United Nations International Meeting on the Applications of Global Navigation Satellite Systems

Presentation Session 1: Policies and strategies for promoting sustainable development

Quasi-Zenith Satellite System

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Contents

- *Outline of the QZSS*
- *Launch and Demonstration results*
- *Promotion of QZSS Project*
- *Summary*

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.*

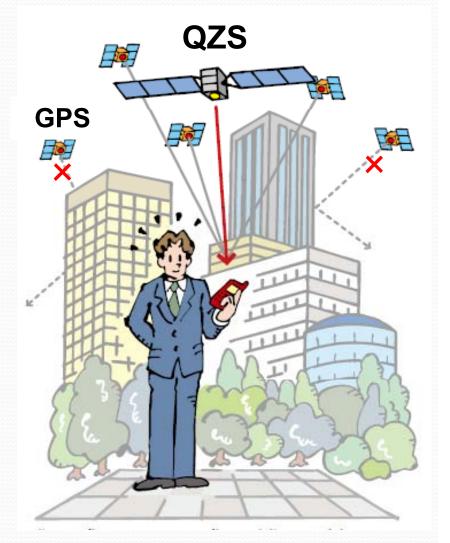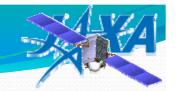- *First satellite: launched in September 2010.*

GPS Complementary

QZSS improves positioning availability time

Complementary signals sent from high elevation will improve the time percentage of positioning availability from 90 % (GPS only) to 99.8 % * (GPS + QZSS.)

* The time percentage that the position dilution of precision (PDOP) is less than 6 when a satellite whose elevation angle is 20 degrees or over is used for positioning calculation.

QZS

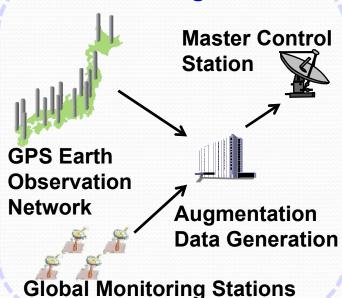**GPS**

GPS Reinforcement
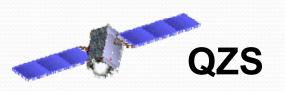
QZSS improves positioning accuracy

QZSS upgrades the positioning accuracy to a sub-meter or several centimeter level.

Augmentation Data
- **Acquisition Support Data**
- **Correction Data**
- **Integrity Data**

Navigation Signal

GPS   Galileo   GLONASS

QZS

Ground Segment

Master Control Station

GPS Earth Observation Network

Augmentation Data Generation

Global Monitoring Stations

Navigation Signal and Augmentation Data

L1-SAIF (250 bps)
LEX   (2000 bps)

User Segment
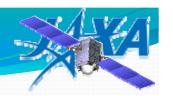
LEX   L1-SAIF
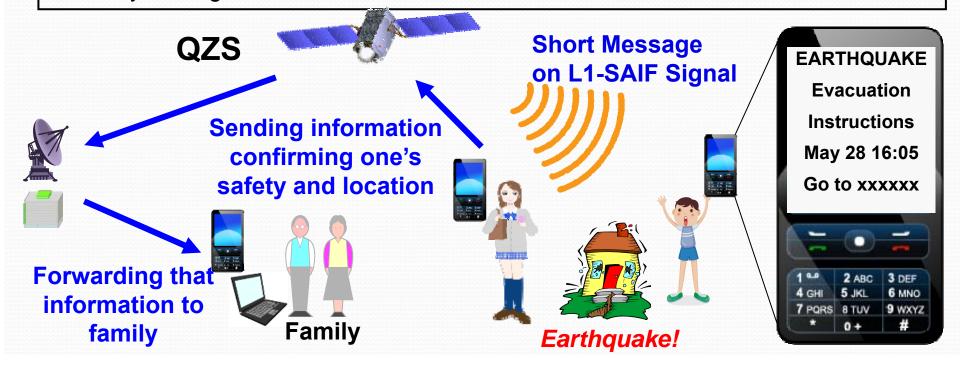centimeter   (accuracy)   sub-meter

