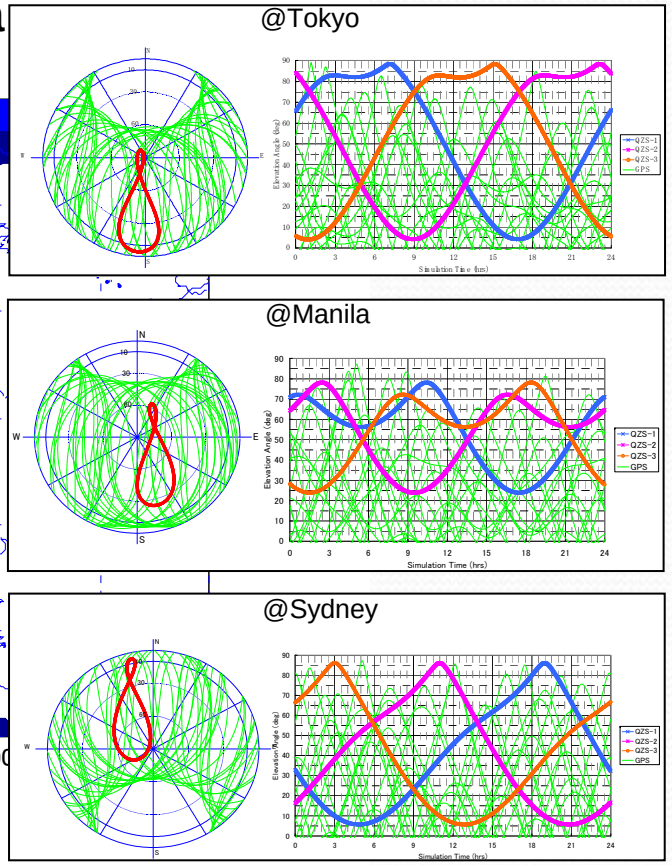
- *First satellite will be launched in 2010. The 2nd and 3rd satellite will be approved after assessment of the technical demonstration result.*

