# QZSS

## The Japanese Quasi-Zenith Satellite System

## Program Updates and Current status


**Fifth International Committee on GNSS**

**Torino, Italy**

**October 18, 2010**

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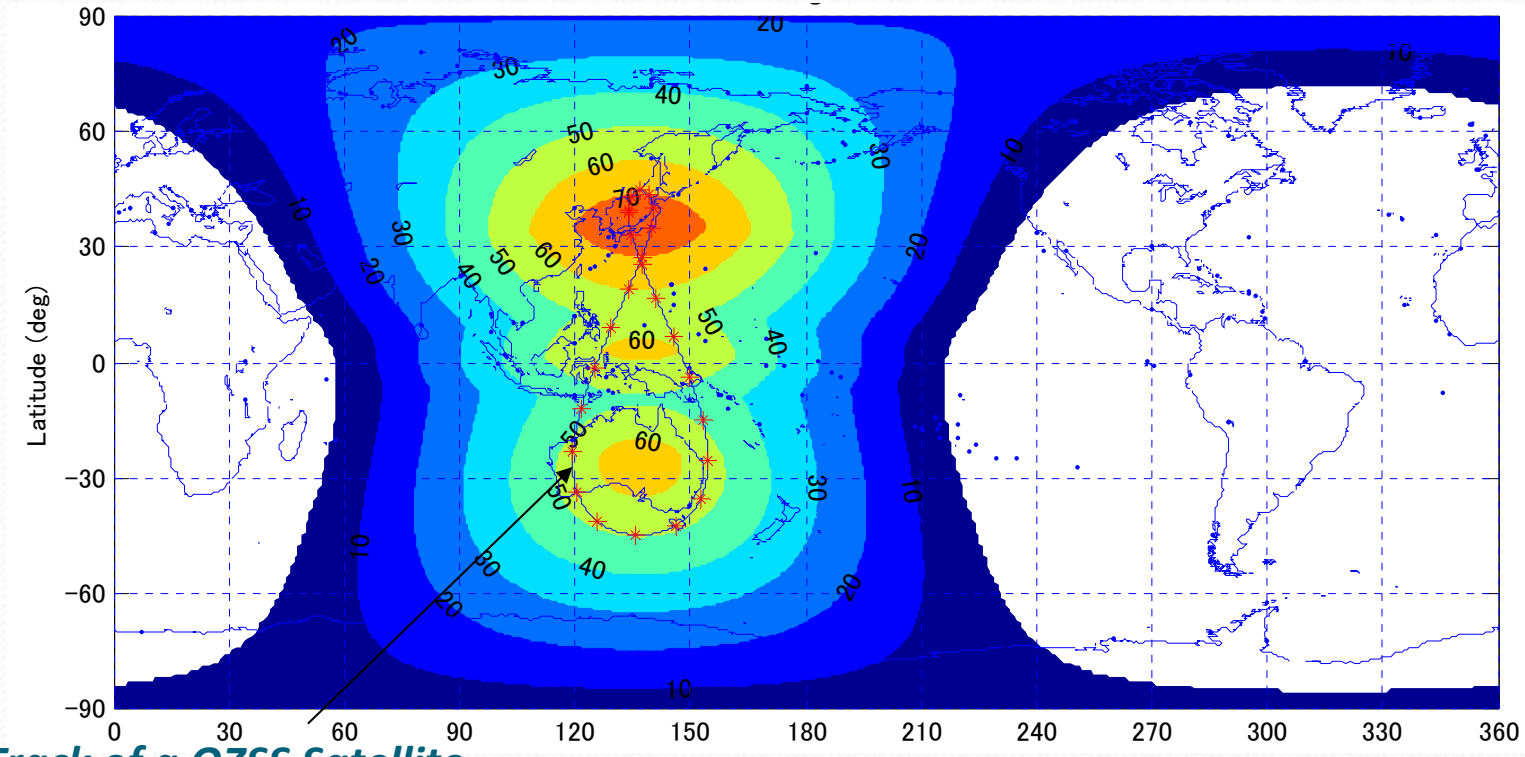
# QZSS outline

# Quasi-Zenith Satellite System

- ***Coverage*: East Asia and Oceania region**
- ***Six Signals*:**
  - **L1C/A, L1C, L2C and L5**
    - **can provide seamless PNT services by combining usage with GPS.**
    - **Increasing coverage and availability of PNT services even in downtown and mountainous areas.**
  - **L1-SAIF on 1575.42 MHz**
  - **LEX on 1278.75MHz**
    - **can enhance GPS performance by transmitting error correction and integrity information.**
- ***Accelerate:* the modernization of GPS in Asia Oceania region.**
- ***Platform:* for Multi-GNSS augmentation.**
- ***First satellite*: launched in September 2010.**
- ***Plan*: the 2nd and 3rd satellite will be approved after assessment of the technical and application demonstration result.**

