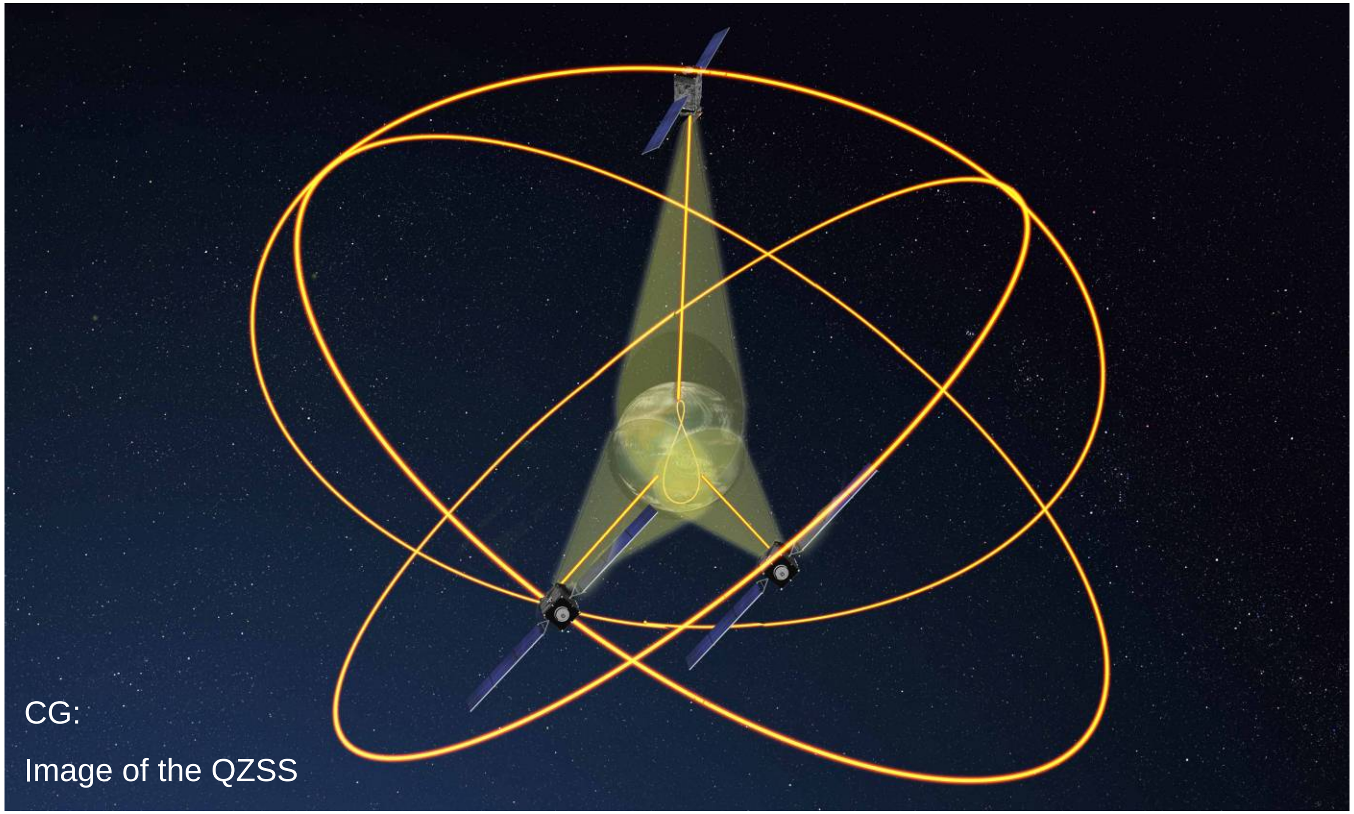
Precisely know your location anywhere, anytime.

Quasi-Zenith Satellite System (QZSS)
First Quasi-Zenith Satellite System 'MICHIBIKI'

Quasi-Zenith Satellite System Project Team
Space Application Mission Directorate
Japan Aerospace Exploration Agency

Purpose of the Quasi-Zenith Satellite System (QZSS)

The QZSS aims to deploy three satellites on orbit so as to always have one flying near the zenith over Japan. By doing so, the system can provide a highly accurate satellite positioning service covering close to 100% of Japan even in urban canyons and mountainous areas.



CG:

Image of the QZSS

Background of the QZSS Development
- Positioning System in Other Countries-

The satellite positioning system has been developed or is planned to be deployed in many space-developed countries due to its importance and future potential

<u>U.S.A: GPS (under operation)</u>
(Global Positioning System)

System structure:
6 orbit planes x 4 satellites on each plane = 24 satellites in total (As of July 2010, 30 satellites are under operation.)