# Quasi-Zenith Satellite System

## QZSS coverage and Visibility in Asia & Oceania




*Ground Track of a QZSS Satellite*



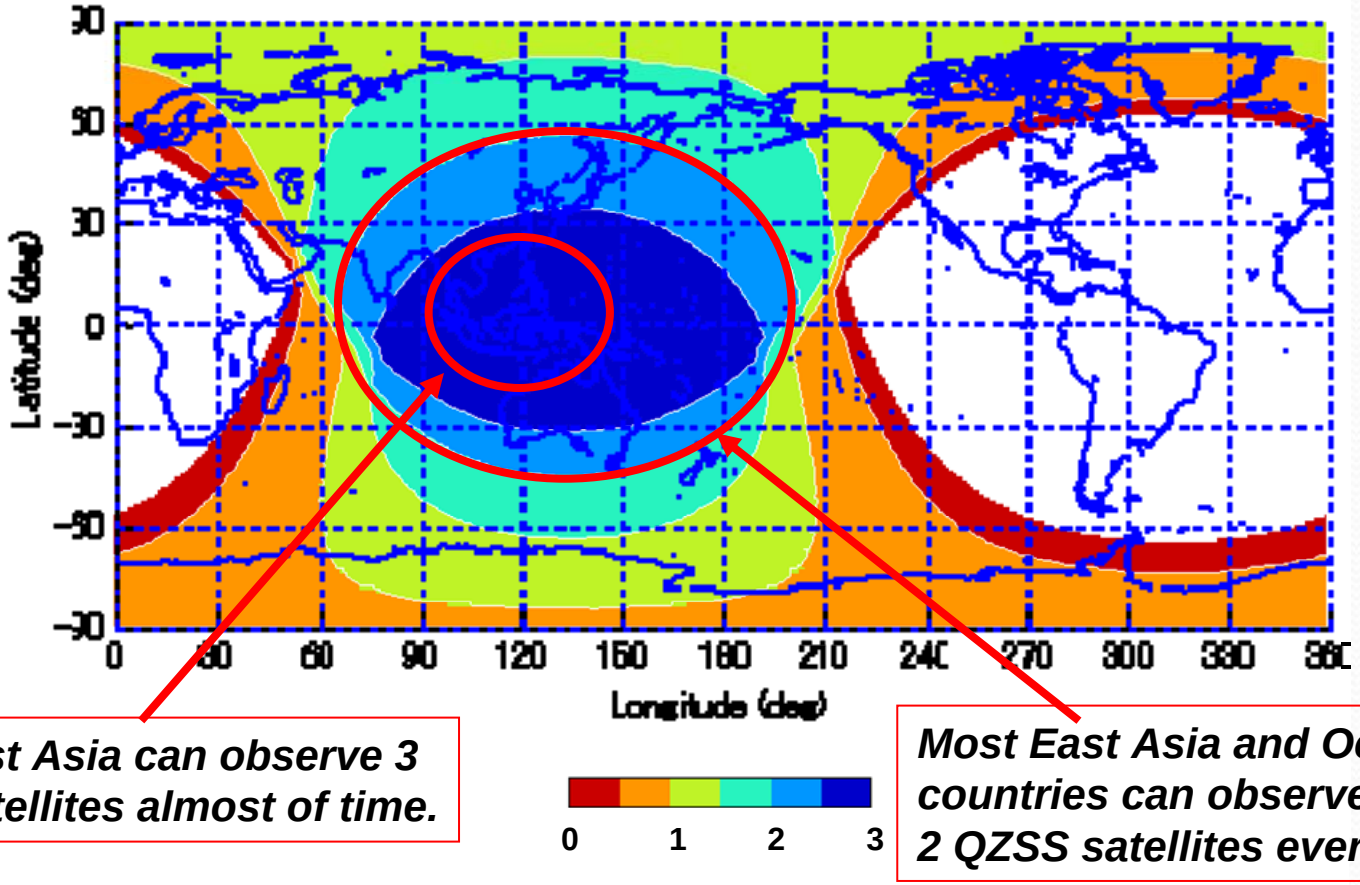

*Azimuth Elevation plot & Elevation Angle Variation*

***At least one QZSS satellite can be observed more than specified elevation angle any time. For instance, users in orange colored area can receive at least one QZSS satellite with 70 degrees or more.***

# Quasi-Zenith Satellite System

- Coverage

Average visible satellite number for QZSS (3 SV constellation)

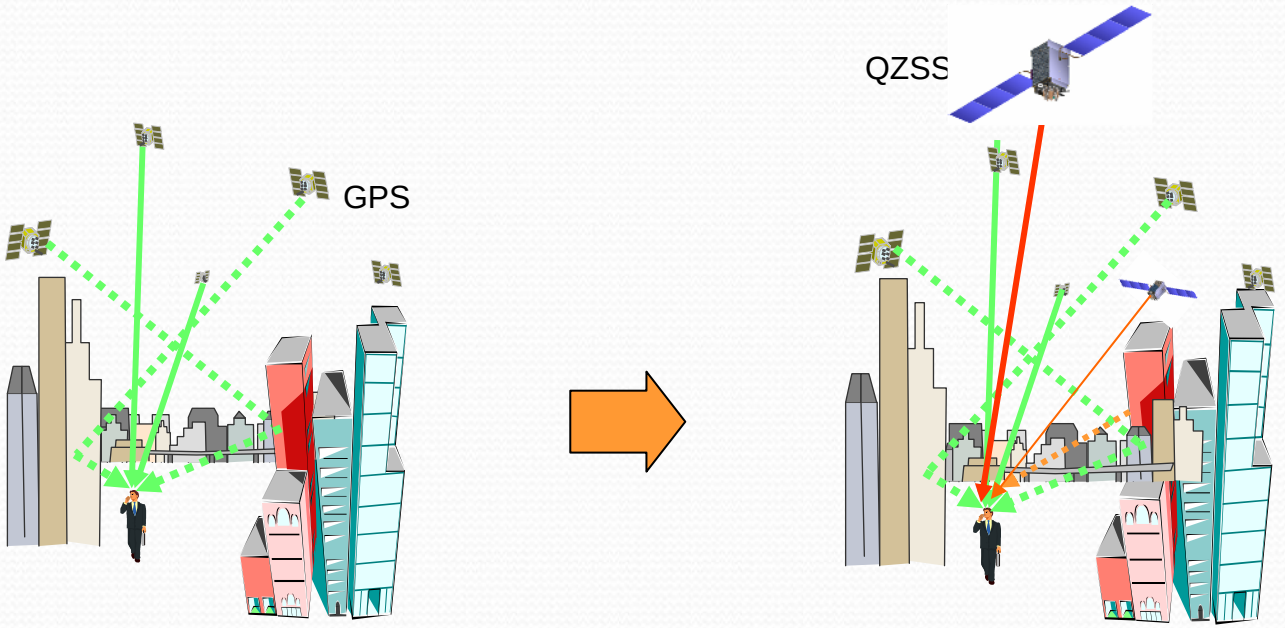



***Southeast Asia can observe 3 QZSS satellites almost of time.***

***Most East Asia and Oceania countries can observe more than 2 QZSS satellites every time***

# How QZSS works (1/3)

- GNSS application needs more than four ranging measurements between Satellites and User receiver
  - Computation X, Y, Z and Time
  - Sometime, not easy to get four measurements
    - In urban canyon, deep forest, mountainous terrain and etc.




***Current: Less than four measurements*** ***After QZSS: more than four***

**QZSS improves availability and coverage of GNSS**

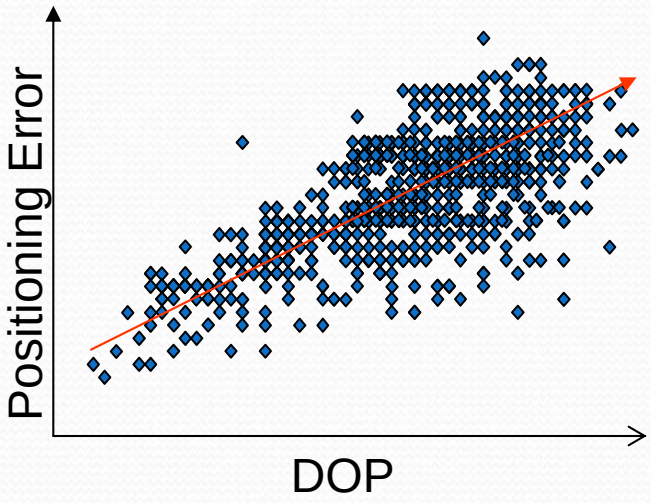
# How QZSS works (2/3)

