Status Update on the Quasi-Zenith Satellite System

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National Space Policy Secretariat (NSPS)
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ICG-11@Sochi, Russian Federation
Acknowledgment

• Slides in this presentation were provided by Mr. Yoshiyuki Murai, QSS (Quasi-Zenith Satellite System Service Inc.) with some modifications.
1. Project/System Overview and Program Status

2. Mission of the QZSS

3. Recent Demonstration results of the QZSS

4. The QZSS Expansion Activities for Asia–Oceania Countries

5. Summary
1. System Overview

Functional Capability:
- GPS Complementary
- GNSS Augmentation
- Messaging Service

Coverage: Asia and Pacific region

Signals (QZS-1):
- L1C/A, L1C, L2C and L5
- L1S (L1-SAIF) on 1575.42 MHz
- L6 (LEX) on 1278.75 MHz
- L1Sb will be added as SBAS from 2020’s

(Today) 1st QZSS satellite “MICHIBIKI”

Four satellites constellation will be established and the service will start in 2018.
The contract for QZSS Satellites procurement has been concluded between Cabinet Office and MELCO.
Not only MICHIBIKI, 3 other satellites are also able to substitute anytime.

Ground System always maintains these 4 satellites (3 QZSS orbit, and 1 geostationary orbit) as 1 component.

PFI project

SBAS project

SBAS Signal Generator facility
QZSS Satellite(s) Overview

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

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

RAAN: Right Ascension of the Ascending Node
QZSS Satellite(s) Overview

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

<table>
<thead>
<tr>
<th>Orbit Parameter</th>
<th>Nominal Allocation</th>
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<tbody>
<tr>
<td>Longitude</td>
<td>E 127</td>
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<td>Latitude</td>
<td>0</td>
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</table>
Two-Ground Station (Control Center) will be available in the end of 2016.

Initial Operation will be started from 2018.
QZSS TTC & Monitor Station

- All of TTC monitor stations will be founded by the end of 2016.
- Initial Operation will be started from 2018.
1. QZSS Overview

Functional Capability:
- GPS Complementary
- GNSS Augmentation
- Messaging Service

Coverage: Asia and Pacific region

Japan Region
- Over 20 degrees elevation
  More than 2 QZS are available
- Over 60 degrees elevation
  1 QZS is available

Four satellites constellation will be established and the service will start in 2018.
QZSS Visibility Time

Ref. : IS−QZSS v1.7, JAXA, 7 Jul. 2016
Positioning Signal of QZSS (as of Nov. 2016)

Not only positioning complementation signal, but satellite orbit, time, and ionosphere correction information will be also transmitted as augment information.

<table>
<thead>
<tr>
<th>L1C/A</th>
<th>1575.42 MHz</th>
<th>Positioning</th>
<th>complement GPS</th>
<th>1st Satellite</th>
<th>2nd–4th Satellite</th>
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<tbody>
<tr>
<td>L1C</td>
<td>1575.42 MHz</td>
<td>Positioning</td>
<td>complement GPS</td>
<td>○</td>
<td>○</td>
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<tr>
<td>L1S</td>
<td>1575.42 MHz</td>
<td>Augmentation (SLAS)</td>
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<tr>
<td>L2C</td>
<td>1227.60 MHz</td>
<td>Positioning</td>
<td>complement GPS</td>
<td>○</td>
<td>○</td>
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<tr>
<td>L5</td>
<td>1176.45 MHz</td>
<td>Positioning</td>
<td>complement GPS</td>
<td>○</td>
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<tr>
<td>L5S</td>
<td>1176.45 MHz</td>
<td>Augmentation Experimental Use</td>
<td>○</td>
<td>○</td>
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<tr>
<td>L6</td>
<td>1278.75 MHz</td>
<td>Augmentation (CLAS)</td>
<td>○</td>
<td>○</td>
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<tr>
<td>L1Sb</td>
<td>1575.42 MHz</td>
<td>Augmentation</td>
<td>SBAS</td>
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</table>

SBAS Service will be available from the beginning of 2020’s.
### QZSS Program Schedule (Update)

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<tbody>
<tr>
<td><strong>1st Michibiki</strong></td>
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<td>Post-Michibiki</td>
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<td>In-Operation</td>
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<td><strong>Launch (Prospect)</strong></td>
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<td><strong>QZSS 4-Sat. Constellation</strong></td>
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<td>Launch No.2,3,4(Estimate)</td>
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<tr>
<td>SBAS Service</td>
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<td>Development / Design (Additional 3 Sats.)</td>
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<tr>
<td><strong>QZSS 7-Sat. Constellation</strong></td>
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SBAS Service will be available from 2020’s under Ministry of Land, Infrastructure, Transport and Tourism jurisdiction.
2. Mission of the QZSS
2. Mission of QZSS

QZSS provides positioning-related service and messaging service.