<u>Europe: Galileo (under testing)</u>

System structure:
3 orbit planes x 10 satellites on each plane = 30 satellites
(The first test satellite was launched in Dec. '05, then the second one in April' 08. The whole system will be completed sometime between 2016 and 19.)

<u>Russia: GLONASS (under operation)</u>
(Global Navigation Satellite System)

System structure:
3 orbit planes x 8 satellites on each plane = 24 satellites (As of July' 10, 21 satellites are under opera

<u>China: COMPASS (partially under operation)</u>
(Compass Navigation Satellite System)

System structure:
5 geostationary satellites and 30 mid- to high-altitude satellites
(Since the launch of the first satellite in Oct. '00, four test satellites have been launched. Four second generation satellites have also been launched since April' 07. The whole system will be constructed by 2020.)

<u>INDIA: IRNSS (under development)</u>
(Indian Regional Navigation Satellite System)

System structure:
3 geostationary satellites and 4 geosynchronous orbit satellites
(The first satellite is scheduled to be launched in 2011, and the whole system will be structured by 2014.)

Background of the QZSS Development
- Challenges of the current positioning system -

- **Impact of obstacles**
  - For positioning (3D-positioning,) four or more positioning satellites are necessary. However, Japan's terrain is mountainous, and cities are crowded with high rises. As the number of satellites that have a clear view decreases due to these obstacles, the time percentage of positioning availability is decreased, and positioning accuracy is also deteriorated (deterioration of satellite deployment.)
- **Issue of positioning accuracy**
  - When information is received from the GPS and processed, the ionosphere, water vapor in the atmosphere, multipath, reflection by buildings and trees, and other factors cause an error. Therefore, the current positioning accuracy is about 10 meters. As the area of positioning service application is getting broader, more and more accurate positioning is called for.

Background of the QZSS Development
- Cooperative relations with American GPS -

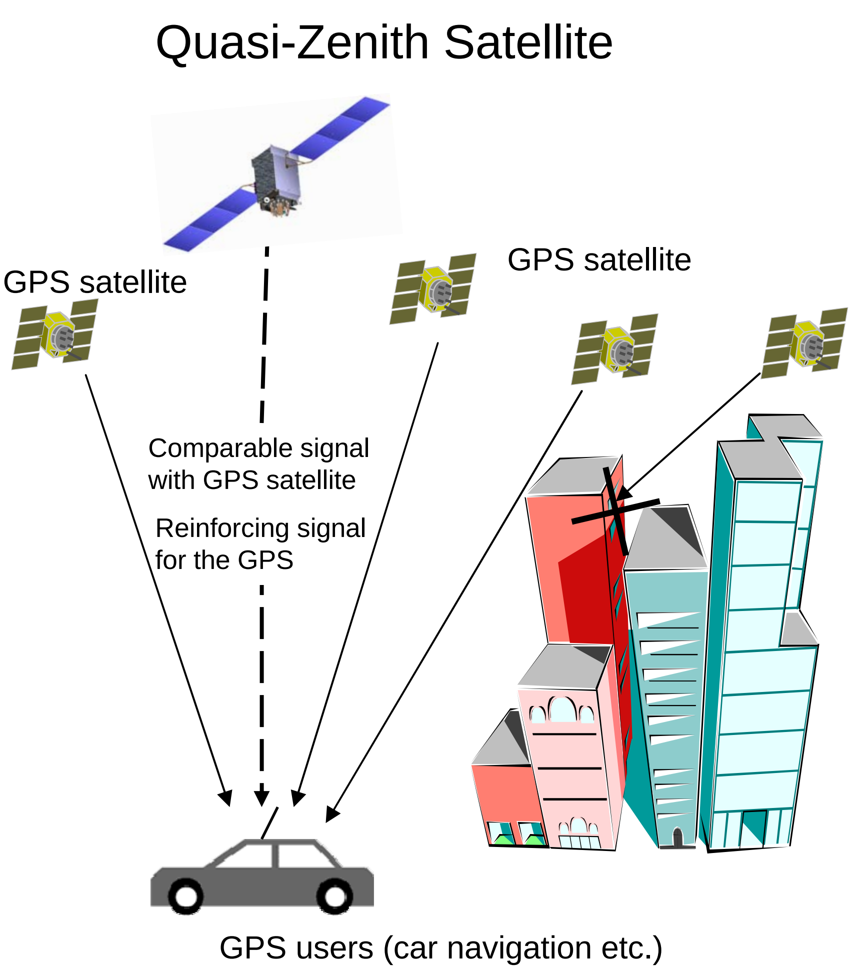
- September 1998: "Joint Statement by the Government of the United States of America and the Government of Japan on Cooperation in the Use of the Global Positioning System" (Prime Minister Obuchi – President Clinton joint announcement)
  - The two governments decided to hold an annual Japan-U.S. GPS Plenary Meeting to discuss important issues concerning GPS use.
- At the Meeting in Oct. 2002, the two governments agreed to set up a Technical Working Group (TWG) to coordinate technical issues between the QZSS and the GPS.
- To date, the following have been agreed to at the TWG.
  - Compatibility: the two systems shall be operated without causing any harmful radio wave interference.
  - Interoperability: both systems must be able to receive each others' positioning signals by the same antenna and receiving circuit