# QZSS Service

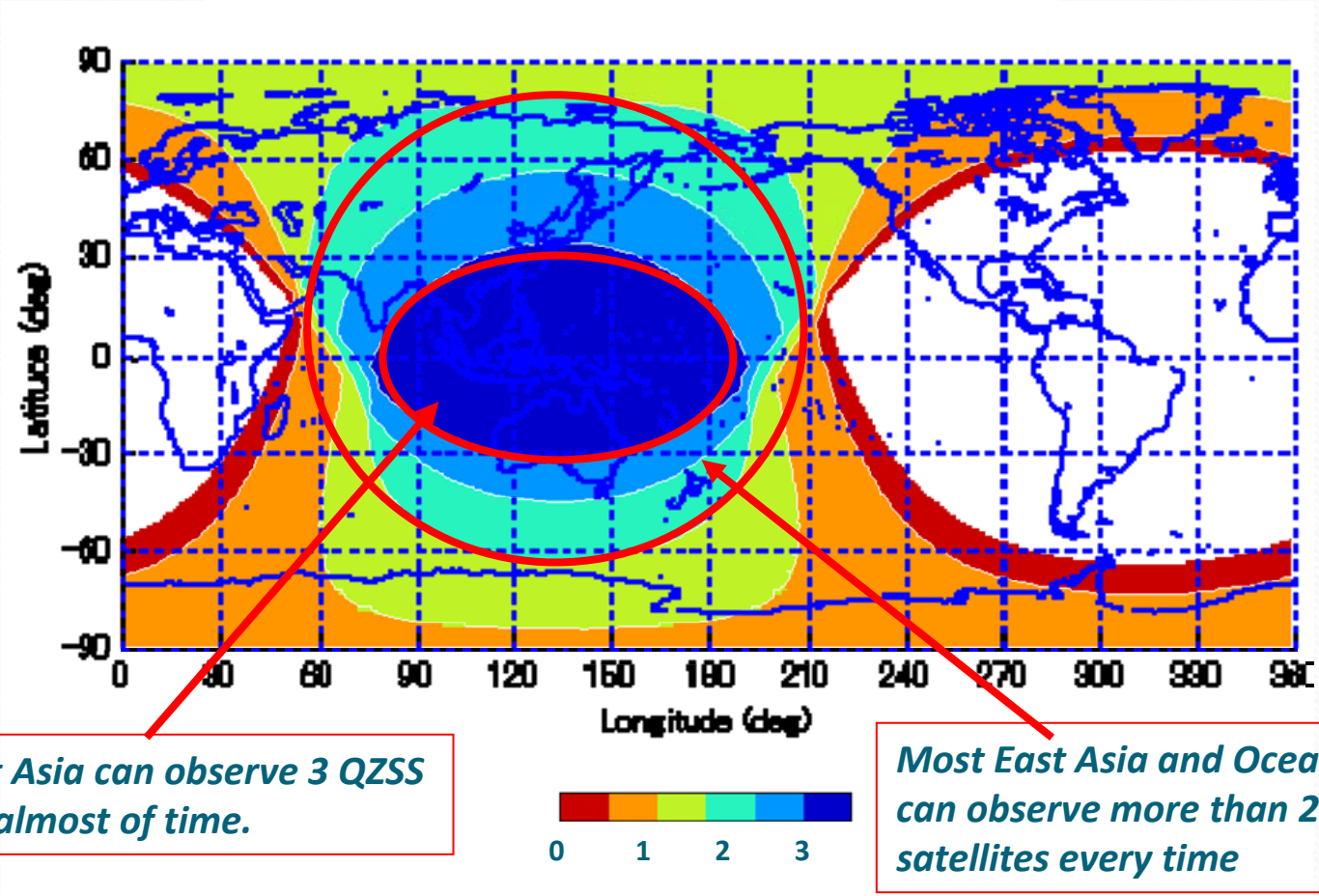
# QZSS Service Coverage the Elevation




*Ground Track of a QZSS Satellite*

*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.*

# QZSS Service Coverage
# the Number of Satellites




*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*

# QZSS Service

# QZSS Signals

| | Frequency | Notes |
|---|---|---|
| L1-C/A | 1575.42MHz | ➢ Complete compatibility and interoperability with existing and future modernized GPS signals<br>➢ Differential Correction data, Integrity flag, Ionospheric correction<br>➢ Almanac & Health for other GNSS SVs |
| L1C | | |
| L2C | 1227.6MHz | |
| L5 | 1176.45MHz | |
| L1-SAIF* | 1575.42MHz | ➢ Compatibility with GPS-SBAS |
| LEX | 1278.75MHz | ➢ Experimental Signal with higher data rate message (2Kbps)<br>➢ Compatibility & interoperability with Galileo E6 signal |

** L1-SAIF: L1-Submeter-class Augmentation with Integrity Function*

# QZSS Service

# Time System and Frame

- **Time Reference System: QZSST**
  - The length of one second is identical to **International Atomic Time (TAI)**.
  - Integer second offset for TAI is the same as GPS, and TAI is **19 seconds** ahead of QZSST.
  - Interface with GPS:
    - The SV clocks of QZS and GPS satellites are both controlled with respect to the offset with the GPS time scale (GPST).
    - GQTO: The time scale offset with the GPS is less than **2.0 [m] (95%)**.
- **Geodetic Reference Frame: JGS**
  - The QZSS coordinate system is known as the Japan satellite navigation Geodetic System (**JGS**). This coordinate System is operated so as to approach the **International Terrestrial Reference System (ITRS)**.
  - The coordinate system offset with GPS is less than **0.02 [m]**.

# QZSS Service

# Accuracy

- The Signal-in-Space (SIS) User Range Error
  - is less than 1.6 m (95%) without 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%) |
| Positioning Accuracy Single frequency user | 21.9m(95%) | 7.02m(95%) |
| Positioning Accuracy Dual frequency user | 7.5m (95%) | 6.11m(95%) |

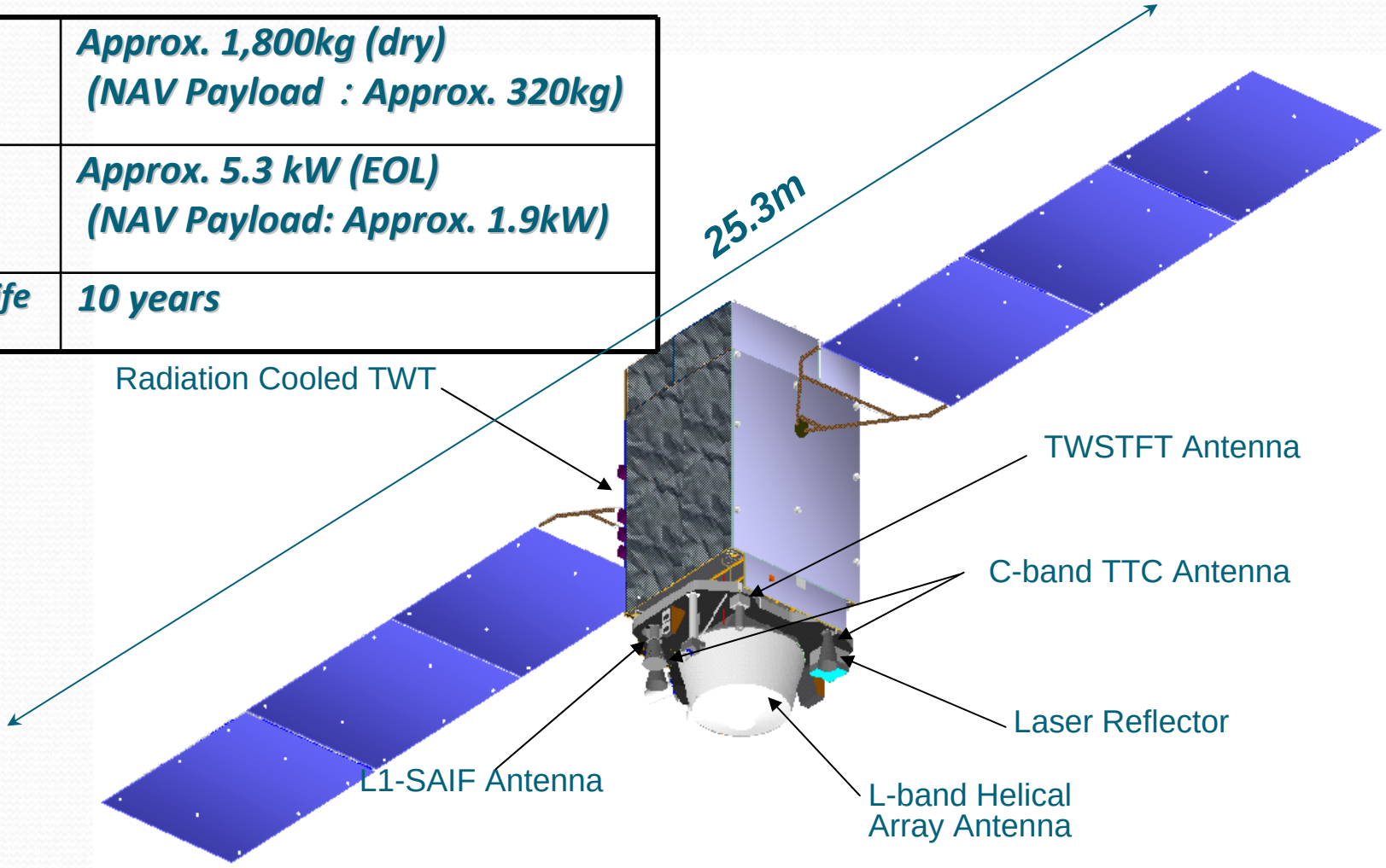
- L1-SAIF signal can provide WDGPS correction data, its positioning accuracy is 1m (1 sigma rms) except in cases of large multipath error and large ionospheric disturbance.