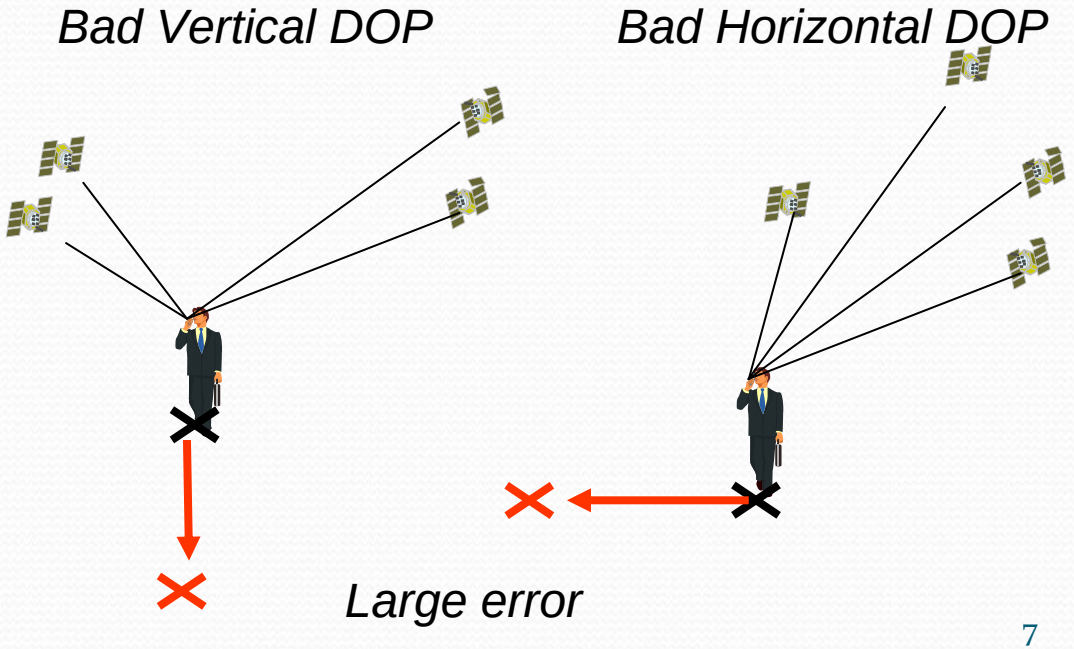
- GNSS accuracy is modeled

  User Positioning Error

  = **DOP (Dilution of Precision)** X URE (User Range Error)

  - DOP is geometry among satellites and user.



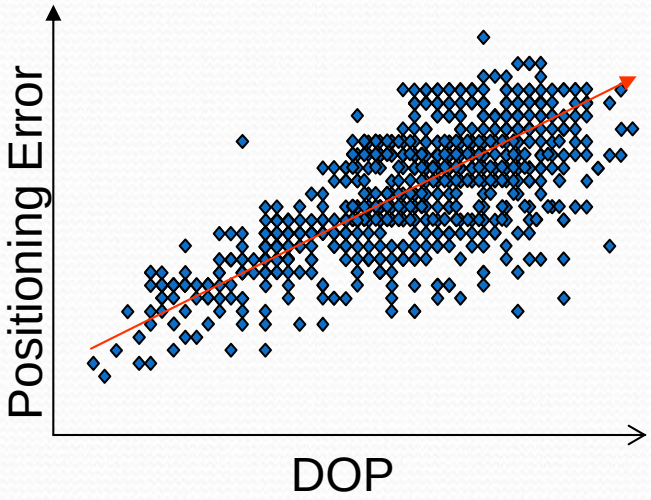
# How QZSS works (2/3)

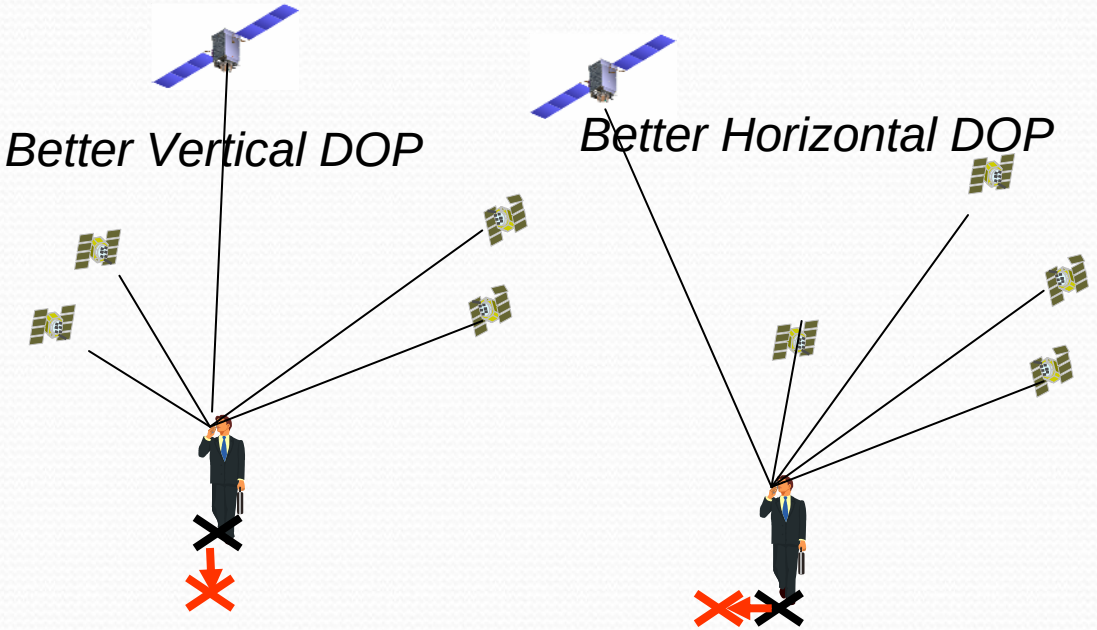
- GNSS accuracy is modeled

  User Positioning Error

  = **DOP (Dilution of Precision)** X URE (User Range Error)