Role of the QZSS

"GPS Complementary"
To increase the time and area of positioning service availability with the GPS by transmitting GPS compatible signals

"GPS Reinforcement"
To improve positioning accuracy and reliability by transmitting information on GPS signal errors received at a reference point and on GPS signal use feasibility.

"Acquisition of the Next Generation Basic Technology"
To conduct a satellite positioning experiment, and research and development and on-orbit experiments of simulation clock technology using L-band experiment signals (LEX)



Positioning Service Improved by the QZSS

- Improvement of 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 + 3 QZS satellites.)

    * 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.

- Improvement of positioning accuracy
  - Reinforcement signals will upgrade the positioning accuracy to one meter or even a centimeter level
- Improvement of positioning reliability
  - An anomaly of a QZS or GPS satellite will be notified within 20 to 30 seconds.
- Improvement of acquisition time
  - By transmitting acquisition support information, the startup time required for signal acquisition after turning on a receiver will be reduced to about 15 seconds from the current 30 seconds to one minute for the GPS acquisition.

Future Changes Brought by the QZSS

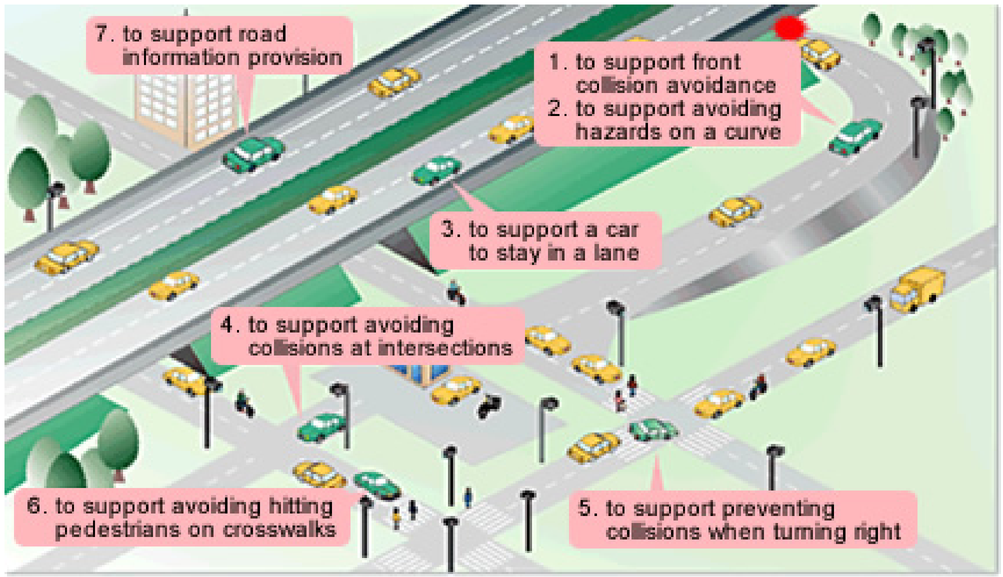
- Contribution to traffic safety: Improving traffic information service -

Also contributing to the environment!

- With the MICHIBIKI, the view area and time of positioning will be expanded. The positioning accuracy will also improve to about one meter by using MICHIBIKI's reinforcement signals (L1-SAIF signals) from the current accuracy of a few meters to a tens of meters only with the GPS.

Through establishing the support service for driving with accurate positioning information, it is possible to "prevent accidents," "avoid traffic jams," and "optimize driving routes."

As a result, gasoline consumption will be reduced, and, ultimately, that is expected to contribute to CO2 emission reductions.