# QZSS System Description

# QZSS System Description

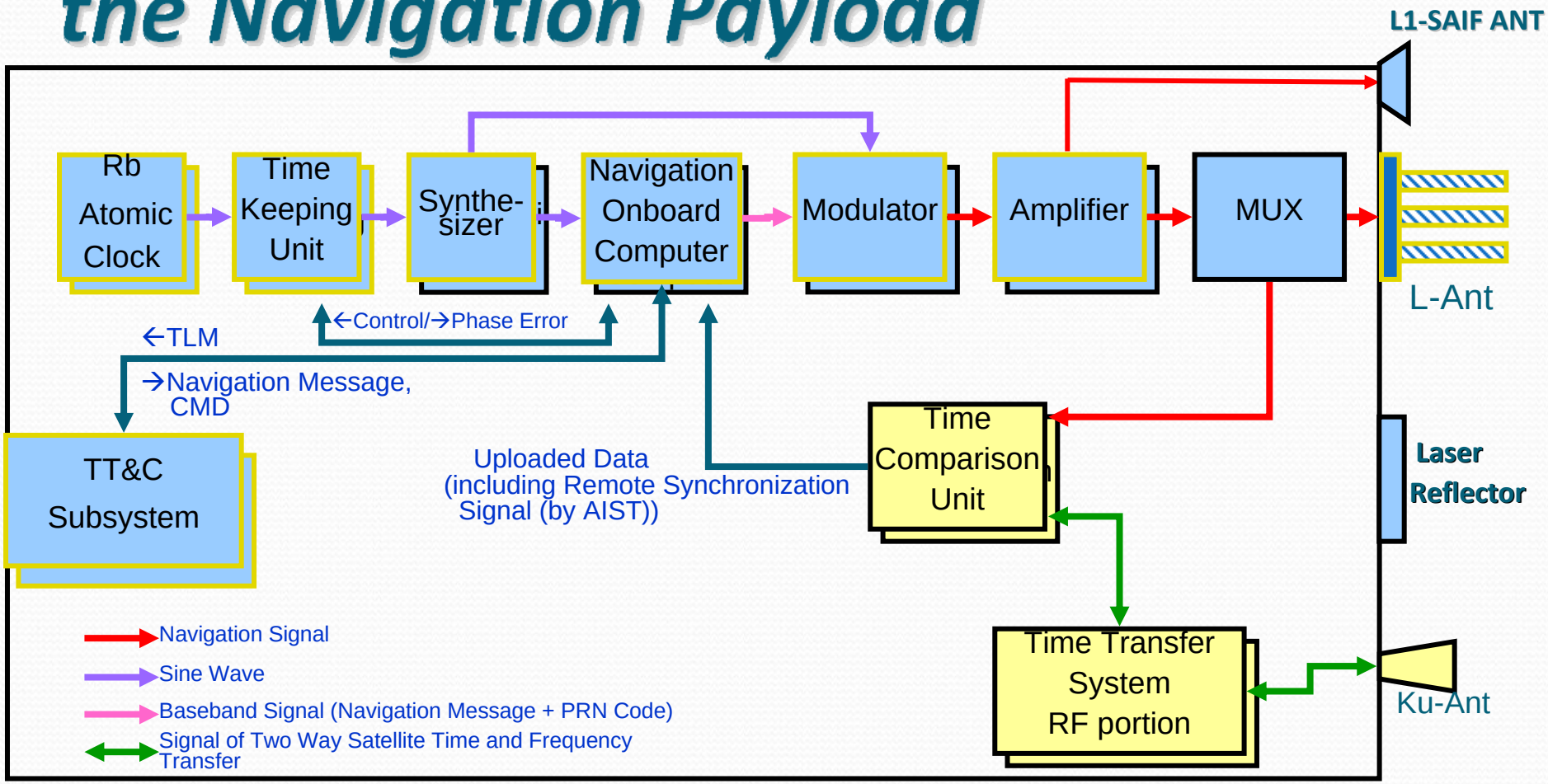
## the Satellite named "Michibiki"

| | |
|---|---|
| Mass | Approx. 1,800kg (dry)<br>(NAV Payload : Approx. 320kg) |
| Power | Approx. 5.3 kW (EOL)<br>(NAV Payload: Approx. 1.9kW) |
| Design Life | 10 years |