QZSS Functional Capability 3

Short Message and Collection of Information

QZSS can <u>send short messages and gather information</u>
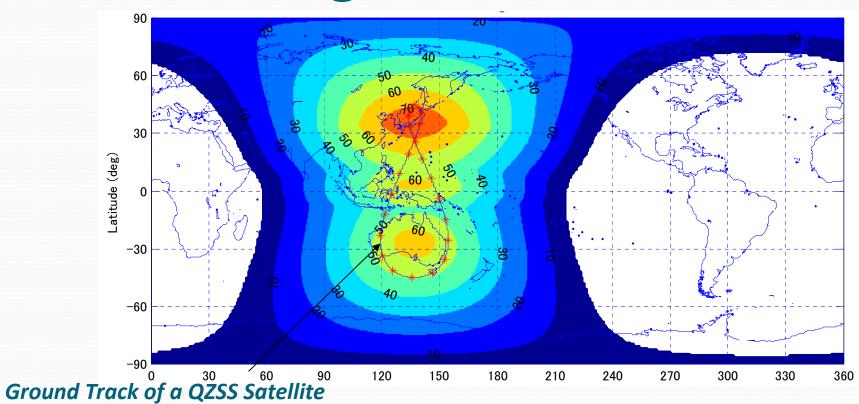
- QZSS can send short messages such as emergency warnings simultaneously to everyone with a mobile phone.

- We are planning to equip the future QZSS satellites with an information gathering function which will enable people to send information confirming their safety during a crisis or disaster.

QZS

Short Message on L1-SAIF Signal

EARTHQUAKE

Evacuation

Instructions

May 28 16:05

Go to xxxxxx

Sending information confirming one's safety and location

Forwarding that information to family

Family

Earthquake!

QZSS Outline
the Coverage and 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 Outline
QZSS Signals

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

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

QZSS Outline
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 Outline

Accuracy

- **The Signal-in-Space (SIS) User Range Error**
  - *is less than **2.6 m (95%)** including time and coordinate 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 w/o time & coordinate offset	**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.**

Current Status

- *The first satellite, "MICHIBIKI", was launched on 11 September, 2010.*

- *Following to 3 months On-Orbit Checkout phase, the technical verifications and application demonstrations have been conducted since December 2010.*

- *The accuracy of broadcasting ephemeris and clock parameters, i.e. SIS-URE met its specification value by June 2011.*

- *After confirmation of the stability to provide specified performance in IS-QZSS, L1 C/A and L2C signals were set healthy on 22 June and L5 and L1C signals were set healthy on 14 July, 2011.*

Lift off and Separation from Launch Vehicle

Sep.11 2010 at 20:17 (JST)
Lift-Off @JAXA TNSC

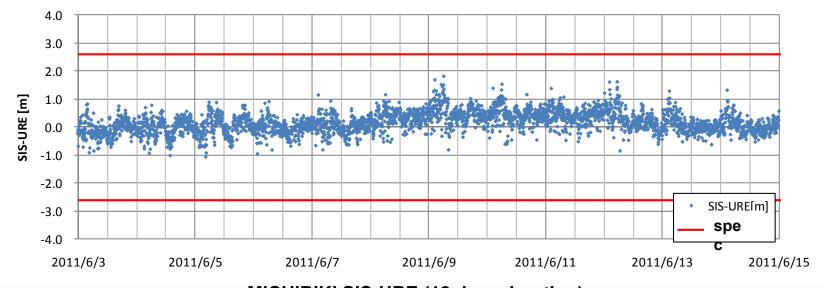at 20:45 (JST)
Separation from H-IIA

Accuracy (SIS-URE)

SIS-URE in the IS-QZSS (Interface Specification of QZSS) is +/- 2.6m (95%). We confirmed that the stability of MICHIBIKI SIS-URE using 12 days duration, and the time percentage in spec is 100%.
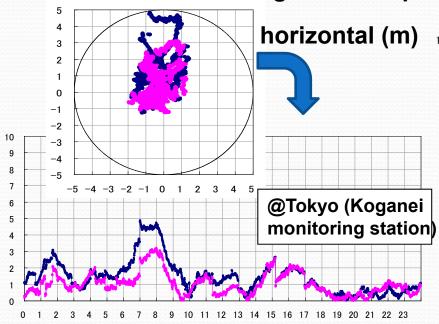

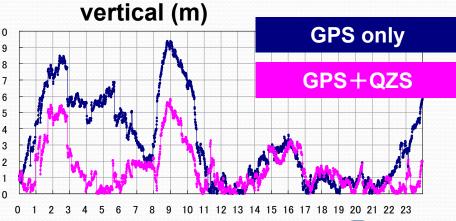MICHIBIKI SIS-URE (12 days duration)

After MICHIBIKI performance including accuracy, integrity and availability met the IS-QZSS, <u>the L1-C/A and L2C signals were set healthy from June 22th</u>. L5 and L1C signals were also set healthy from July 14h.