Example of driving support in an urban area using accurate positioning information (Reducing traffic jams by accident prevention) Image by Road Bureau, Ministry of Land Infrastructure, Transport and Tourism

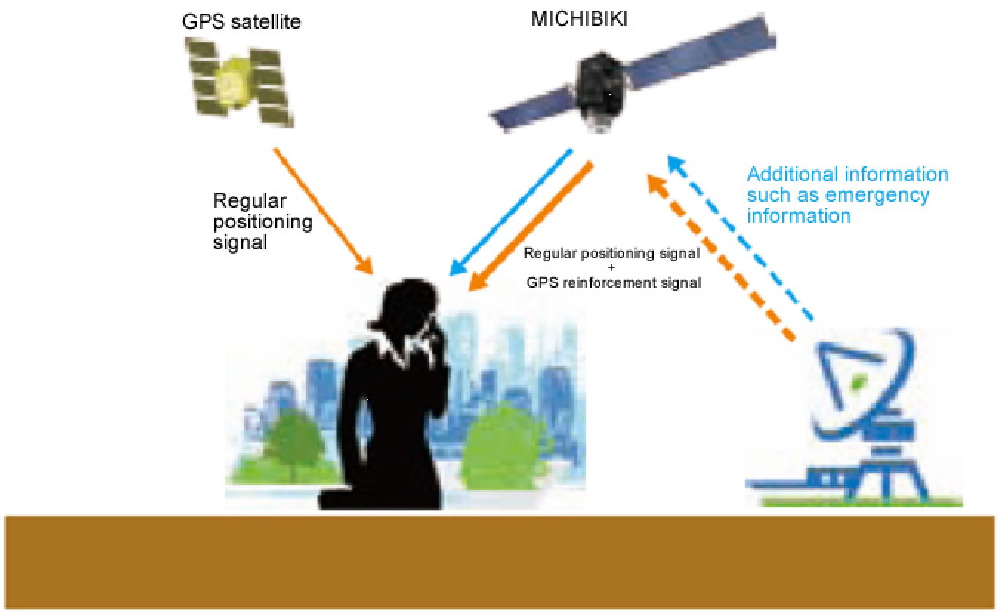
Future Change Brought by the QZSS

- Contribution to disaster prevention: Providing emergency information in case of emergency –

- Acquiring accurate information at the time of a large scale disaster is extremely important to understand the damage and situation and to prevent secondary disaster
- With the GPS only, we can learn only location and time, but the MICHIBIKI enables us to add emergency information such as disaster information to positioning signals and reinforcement signals, and transmit such signals with additional information to all at once.

Emergency information can be received by mobile phones that are compatible with the GPS/MICHIBIKI; therefore, it is very effective to transmit disaster prevention information especially in Asia and Oceania, where mobile phones have permeated.