# QZSS System Description

## the Navigation Payload

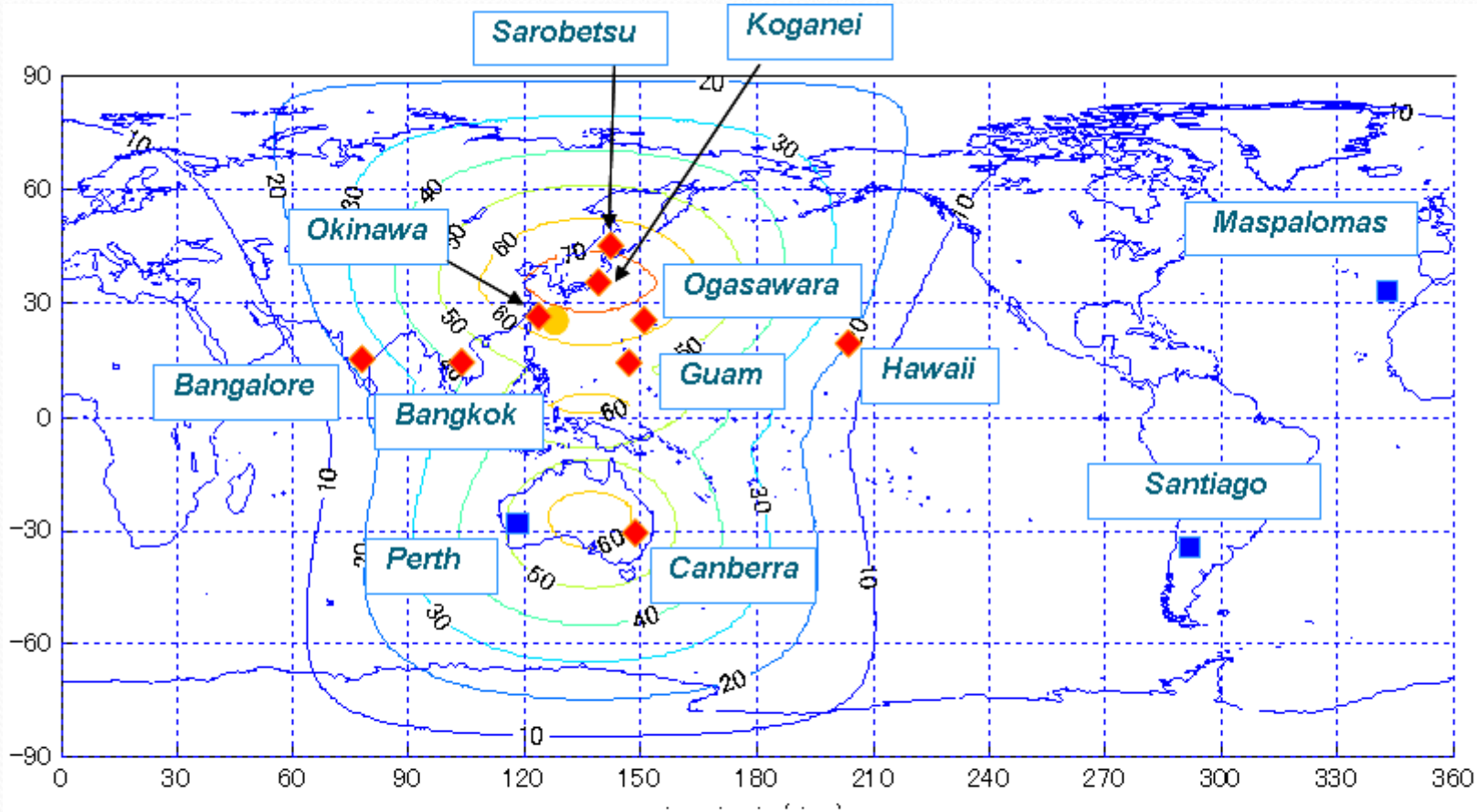



JAXA NICT

(previously: CRL)

# QZSS System Description

# the Ground Stations




***Okinawa is primary TT&C station for nominal operation.***

***LEOP operation is to be conducted by using JAXA's Ground TT&C Network***

- GPS MS site
- QZSS & GPS MS site
- TT&C -NAV Message Uplink Station

# Development, Launch & Next Step

# Development the MCS and the TTC Station

- Master Control Station (MCS)
  - MCS is located in Tsukuba Space Center
  - Installation and integration test were completed
- Tracking & Control Station
  - Built new C-band TT&C capability in Okinawa
  - Installation and integration test were completed

TT&C-NAV Message Uplink Station @Okinawa

# Development the Monitor Stations

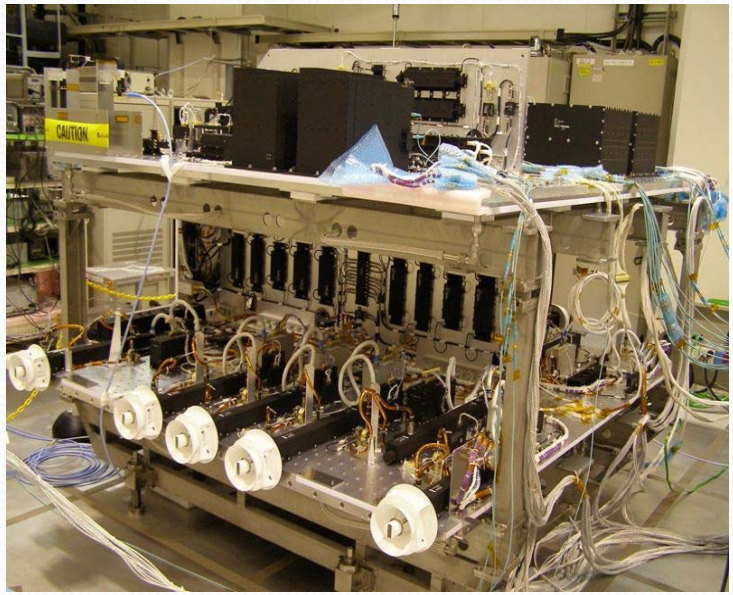
- *9 sites distributed in Asia Oceania region*
- *Established in collaboration with international partners*
  - Guam;
    - NOAA, National Weather Service Forecast Office (WFO)
  - Hawaii;
    - NASA, Kokee Park Geophysical Observatory (KPGO)
  - Bangalore;
    - Indian Space Research Organization (ISRO)
  - Canberra;
    - Geosciences Australia (GA)
  - Bangkok;
    - Asian Institute of Technology (AIT)


Monitoring Station @Guam (Aug 2009)

# Development
# the Payload Development

PFM L-band Antenna Pattern Test

(July 2008)



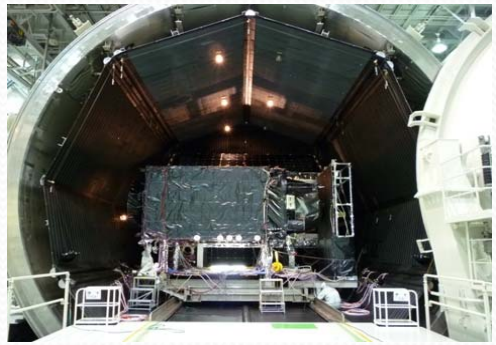

NAV Payload PFM TVT

(Jan 2009）

# Development the Satellite Development

IPT (8/20/2009-9/3/2009)

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



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

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

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

Separation Shock Test
(1.13/2010–1.14/2010)

Ship to Launch site
(6/5/2010)

# …and the Launch


# Launch and Next Step

# Launch and OOC

- **Launch:**

  The 1st satellite (QZS-1; MICHIBIKI) was launched on September 11th, 2010, JST.

- **On-Orbit-Checkout: OOC:**
  - 3 months On-Orbit-Checkout (OOC) period after the launch;
    - Orbit raising in the Orbit Transfer Period
    - Orbit settlement in the Orbit Drift Period
    - and the Initial Check Operations.