  - DOP is geometry among satellites and user.

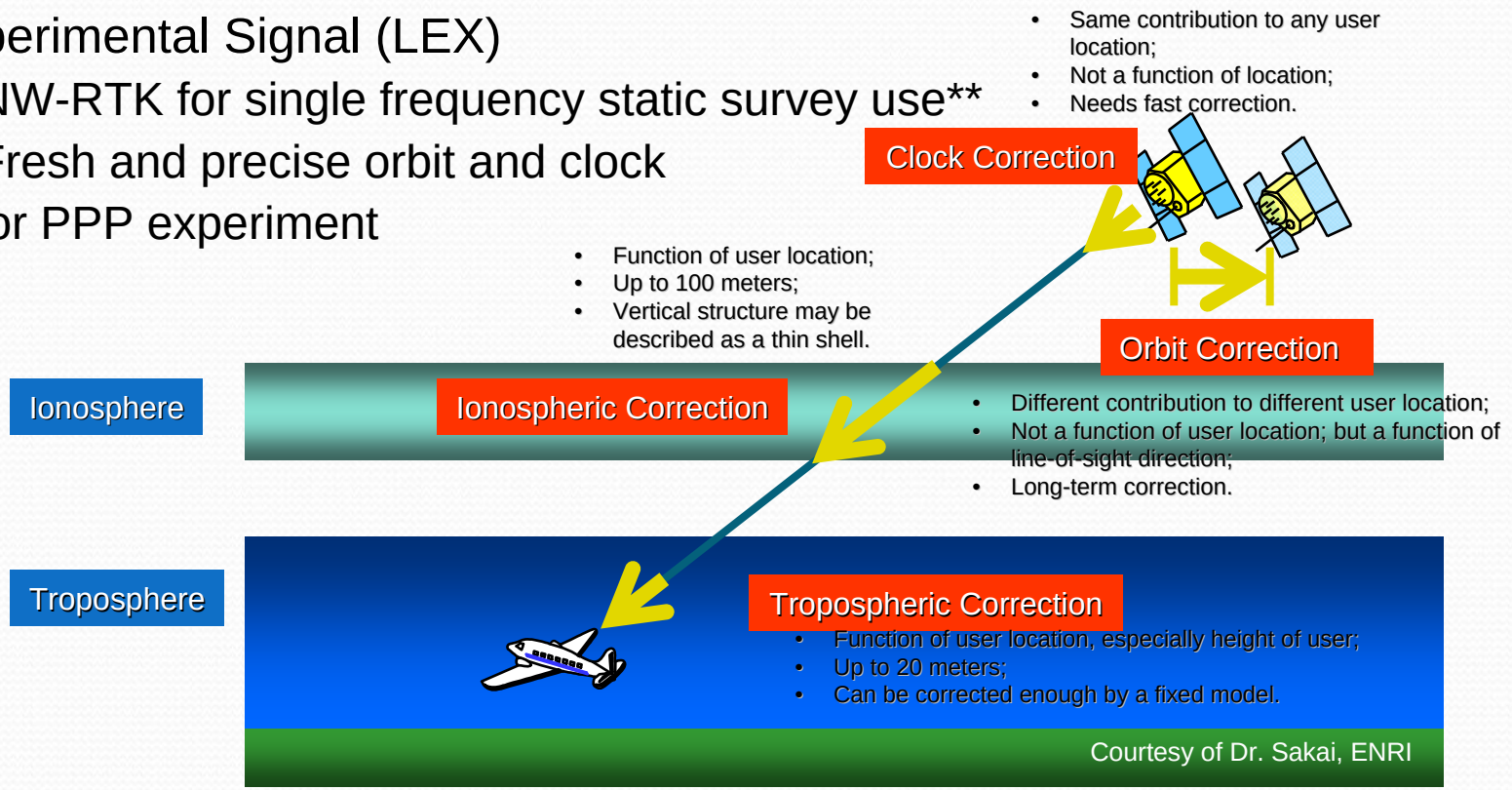



***Improve user positioning error***

# How QZSS works (3/3)

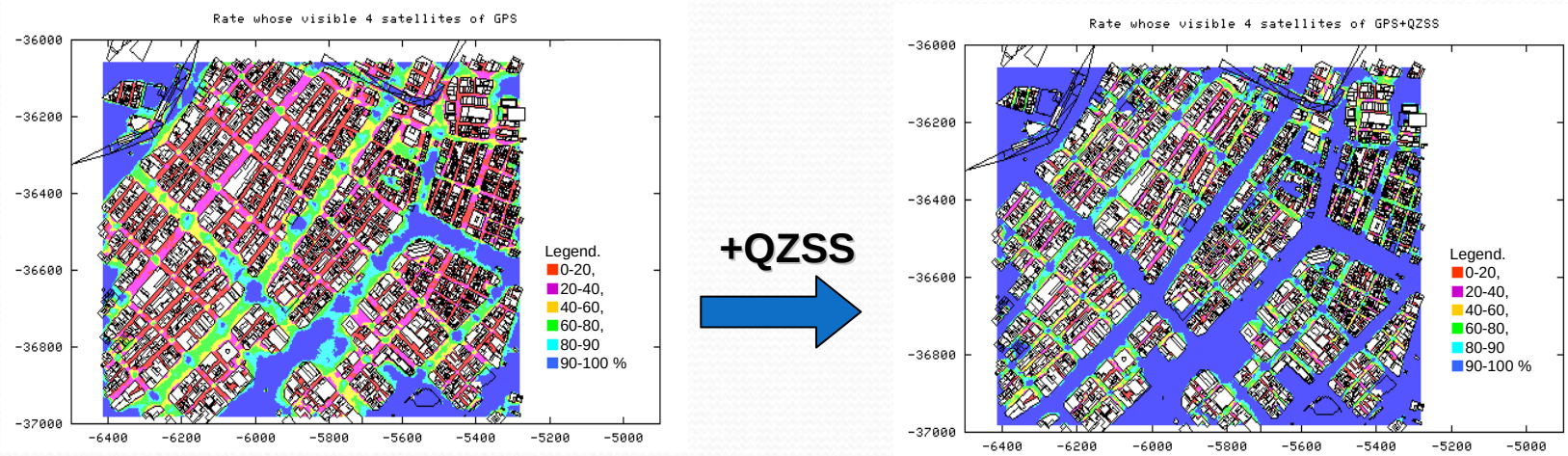
- User Positioning Error
  = DOP (Dilution of Precision) X **URE (User Range Error)**
  - There are several error correction methods to improve URE.
  - QZSS will transmit
    - L1-SAIF SBAS type WDGPS correction*
    - Experimental Signal (LEX)
      - NW-RTK for single frequency static survey use**
      - Fresh and precise orbit and clock for PPP experiment