Image of emergency information transmission using the MICHIBIKI

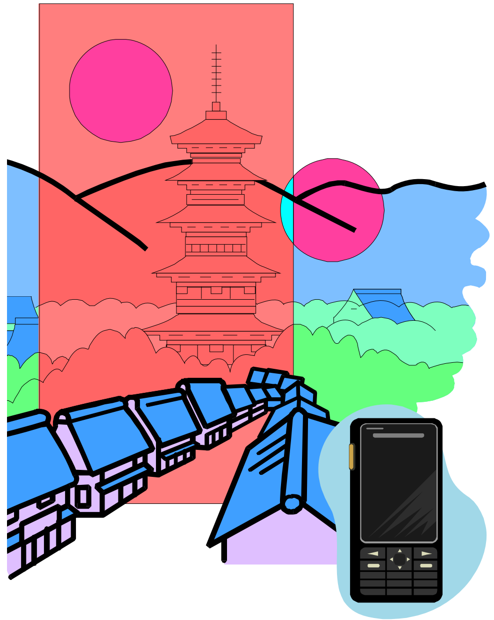


空へ挑み、宇宙を拓く

Future Change Brought by the QZSS

- Application to leisure: Expanding applicable areas -

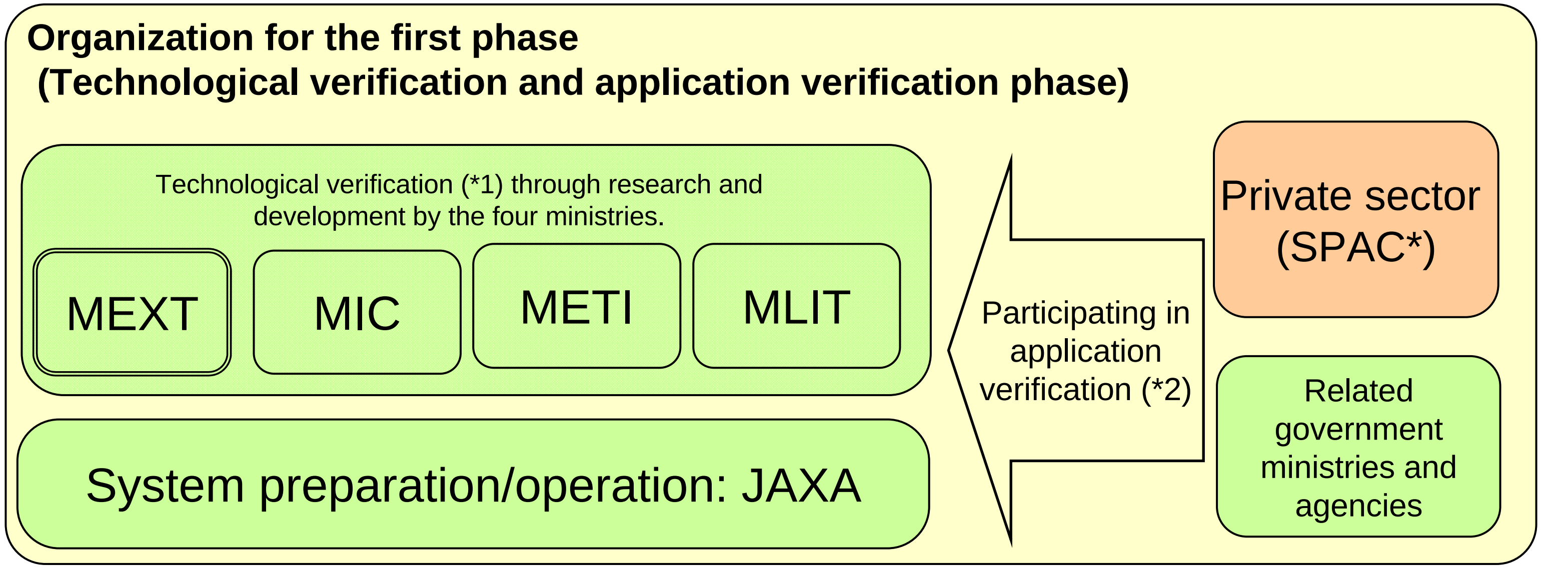
- Sightseeing service using GPS function on mobile phones
  - Tourists can look around places of interest efficiently in a limited time, while sightseeing spots also benefit from more visitors, and, ultimately, that invigorates the local economy.
  - With only the GPS, radio waves may not reach mountainous areas and urban canyons. As a positioning satellite will always be near the zenith by the QZSS, positioning information will become available quickly and accurately in these problematic areas.



Positioning service will be available for sightseeing in an urban area where a lot of hot spots are concentrated and for trekking in a gorge or a forest.
In case of being lost in a gorge or a forest, you will be able to locate yourself by receiving signals from the MICHIBIKI who will be just above you.

Development Organization of the QZSS

The first development phase of the QZSS, "Technical verification and application verification by the First Quasi-Zenith Satellite 'MICHIBIKI'," was led and complied by the Ministry of Education, Culture, Sports, Science and Technology (MEXT.) It has since been promoted in cooperation with the Ministry of International Affairs and Communications (MIC,) the Ministry of Economy, trade and Industry (METI,) and the Ministry of Land Infrastructure Transport and Tourism (MLIT.)