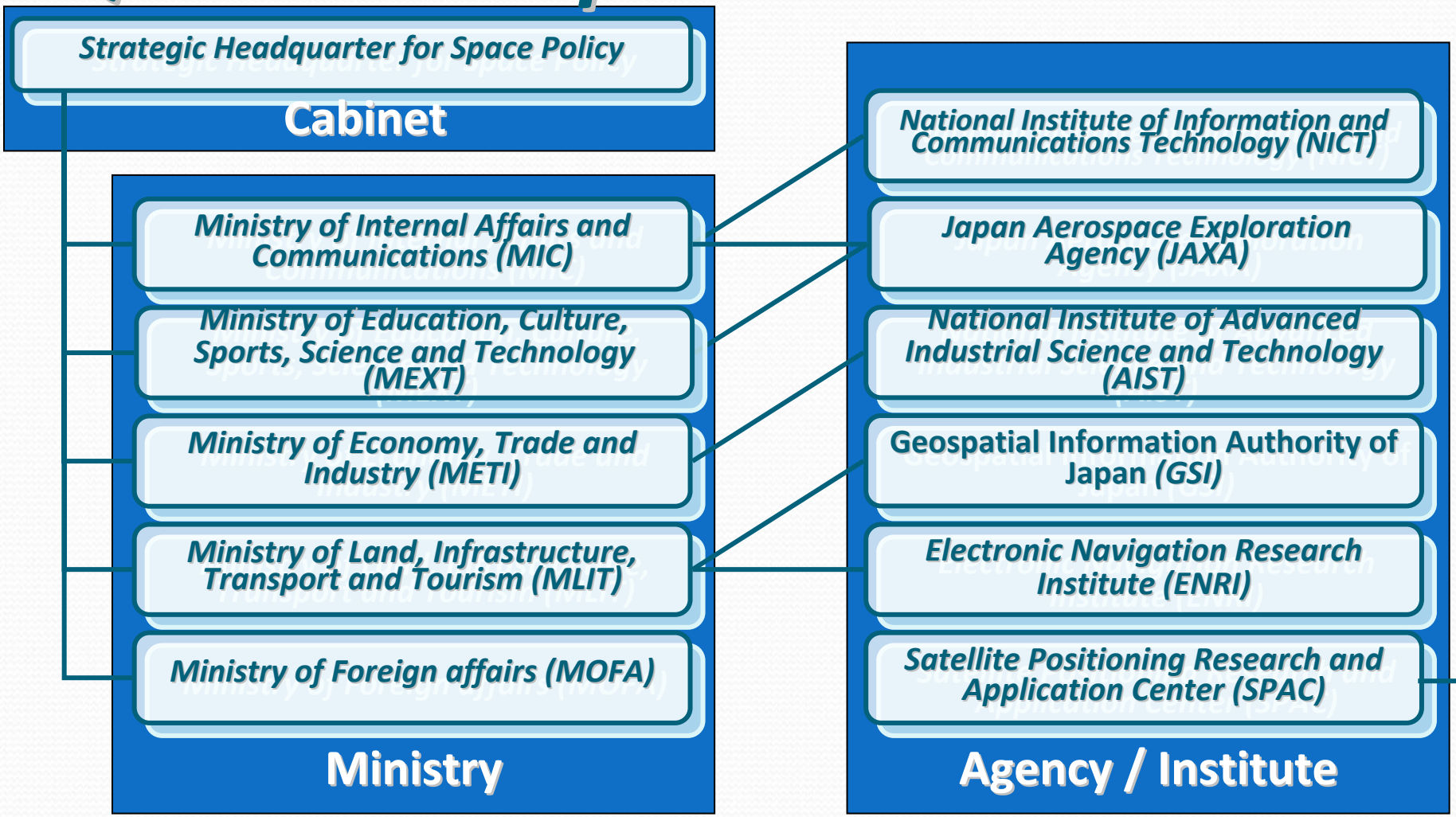
# Next Step: Demonstrations

*Demonstrations will be started after OOC*

- *Technical Demonstration:*
  - *Various parameters are tuned*
  - *Ephemeris accuracy is to be improved.*
  - *And after the time when SIS URE is verified to meet the specification, QZS-1 will be set healthy.*
- *Application Demonstration:*
  - *101 companies will participate.*
  - *58 programs will be implemented.*

# Organization

# Organization of QZSS Development & Utilization



# Service Provided and Provision Policies

# QZSS Service Provision Policies

- **GPS interoperable signals, L1 C/A, L2C, L5 and L1C, are to be provided on the basis of no direct user fee.**

- **GPS performance enhancement signals, L1-SAIF and LEX, charging policy is under examination.**

# Inter-GNSS

## Inter-GNSS

# Views on Interoperability

- Interoperability is NOT mandatory, but highly desirable in the users' point of view.

- Japan will continue to keep the interoperability at the higher level for all user communities including low-cost receivers
  - L1 and L5 with GPS, Galileo, COMPASS, as well as future GLONASS CDMA signals
  - L2C with GPS
  - LEX with Galileo

# Views on Compatibility

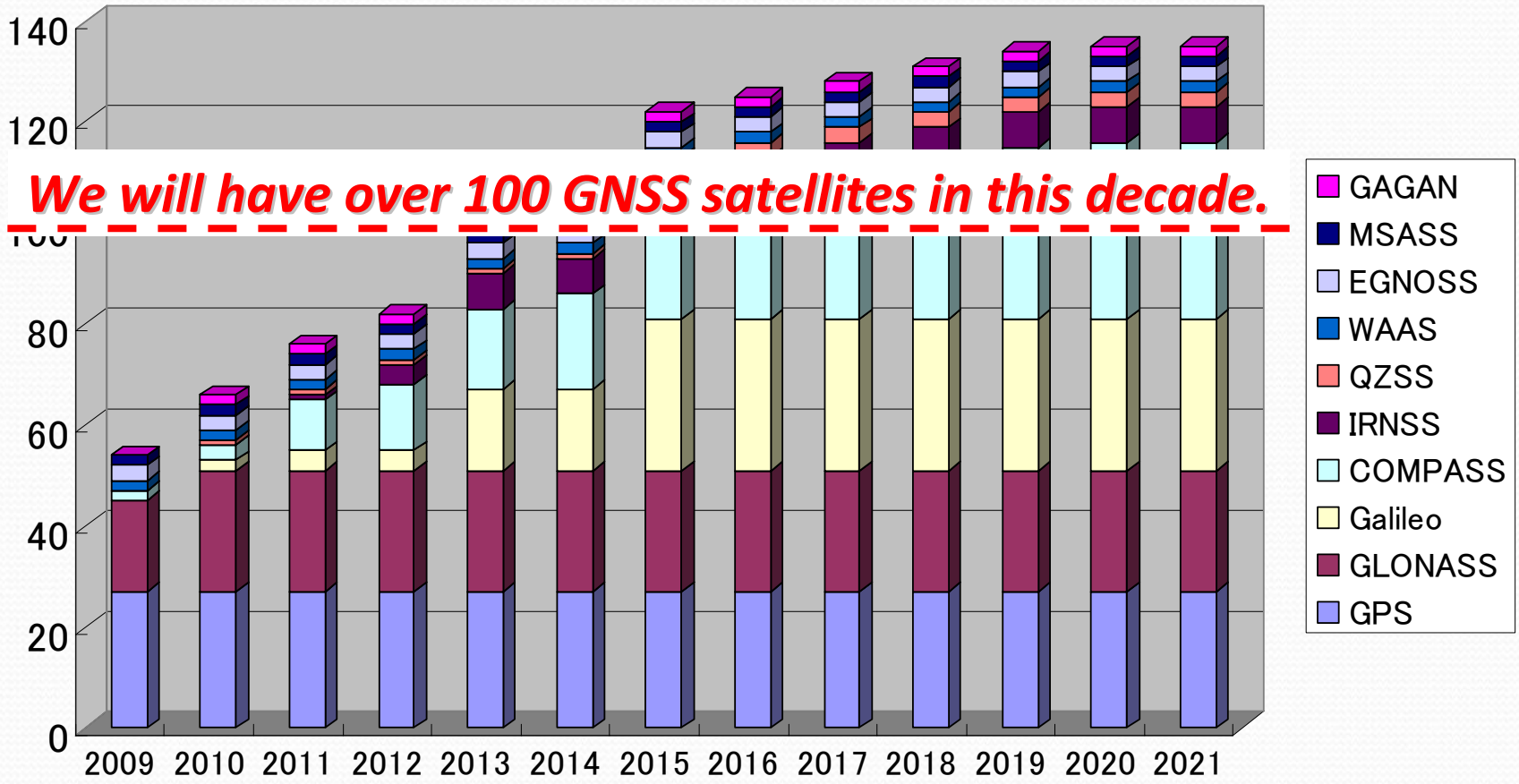
- Compatibility is a mandatory requirement to share the same frequency bands among multi GNSS systems without harmful interference

- Japan will continue to comply with the international rule and consensus.
  - ITU Radio Regulation
  - ICG definition