**Positioning-related service**

1. **Satellite Positioning Service**
   The service to provide the same as GPS satellites in spite of urban area or mountain area.

2. **Sub-meter Level Augmentation Service**
   The service to provide accurate positioning around 2-3 meters. (※)

3. **Centimeter Level Augmentation Service**
   The service to provide highly accurate positioning around 10 centimeters. (※)
   ※ Ionosphere disturbance (fluctuations), multipath and others will affect the accuracy.

4. **Positioning Technology Verification Service**
   The service to provide an application demonstration for new positioning technology.

**Messaging Service**

5. **Satellite Report for Disaster and Crisis Management (DC Report)**
   The service to provide users in the field with disaster management and rescue.

2, 3, 5: These services are under investigation for overseas users.
# 2. Mission of QZSS

Performance Standard (PS-QZSS) and Interface Specification (IS-QZSS) will be released in the website [http://qzss.go.jp/en/technical/ps-is-qzss/ps-is-qzss.html](http://qzss.go.jp/en/technical/ps-is-qzss/ps-is-qzss.html)

<table>
<thead>
<tr>
<th></th>
<th>Performance Standard</th>
<th>Interface Specification</th>
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<tbody>
<tr>
<td>Sub-meter Level Augmentation Service (SIAS) / Satellite Report for Disaster and Crisis Management (DC Report)</td>
<td></td>
<td>IS-QZSS-L1S-001 (in preparation)</td>
</tr>
<tr>
<td>Centimeter Level Augmentation Service (CLAS)</td>
<td></td>
<td>IS-QZSS-L6-001 (Draft, July 12, 2016 / PDF: 1,389KB)</td>
</tr>
<tr>
<td>Positioning Technology Verification Service</td>
<td></td>
<td>IS-QZSS-TV-001 (Draft, July 12, 2016 / PDF: 637KB)</td>
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</table>
3. Recent Demonstration results of the QZSS
Since June, 2011, QZSS have provided navigation signals with good qualities, satisfying with their performance specifications, continuously.

SIS-URE for the first satellite is 40cm (rms) level which is comparable with those for GPS Block IIRm and IIF satellite.

During one month in June 2016, 33cm (RMS)
Demonstration 2: Dual-Frequency Positioning

- Verify the validity of the ionosphere correction by dual-frequency positioning

- RNSS (Radio Navigation Satellite System): QZSS, GPS, GLONASS
  - GPS (IIF(M), IIF) / QZSS (L1 + L2, L1+L5 in the future)
  - GLONASS (L1 + L2)

- Demonstration Area
  - Japan: OKINAWA (GPS and QZSS)
  - Asia: MANILA, Philippine (GPS/QZSS, GLONASS)
Demonstration of Dual-Frequency Positioning in Philippine

- Verify the validity of the ionosphere correction by dual-frequency positioning
- Experimental Spot (Place): Reference station at Philippine University
- GNSS: QZSS + GPS (L1 + L2), GLONASS (L1+L2)
- Date: 19th Feb., 2016, 10:56 ~ 11:47

Center Point: Philippine University (Diliman)
Demonstration of Dual-Frequency Positioning in Philippine
4. The QZSS Expansion Activities for Asia–Oceania Countries
QZSS Expansion Activities

**QZSS Round Table**  
(2014.12.1)

**MGA/AOR Workshop**  
(2016.11.14–16)

**8th Multi-GNSS Asia (MGA) Conference**  
PROVIDING THE SOLUTIONS USING MULTI-GNSS AND OTHER SPACE TECHNOLOGY APPLICATIONS IN THE ASIA-PACIFIC REGION  
14 November - 16 November 2016  
Sofitel Philippine Plaza Manila,  
Metro Manila, Philippines

We are pleased to announce that the 8th Multi-GNSS Asia Conference will be held on 14th-16th November 2016 in the Sofitel Philippine Plaza Manila (Metro Manila), Philippines.