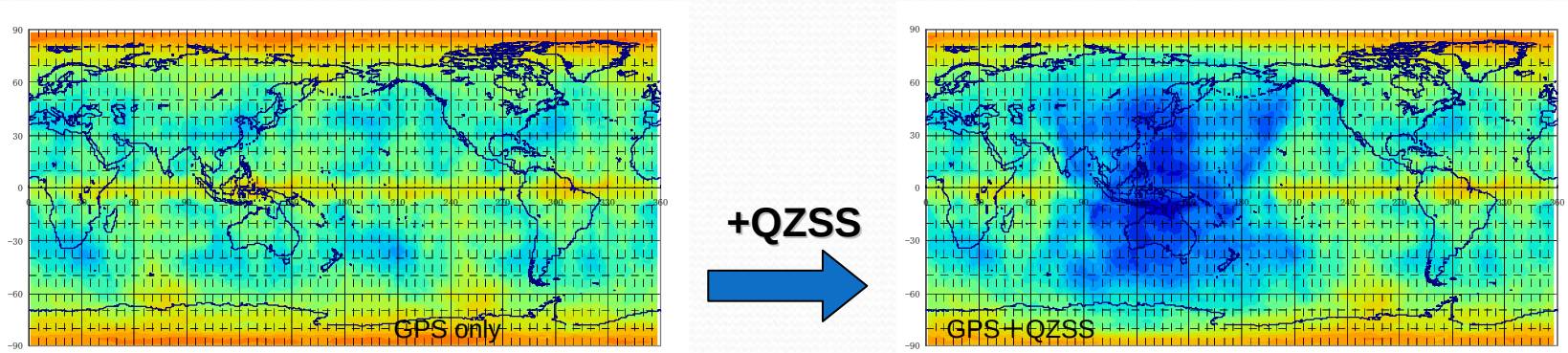

* developed by Electronic Navigation Research Institute (ENRI). ** developed by Geographical Survey Institute (GSI)

# Enhancement GPS Capability

## *Improvement of GPS Coverage and Performance*




***3D Simulation Result at Tokyo Downtown Area:***
***Positioning Availability (Time percentage of more than four satellites are visible)***




***Global Distribution of PDOP Availability***
***(Time percentage that PDOP is less than six with mask angle 30 degrees)***