# Multi-GNSS

Multi-GNSS

# Total Number of GNSS Satellites




**We will have over 100 GNSS satellites in this decade.**

# Multi-GNSS

# New Applications are Expected

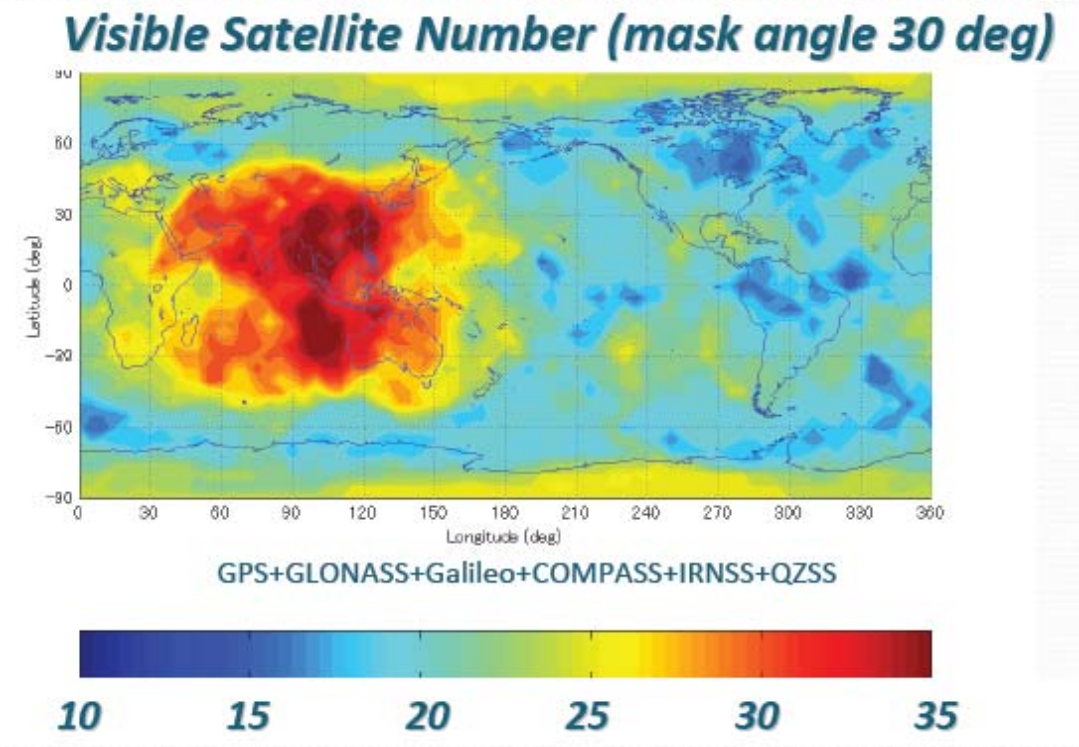
- User benefits from Multi GNSS
  - Increase in usable SVs, signals and frequencies

  - Increase in availability and coverage
  - More robust and reliable services
  - Higher accuracy in bad conditions
  - Less expensive high-end services

**Emerging new and expanding existing applications are to be expected.**

# Multi-GNSS

# Asia Oceania Showcase




*Asian People can use multi-GNSS signals earlier than other region in the world*

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

→

- *Higher accuracy*
- *More reliable, robustness*
- *Wider coverage*

→

**New Applications**

# Multi-GNSS

http://www.multignss.asia/

# Demonstration Campaign

- *is a series of activities for five years from 2010*
- *comprises the following parts*

1. **Multi-GNSS Monitoring Network**
   - *CORS* (Continuously Operating Reference System), *Data center, Analysis Center*
   - *Sharing resources and observed data among participated organization*
2. **Applications Development & Demonstration**
   - *Development of multi GNSS applications*
   - *Carrying out Experiments and Demonstrations*
3. **Regional Work Shop**
   - *Annual base Workshop in Asia Oceania region*
   - *Announcement of joint experiment plans and reporting results of the experiments*

# Multi-GNSS Demonstration Campaign

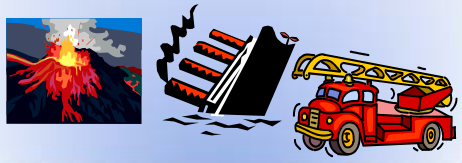
http://www.multignss.asia/

# Planned Applications

## Monitoring Network

## Application Demonstration

### Disaster Mitigation



### Precise Positioning

### ITS, Mapping, LBS

### Other, ionospheric observation etc

## Regional Workshop

*1st Asia Oceania Regional Workshop on GNSS, 25,26 JAN, 2010, Bangkok*


*195 Participants, 18 Countries, 95 Organizations*

*Next is 21,22 Nov. 2010 @ Melbourne, Australia*

# Multi-GNSS Demonstration Campaign

http://www.multignss.asia/

# the Status (past)

- The concept of "Multi-GNSS demo. Campaign" was presented at ICG-4 and obtained endorsements from Two WGs (WG-A and D)
- The 1st regional Workshop was held at Bangkok, Thailand on January 25-26, 2010 successfully.
  - Hosted by SPAC*, JAXA, and GISTDA** of Thailand and supported by UN International Committee on GNSS (ICG)


*SPAC: Satellite Positioning Applications Center
** GISTDA: Geo-Informatics and Space Technology Agency

  - 195 participants from 18 countries
  - 4 discussion groups were established for future joint experiments
    1. Multi-GNSS monitoring network
    2. Disaster Mitigation and Management
    3. Precise Positioning
    4. ITS

# Multi-GNSS Demonstration Campaign

http://www.multignss.asia/

## the Status (future)

- JAXA started a procurement for multi-GNSS receivers for the multi-GNSS monitoring network.
- The 2nd Workshop is to be held in Melbourne, Australia on November 21-22, 2010.
  - To discuss future joint demonstration projects
    - Multi-GNSS Monitoring NW
    - Disaster Mitigation
    - Precise Positioning
    - Intelligent Transportation System (ITS)
    - Mapping, Location Based System

# Summary

- *QZSS is a regional space-based PNT system covers East Asia and Oceania region and transmits six civil PNT signals.*
- *First satellite (QZS-1; MICHIBIKI) was launched on September 11th, 2010, JST.*
- *We are performing 3-month-On-Orbit-Checkout (OOC) after the launch. Technical and application demonstrations will be started after OOC.*
- *Asia Oceania is the Showcase of New Multi GNSS Era*
  - *Next workshop will be held in 21, 22 Nov 2010 in Melbourne, Australia*

# Our Planet from QZS-1

***Thank you for your attention***

# Backup Sheets

# Political Back ground

# Launch and Next Step

## Back Ground Act; Geo-Spatial Information

- Basic Act on Promotion of Utilization of Geographical Information (AUGI)
  - August 2007, Basic Act on AUGI entered into force
  - April 2008, Basic Plan for AUGI was approved by the Cabinet (based on Article 9 of the Basic Act on AUGI)
    - QZSS is a key element and implemented by phased approach;
      - Phase 1 : First satellite launch and technology and application demonstration
      - Phase 2 : 2nd and 3rd satellite will be launched after assessment of the result of phase 1
- Public-Private-Partnership for Promoting Utilization
  - QZSS project is based on the collaboration between private sector and government