Accuracy (Combination of GPS + QZS)

We confirmed the accuracy of the combination of GPS+QZS improves because of DOP and good ionospheric correction parameters from MICHIBIKI.

horizontal (m)

vertical (m)

GPS only

GPS＋QZS

@Tokyo (Koganei monitoring station)

Improvement

Evaluation conditions
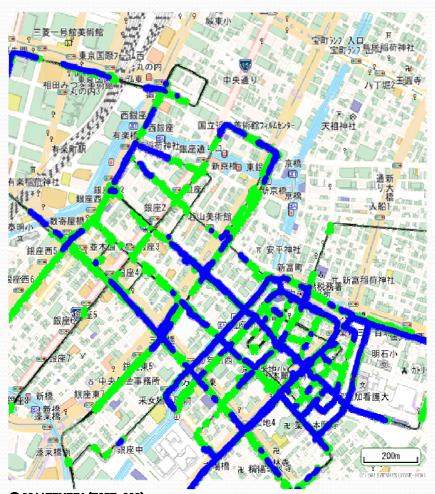
- point: Tokyo (Koganei Monitoring Station)
- date: 2011/06/03 00:00:00-23:59:30(GPST)
- mask elevation angle: 10 degrees
- ionospheric correction
  GPS only : using the parameters from GPS
  GPS+QZS : using the parameters from QZS

Positioning accuracy (m)		GPS only	GPS+QZS
Horizontal	Average	1.451	1.027
	RMS	1.773	1.232
	Max	4.885	3.209
Vertical	Average	3.204	1.540
	RMS	4.122	2.080
	Max	9.388	5.828

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— Reference trajectory (measured by MMS)
● Positioning result for GPS standalone use
● Positioning result for GPS+QZSS combining use

Date of Observation: 2011/2/19
250 minutes driving observation data during 6:00-12:30 obtained under JAXA-Melco joint research experiment

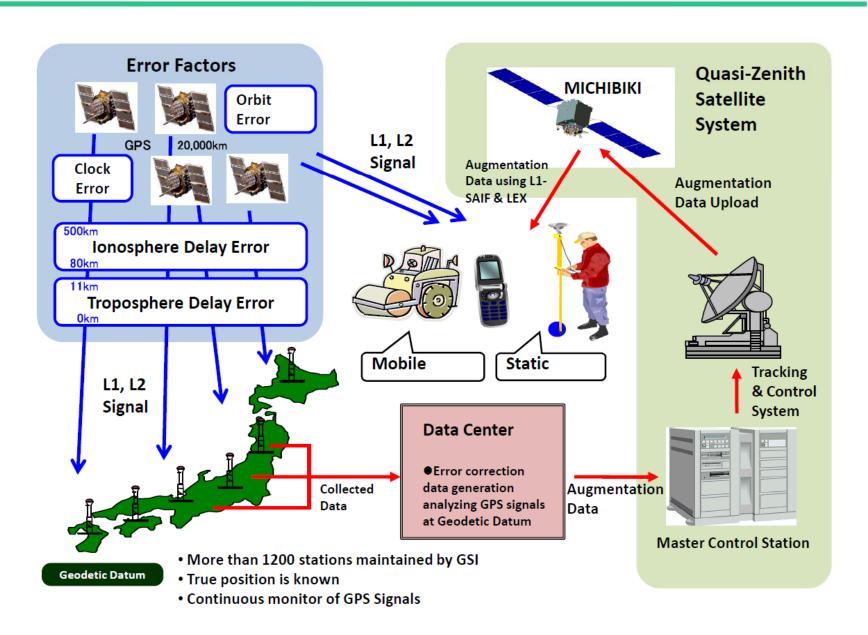**Single Frequency DGPS positioning Availability**