# Expected Performance - Accuracy -

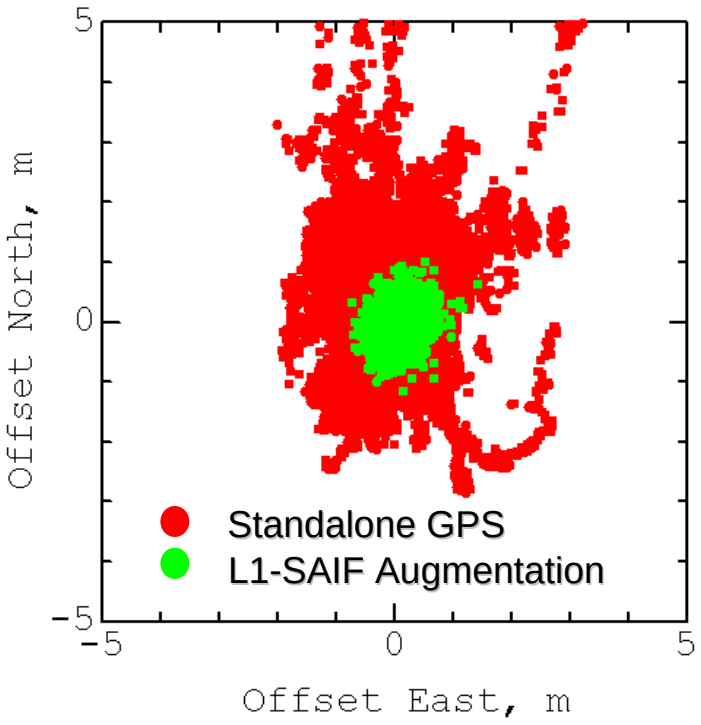
- The Signal-in-Space (SIS) User Range Error
  - **is less than 1.6 m (95%) Including time and coordination offset error.**
- User positioning Accuracy
  - define as positioning accuracy combined GPS L1_C/A and QZSS L1_C/A for single frequency user, L1-L2 for dual frequency user.

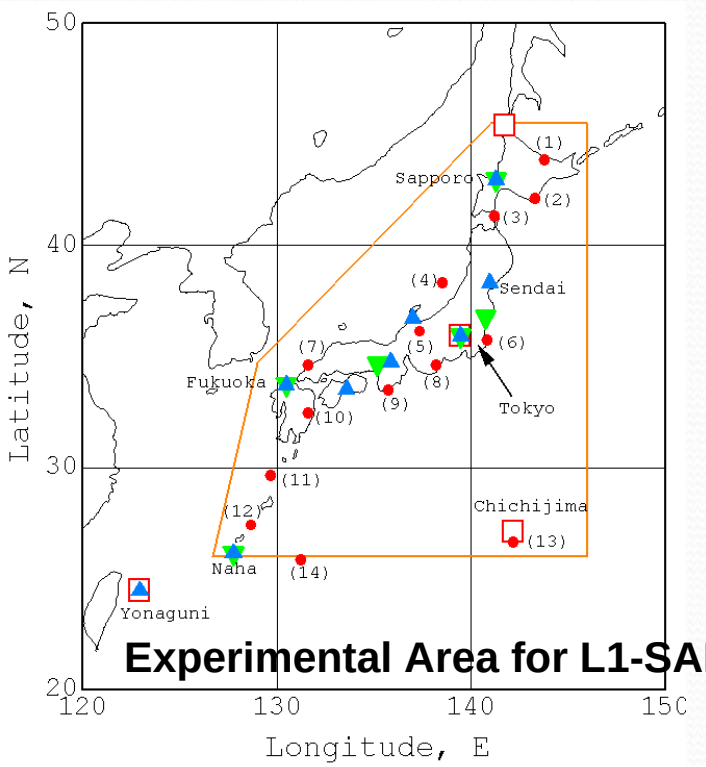
| | *Specification* | *Simulation result* |
|---|---|---|
| *SIS-URE* | *1.6m (95%)* | *1.5m (95%)* |
| *Single frequency user* | *21.9m(95%)* | *7.02m(95%)* |
| *Dual frequency user* | *7.5m (95%)* | *6.11m(95%)* |

  - L1-SAIF signal can provide WDGPS correction data, its positioning accuracy is 1m (1 sigma rms) except in cases of large multipath error and large ionospheric disturbance.

# Enhancement GPS Capability

- *L1-SAIF Augmentation*
  - *Example of user positioning error at Takayama was simulated by ENRI.*
    - *MSAS-like 6 monitor stations;*
    - *Period: 19-23 Jan. 2008 (5 days).*




**Experimental Area for L1-SAIF**

| System | | Horizontal Error | Vertical Error |
|---|---|---|---|
| Standalone GPS | RMS | **1.45 m** | 2.92 m |
| | Max | 6.02 m | 8.45 m |
| L1-SAIF | RMS | **0.29 m** | 0.39 m |
| | Max | 1.56 m | 2.57 m |

**Courtesy of Dr. Sakai, ENRI**

# Carrier Phase Positioning

- By using Carrier Phase Positioning, we can obtain
  - **mm** accuracy for science applications by offline analysis
  - **cm - dm** accuracy for real time applications

- Technical trend of real time carrier phase positioning
  - **RTK**
    - Relative positioning, need reference point
    - Less than 10 km away from ref. point.
    - Two receivers and communications radio link
  - **NW-RTK**
    - Relative positioning, need local reference point network
    - Less than 100 km in the ref. point network
    - One receiver and communications radio link
  - **PPP (Precise Point Positioning) or SPP (Single Point Positioning)**
    - Absolute positioning, need global monitoring network
    - Independent with ref. point
    - Precise and fresh satellite orbit and clock is requested.
    - Multi-GNSS use can facilitate to apply PPP technique
    - One receiver