# Organization of 1st satellite Development

- ***JAXA (MEXT):*** *Development of satellite navigation technologies, integration of QZSS navigation system, and development of the first QZSS satellite and satellite control & tracking ground station.*
- ***NICT (MIC):*** *Development of timing control technologies.*
- ***ENRI (MLIT):*** *Development of submeter class GPS Augmentation technologies with L1-SAIF(Submeter-class Augmentation with Integrity Function) signal.*
- ***GSI (MLIT):*** *Development of centimeter or decimeter class GPS Augmentation technologies.*
- ***AIST (METI):*** *Development of precise onboard clock timing control technology.*

# Launch and Next Step

## Back Ground Act; Space

- Aerospace Basic Act
  - May 2008, Aerospace Basic Act was enacted
  - June 2009, Basic Plan for Space Policy was decided by the Strategic Headquarters for Space Policy

    (chaired by the Prime Minister, based on Article 25 of the Aerospace Basic Act)
  - 6 pillars for space activity

    (high QOL, security, diplomacy, advanced R&D, industry and environment)
- Space-based PNT in the Basic Plan for Space Policy
  - Promote highly accurate system such as QZSS and MSAS
  - Create new services in our daily life such as personal navigation systems, with private sector

# Launch and Next Step

# Next Step: 2nd Step

- On 27/AUG, Strategic Headquarter for Space Policy of the cabinet has released their decision on "the near term promotion of space policy".
  - In the decision, the related Ministries have to derive the solution to the 2nd step of QZSS together under the coordination of the cabinet secretary by the early in the next FY2011.
- The QZSS Project Team composed of the Parliamentary Secretary of the main 8 Ministries was established.
  - And on 7/SEP, the PT has started the study how to step into the 2nd step: the 2nd and 3rd satellites.
- On 16/SEP, the Strategic Headquarter released the documents which relates the evidence of the FY2011 budget requirement for the 2nd QZSS study.
- Until the end of OCT, the GNSS Expert Working Group will be also established under the committee of the Strategic Headquarter.