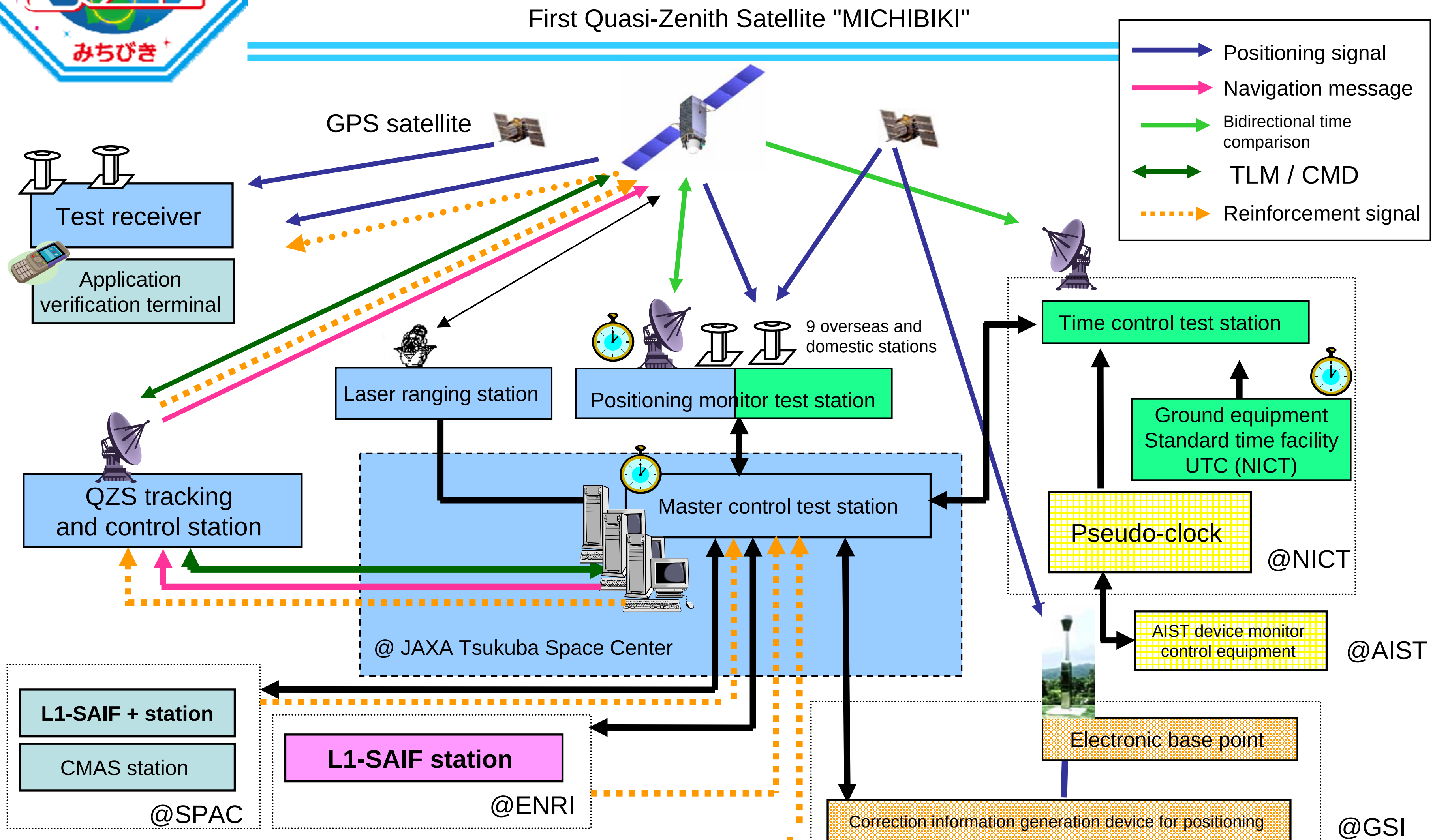


* Satellite Positioning Research and Application Center jointly established by the four related ministries on February 5, 2007

*1 Technological verification: verification experiments to confirm 1) GPS complementary, 2) GPS reinforcement, and 3) function and performance of the next generation basic technology

*2 Application verification: verification experiments of application using positioning signals from a QZS.