*The experiment using QZSS LEX signal is to be carried out*

# Development Status - Space Segment -

**Proto-flight Tests are on going @MELCO**

IPT（8/20/2009-9/3/2009）

Initial Alignment Test
（9/5/2009-9/10/2009）

Preparation for TVT
TVT（10/1/2009-10/30/2009）

Electrical Performance Test
（11/21/2009-11/22/2009）

Alignment Test after TVT
（11/23/2009-11/25/2009）

Sine Vibration Test
（7/12/2009-6/1/2010）

# Development Status - Ground Segment -

- **Muster Control Station（MCS）@Tsukuba Space Center (TKSC),**
  - **Completed installation of computer system at the site. Preparing Integration Test for whole systems.**
- **Monitor Station (MS)**
  - **Koganei, Okinawa, Sarobetsu, and Guam:**
    - **Installation of equipment at the site and Network connection were completed**
  - **Ogasawara, Hawaii, Bangkok, Bangalore, Canberra**
    - **Preparing for installation**
- **Tracking & Control System**
  - **New C-band Antennas has been constructed at Okinawa Space Communications Station.**
  - **Integration test between remote control system located in TKSC are being conducted.**

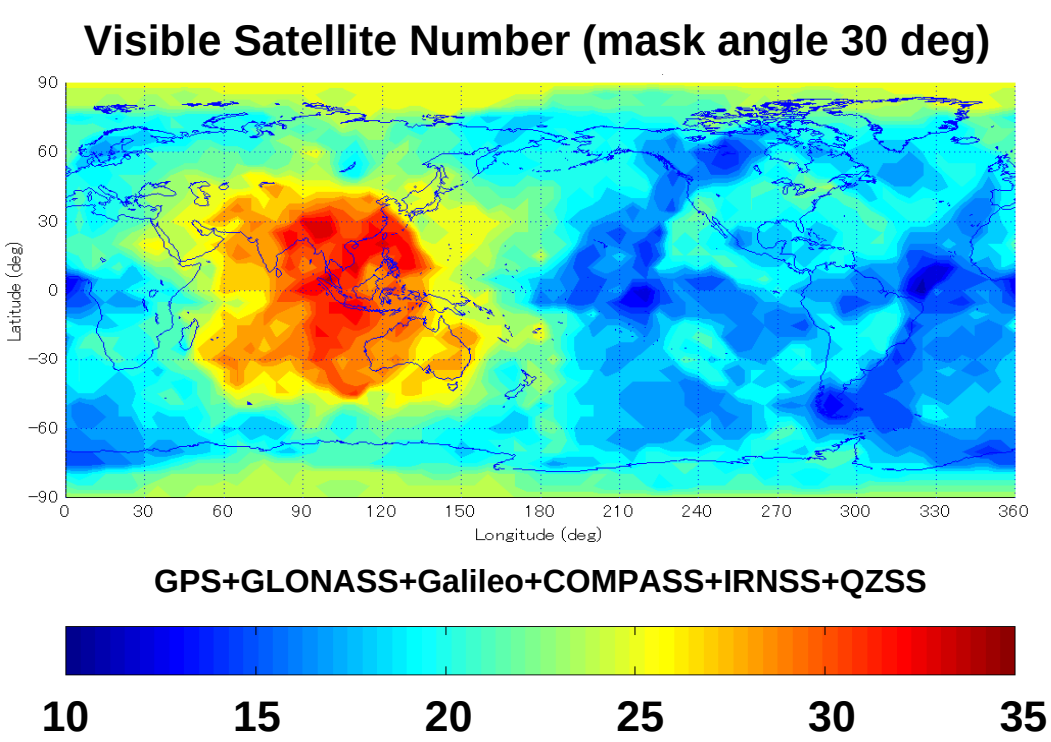
MS equipment（Guam）

MCS／TTC equipment (TkSC)

Operation room in MCS（TKSC）

TTC & NAV message Uplink Station (Okinawa)

# Asia Oceania is the Showcase of New GNSS Era




- GPS
- GLONASS
- Galileo
- COMPASS
- IRNSS
- QZSS
- And more….

- Multi-GNSS
  - More Stars, Signals
- Multi-Frequency

→

- Higher accuracy
- More reliable, robust
- Increase coverage, availability

→ New Applications

# Asia Oceania Multi-GNSS Demonstration Campaign

Aiming to

- Promote new multi-GNSS utilization and applications in the region and feedback needs and requirements related to interoperability from user communities to GNSS providers
- Encourage GNSS provider and users in Asia Oceania region to develop new applications and carry out experiment or demonstration jointly.

*To be Implemented a series of activities for five years from 2010, including;*

1. *Establishment of Multi-GNSS Monitoring Network*
   - *International collaboration with IGS and related organizations*
2. *Development of multi GNSS applications and demonstrations*
3. *Annual Regional Work Shop*

# Asia Oceania Regional Workshop on GNSS

- *held in Bangkok, Thailand on January 25-26, 2010 followed by APRSAF16 to discuss future joint development and experiment for multi GNSS use in Asia Oceania region*
- *Hosted by SPAC*, JAXA, and GISTDA** of Thailand and supported by UN International Committee on GNSS (ICG)*
- *195 participants from 18 countries*
- *The detail information is to be available on;*