**QZSS Utilization Workshop**  
In Thailand  
January 22nd, 2016  
Friday  
at Chulalongkorn University  
Faculty of Engineering  
(100 Years Memorial Buildings)

**QZSS Utilization Workshop**  
(2016.1.22)
QZSS Expansion Activities (in Asian Countries)

Preparation of GNSS reference station (Development of satellite positioning and experiment environment)

Chulalongkorn Univ (Bangkok)  Univ. of Philippine (Diliman)  Indonesia Univ. (Jakarta)

Joint Experiment, Demonstration

QZSS Positioning in Urban City (Hanoi/Vietnam)

Bus Driving (Quezon/Philippine)

Management of orchards fused with remote sensing technology (AIT/PASCO)
Space New Economy NETwork (S-NET)

- Created a new network which enables any entities that have interests in utilizing and developing the space to interact with each other.
- The network involves the value-chain, such as start-ups, business ventures and SMEs that wish to utilize the space as potential business tools.
- Executive office is located at National Space Policy Secretariat, Cabinet Office. It will soon function as coordinators and facilitators in collaboration with related Ministries and participants.
- S-NET welcomes International partners regarding space business.
New economic growth utilizing space infrastructure  
- Fusion of space infrastructure, big data and IoT -

**Automatic Operation of Farm Equipments**
Automated Operation of Farm Equipment and Sophisticated Production Management, utilizing space asset, will be introduced to inefficient large-scale farm, in order to improve self-sufficiency in food and to resolve the shortage of farm operators.  
*Source: YAMAHA*

**Precision Forestry**
Precision Forestry will be expanded widely throughout Japan and overseas, combining cloud services with automatic forest assessments and production management skills.  
*Source: khara, Inc.*

**Logistics**
A reciprocal unmanned freight transport system will be implemented between the main islands and remote ones.  
*Source: YAMAHA*

**Delivery**
The delivery service will be capable of making deliveries to non-fixed address, such as locations inside of a park.  
*Source: MHLW*

**Disaster Prevention**
Disaster information will be provided by a built-in electronic message board for vending machines, utilizing Satellite Reports for Disaster and Crisis Management. In addition, beverages will be offered free of charge through vending machines in the case of a disaster.  
*Source: MHLW*

**Sightseeing**
Pilgrimages to tourist hotspots peculiar to Japanese Animation is recently on the rise. That is why, a system will be expanded, in which animation fans will be able to take pictures with a certain character using augmented reality when they go to the particular locations, and obtain limited goods.  
*Source: khara, Inc.*

**Watching service for elderly person and kids**
An environment, which relatives watch their elderly Parents or children at any time of night or day, will be provided by the fusion of QZS high-accuracy positioning technology and geospatial information.  
*Source: MHLW*

**Society's infrastructure**
The operation and maintenance services for society's infrastructure including bridges and expressways will be provided by utilizing QZS high-accuracy positioning technology.  

**Railway**
QZSS will be applied to operation support systems, security systems, such as car-body tilting and radio-based train controls, through high-accuracy positioning technology in the railway sector.  
*Source: Mitsubishi Electric Corporation*

**Intelligent Transport System (ITS)**
Vehicle stability control, like lane keeping and changing, will be possible thanks to QZS high-accuracy positioning information.  
*Source: denso*

**Electronic Toll Collection (ETC)**
A road pricing system, based on the accurate positioning information from QZSS, will be established in order to achieve a free-flow gateless system.  

**Sophistication of MAP**
- From Conventional 2D map to 3D spatial map -
Based on the decision of the GOJ, the deployment of the operational QZSS is underway.

- 4 satellites constellation shall be established by the 2018JFY.
- Necessary equipment (satellite, ground station and others) are currently in development.
- GOJ has decided to expand the QZSS to 7-satellite constellation around 2023.

Verification, assessment and many demonstrations of the QZSS have been conducted.

- Dual frequency positioning will be effective in the dense area of Total Electron Content, namely equatorial region.
- S-Net initiative has been launched. It is an effort to promote space technologies such as Satnav and Remote-sensing into wide variety of applications.
Thank you for your attention.

For more information, please visit our web site http://qzss.go.jp/en/
- A large circle illustrated “Q” as Quasi-Zenith Satellite System
- Green and blue circle composes 8 shapes; the coverage area of QZSS and they are represented earth and satellite.
- Blue line symbolized precise positioning information as well as enlargement of brand new service to society.
- Color of green stands for environment and safety, and blue stands for space and technology.