Structure of the QZSS

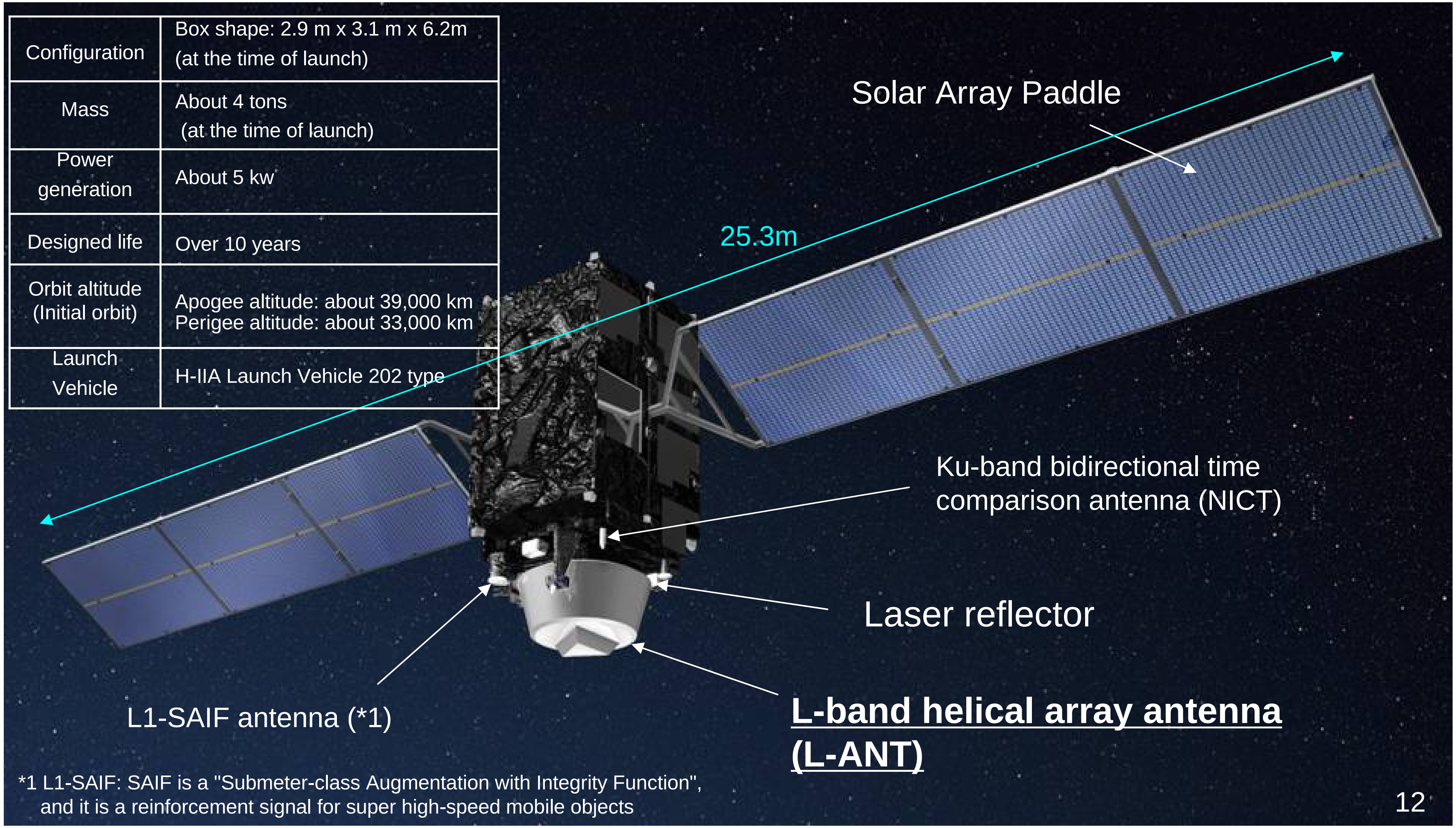


* L1-SAIF: L1-Submeter-class Augmentation with Integrity Function

JAXA | NICT: National Institute of Information and Communications Technology | AIST: Advanced Industrial Science and Technology | ENRI: Electronic Navigation Research Institute | GSI: Geospatial Information Authority of Japan | SPAC: Satellite Positioning Research and Application Center

First Quasi-Zenith Satellite 'MICHIBIKI'
- Satellite Characteristics -

Configuration	Box shape: 2.9 m x 3.1 m x 6.2m (at the time of launch)
Mass	About 4 tons (at the time of launch)
Power generation	About 5 kw
Designed life	Over 10 years
Orbit altitude (Initial orbit)	Apogee altitude: about 39,000 km Perigee altitude: about 33,000 km
Launch Vehicle	H-IIA Launch Vehicle 202 type



*1 L1-SAIF: SAIF is a "Submeter-class Augmentation with Integrity Function", and it is a reinforcement signal for super high-speed mobile objects

First Quasi-Zenith Satellite 'MICHIBIKI'

- Development responsibility sharing -

JAXA

Overall Management

- First Quasi-Zenith Satellite (QZS-1)
  - Bus system
    - Telemetry, tracking and command subsystem (TT&C)
    - Electrical power subsystem (EPS)
    - Solar array paddle subsystem (SPS)
    - Attitude and orbit control subsystem (AOCS)
    - Bipropellant propulsion subsystem (BPS)
    - Structure subsystem (STR)
    - Thermal control subsystem (TCS)
    - Integration hardware subsystem (INT)
  - Navigation payload (NP)
    - Rubidium atomic frequency standard (RAFS)
    - L-band transmission subsystem (LTS)
    - Time transfer subsystem (TTS)
    - Laser reflector array (LRA)
  - Secondary payloads (SP)
    - Monitor camera (CAM)
    - Technical data acquisition equipment (TEDA)