  ***http://www.multignss.asia/***

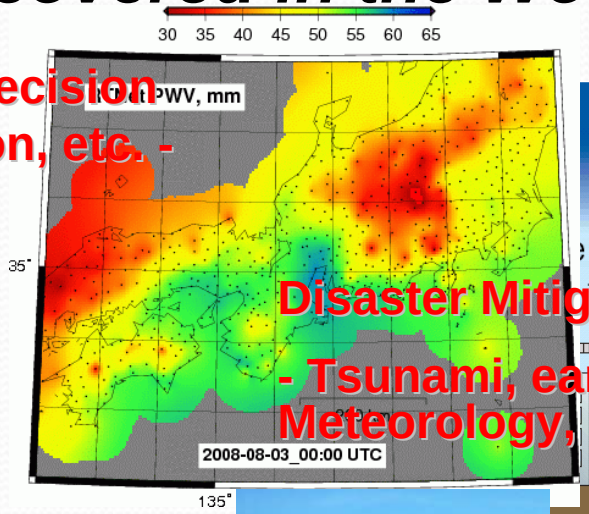

*SPAC: Satellite Positioning Applications Center*

*** GISTDA: Geo-Informatics and Space Technology Agency*

# Asia Oceania Regional Workshop on GNSS

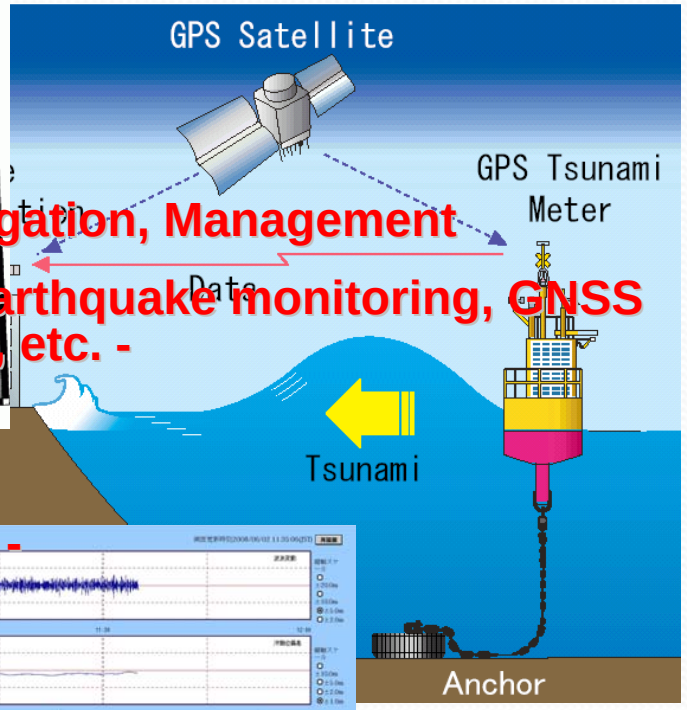
- ***Topics were covered in the Workshop***

**Precise Positioning - Precision Agriculture, Construction, etc. -**



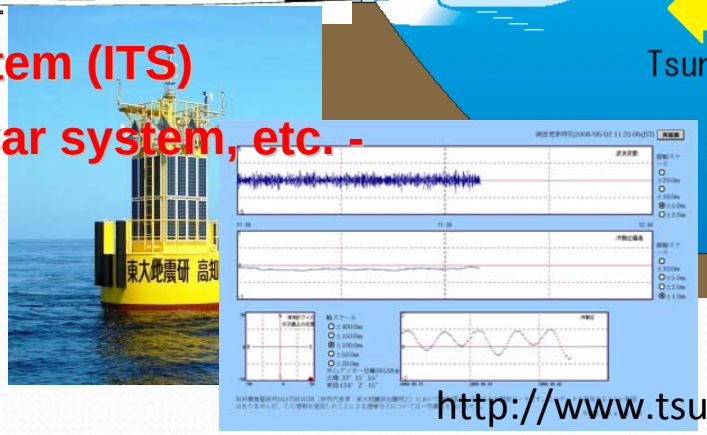

**Disaster Mitigation, Management**

**- Tsunami, earthquake monitoring, GNSS Meteorology, etc. -**




**Intellectual Transportation System (ITS)**

**- Road Pricing system, Probe Car system, etc. -**



**Location Based Services, Pedestrian Navigation**

http://www.tsunamigps.com/

*Courtesy of Hitachi Zosen, U of Hokkaido, KDDI*

# Summary

- *The QZSS*
  - *is a regional space-based PNT (Positioning, Navigation and Timing) system being developed step-by-step approach. The first satellite will be launched in 2010.*
  - *covers East Asia and Oceania region.*
  - *can provide seamless PNT services by combining usage with GPS.*
    - *Increasing coverage and availability of PNT services even in downtown and mountainous areas.*
  - *can enhance GPS performance by transmitting error correction and integrity information.*
  - *can accelerate the Modernization of GPS in Asia Oceania region.*
  - *can be a suitable platform for Multi-GNSS augmentation.*

- ***The 1st Asia Oceania Regional Workshop on GNSS***
  - *was held in Bangkok on 25-26 January, 2010 to discuss future joint development and experiment for multi GNSS usage in Asia Oceania region as an activity of Asia Oceania Multi-GNSS Demonstration Campaign*

- *Thanks a lot for your attention!*

- Contact;
  - Satoshi Kogure
    - Associate Senior Engineer
    - **Japan Aerospace Exploration Agency (JAXA)**
    - QZSS project team/Space Applications and Promotion Center
    - 2-1-1 Sengen, Tsukuba, Ibaraki, 305-8505, Japan
    - Tel: +81-50-3362-2456
    - Fax: +81-29-868-5987
    - E-mail: kogure.satoshi@jaxa.jp