# QZSS Connection

## - Dissemination of the achievement

# QZSS Connection QZ-Vision

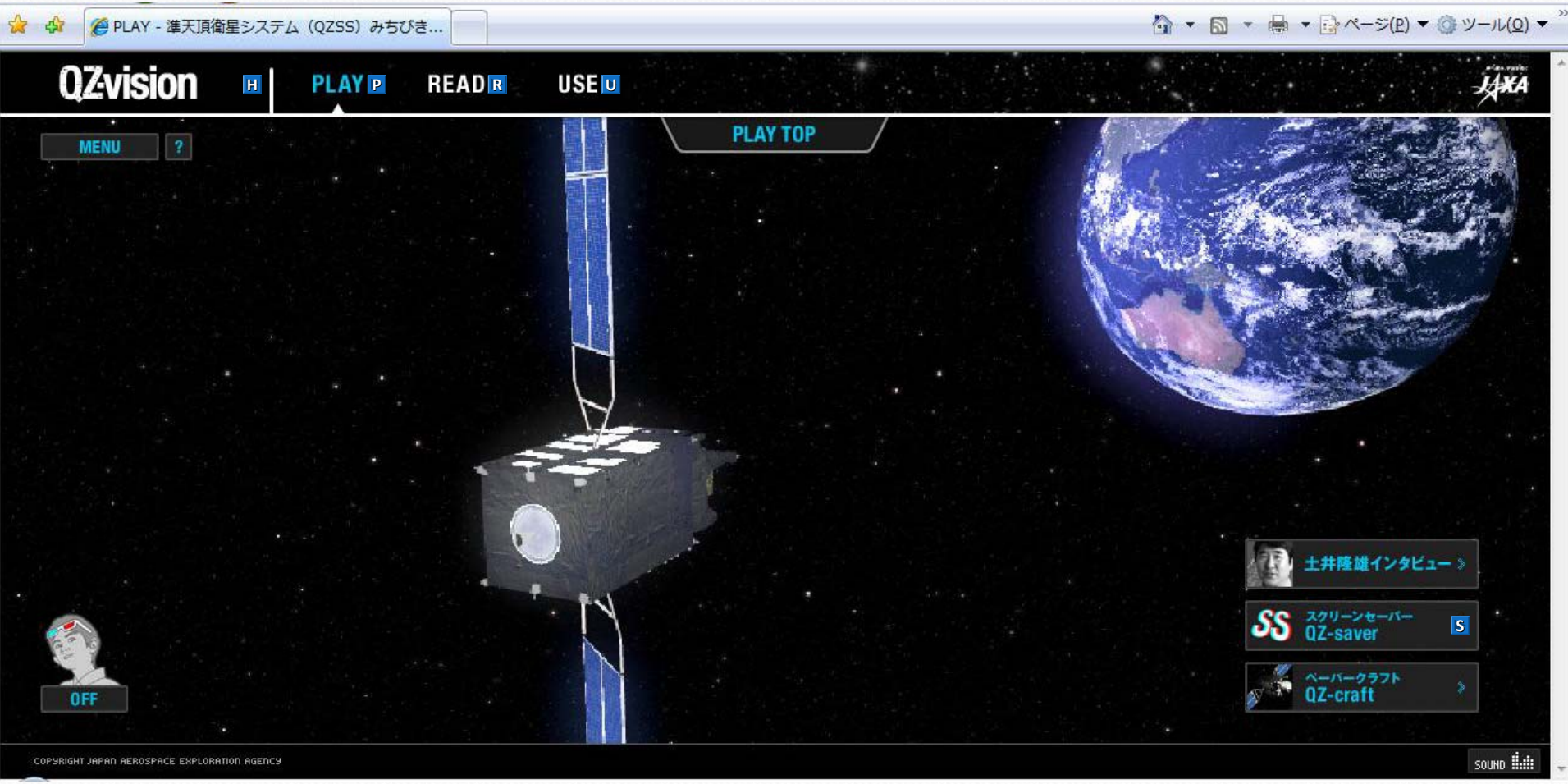
# Connect people to GNSS

http://qz-vision.jaxa.jp/

# QZ-Vision Connects people to GNSS

http://qz-vision.jaxa.jp/

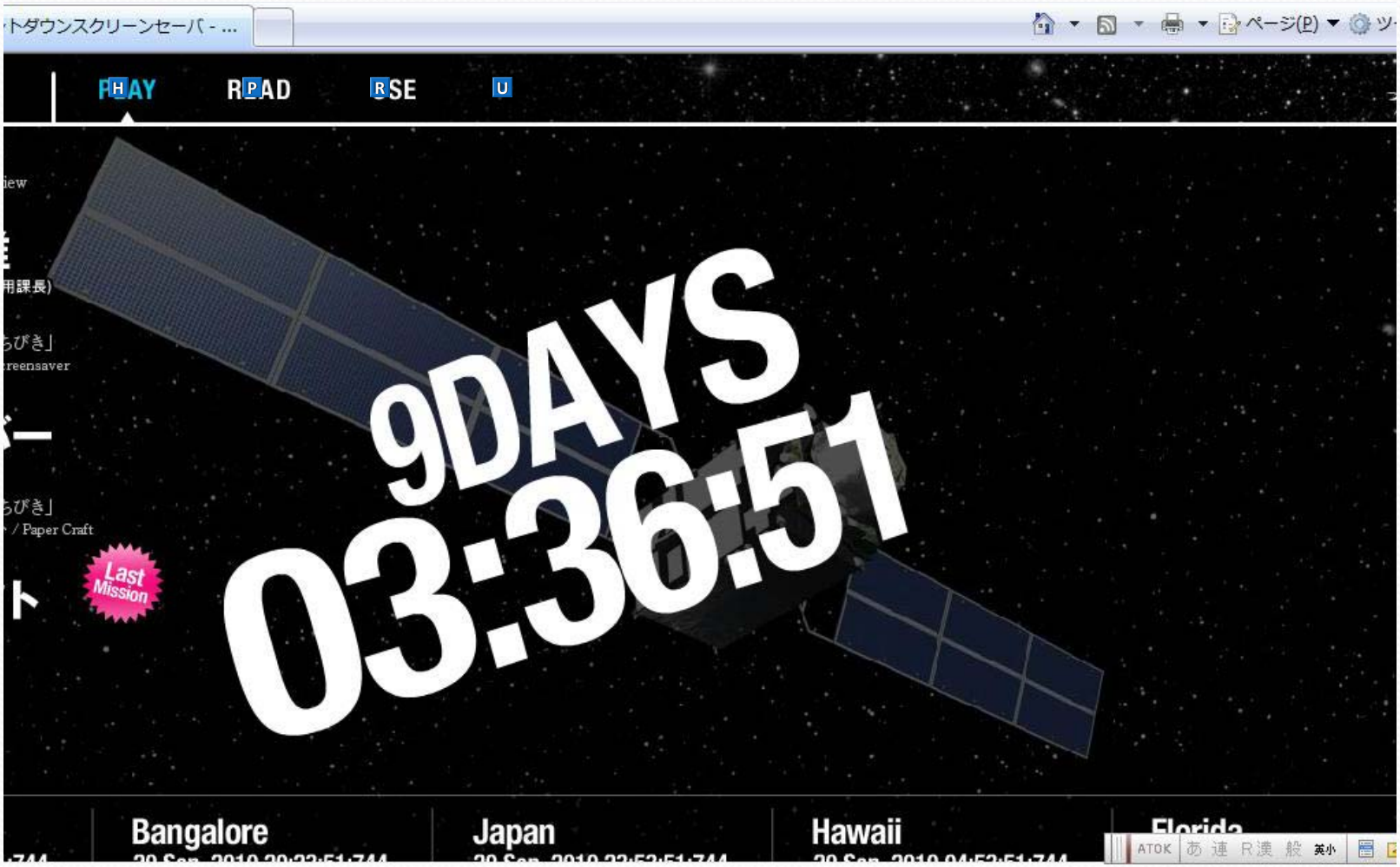
# Children to QZSS



# QZ-Vision Connects people to GNSS

http://qz-vision.jaxa.jp/

# PC to QZSS



# QZ-Vision Connects people to GNSS

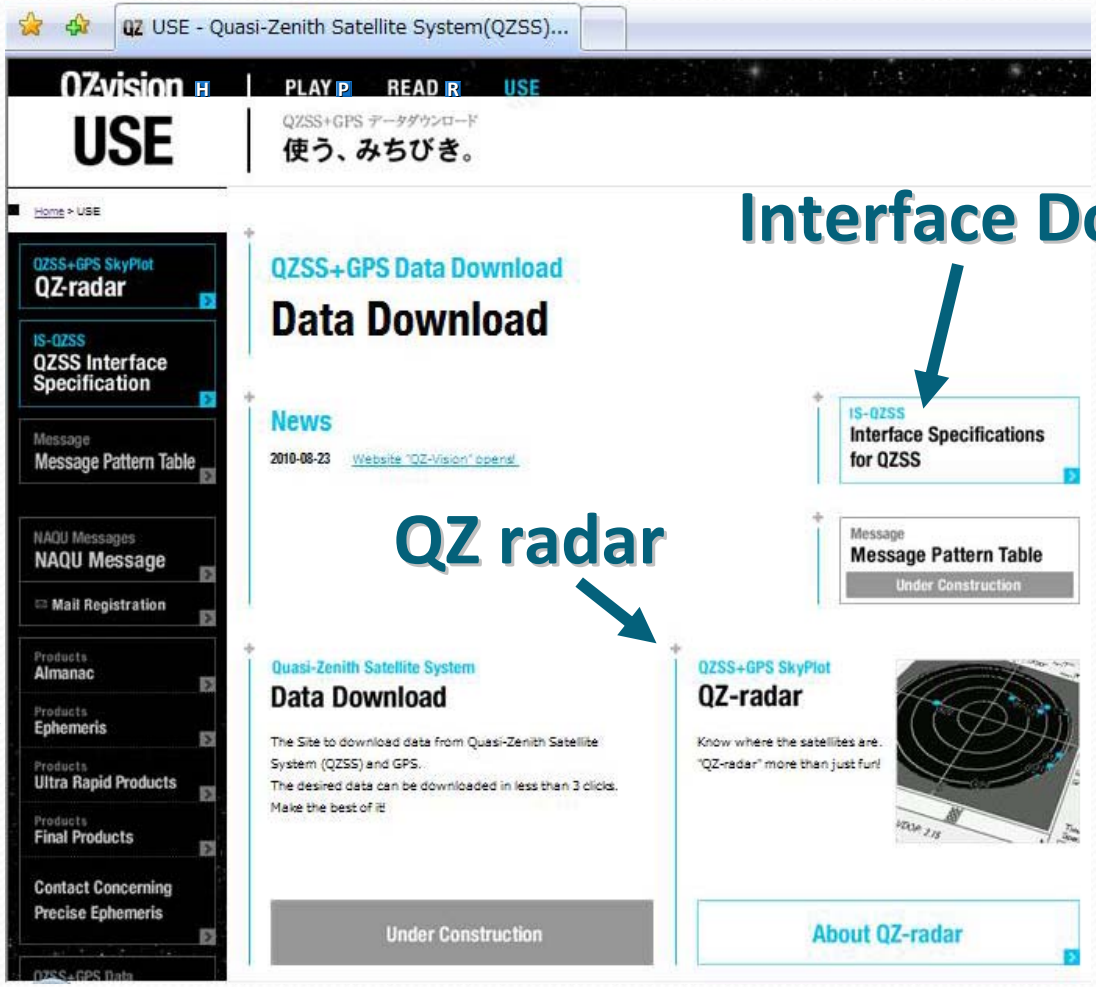
http://qz-vision.jaxa.jp/

# Smart Phone to QZSS

# QZ-Vision Connects people to GNSS

http://qz-vision.jaxa.jp/

## Expert to QZSS




Interface Document

Almanac

Ephemeris

Precise Products

QZ radar

# Orbit de-confliction with GSO and re-orbit procedure

# Avoidance of physical interference to GSO & re-orbit after operation

- ***Each satellite orbit has slight eccentricity so that can keep appropriate separation away from GSO. The vector of eccentricity will be maintained this appropriate separation more than 50 km during operation.***
- ***After whole mission life, the satellite will be injected into "Disposal Orbit", which defined as the orbit with 1000 km higher perigee altitude from GSO's.***