GPS : 39.5%

GPS+QZSS : 69.1%
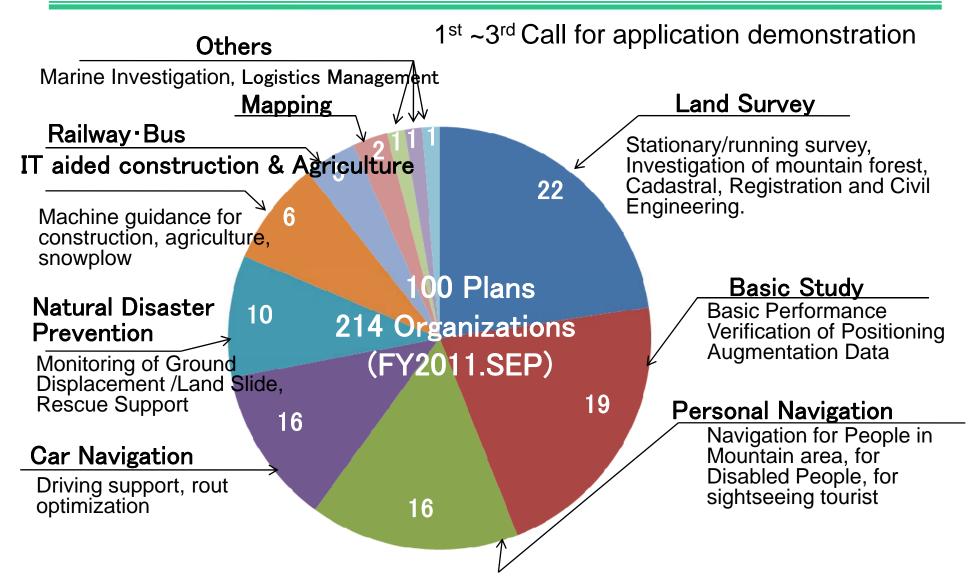
Augmentation System using QZSS

Application Demonstrations by Private Sector

1st ~3rd Call for application demonstration

Others
Marine Investigation, Logistics Management

Mapping

Railway・Bus

IT aided construction & Agriculture
Machine guidance for construction, agriculture, snowplow

Natural Disaster Prevention
Monitoring of Ground Displacement /Land Slide, Rescue Support

Car Navigation
Driving support, rout optimization

Land Survey
Stationary/running survey, Investigation of mountain forest, Cadastral, Registration and Civil Engineering.

Basic Study
Basic Performance Verification of Positioning Augmentation Data

Personal Navigation
Navigation for People in Mountain area, for Disabled People, for sightseeing tourist

100 Plans
214 Organizations
(FY2011.SEP)

22   19   16   16   10   6   3   2   1   1   1   1

16

L1-SAIF Application :Personal Navigation

Car navigation

Identified place
& Historical site

Restaurant

Public
accommodation

Movie theater

List of contents

Mobile Mapping &IT Aided Precise Farming Operation Demonstration (Feb.7-9 @ NIRE)

Mobile Mapping

Precise Farming

IT Aided Construction Demonstration (Feb.7-9 @ JCMA)

After bladed

Promotion of QZSS Project

< **Basic policy on the implementation of the operational QZSS project** >

approved at the Cabinet meeting on September 30, 2011.

The QZSS will contribute to

- **Welfare of the Asia-Pacific region**

- **Broad range of security including the improvement the capacity to respond to natural disasters**

Promotion of QZSS Project

< *Basic policy on the implementation of the operational QZSS project* >

approved at the Cabinet meeting on September 30, 2011.

- **GOJ has decided to accelerate the deployment of the operational QZSS** as expeditiously as possible.

- **Four satellites** constellation shall be established **by the late 2010s.**

- **In the future, seven satellites constellation** shall be completed to enable sustainable positioning.

Promotion of QZSS Project

< Basic policy on the implementation of the operational QZSS project >

approved at the Cabinet meeting on September 30, 2011.

- *The Cabinet Office shall develop, deploy and operate the operational QZSS, based on the achievement of the first QZSS satellite (named "Michibiki"), and shall submit a budget request to cover relevant cost.*

- *Legal amendments shall be made in order for the Cabinet Office to fulfill such a role in time for budget implementation.*

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.*

- *Technical verification results show the improvement of GPS + QZSS performance as expected.*

- *The accuracy of broadcasting orbit and clock parameters met specifications defined in the IS-QZSS and all GPS interoperable signals have been set healthy.*

- *GOJ has decided to accelerate the deployment of the operational QZSS as expeditiously as possible. Four satellites constellation shall be established by the late 2010s. In the future, seven satellites constellation shall be completed to enable sustainable positioning.*

Our Planet from QZS-1 'MICHIBIKI'

Thank you for your attention

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