Applying NEDO's R&D results

Applying USEF's R&D results

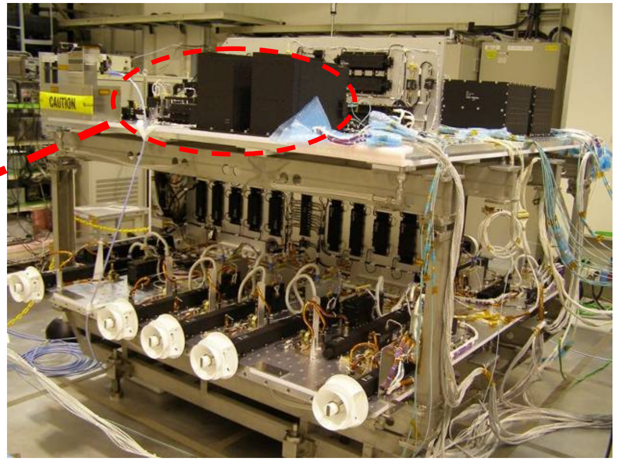
AIST's R&D software is onboard

NICT's R&D product

First Quasi-Zenith Satellite 'MICHIBIKI'

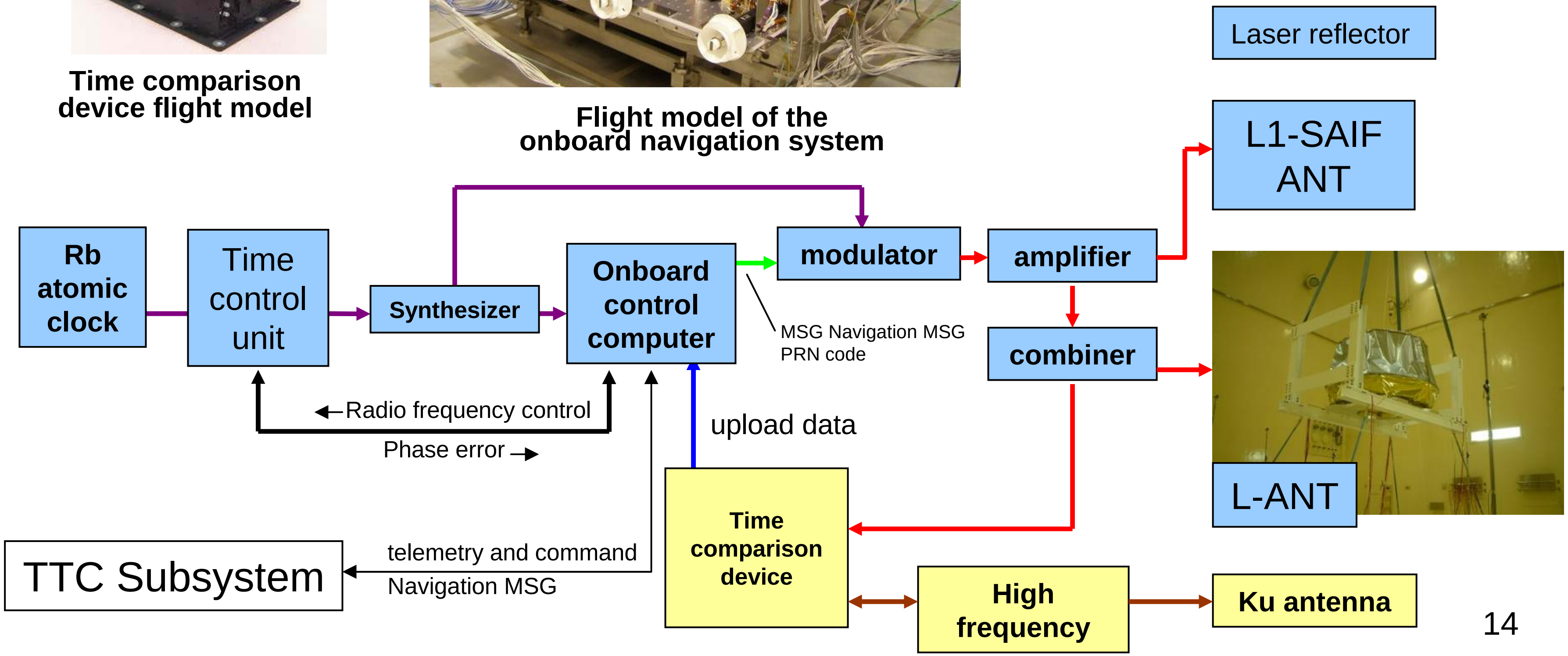
- Overview of Navigation Payload -

Time comparison device flight model



Flight model of the onboard navigation system

Carrier wave
Positioning signal
time comparison siganl
JAXA device
NICT device



Ground Stations Supporting MICHIBIKI Operation

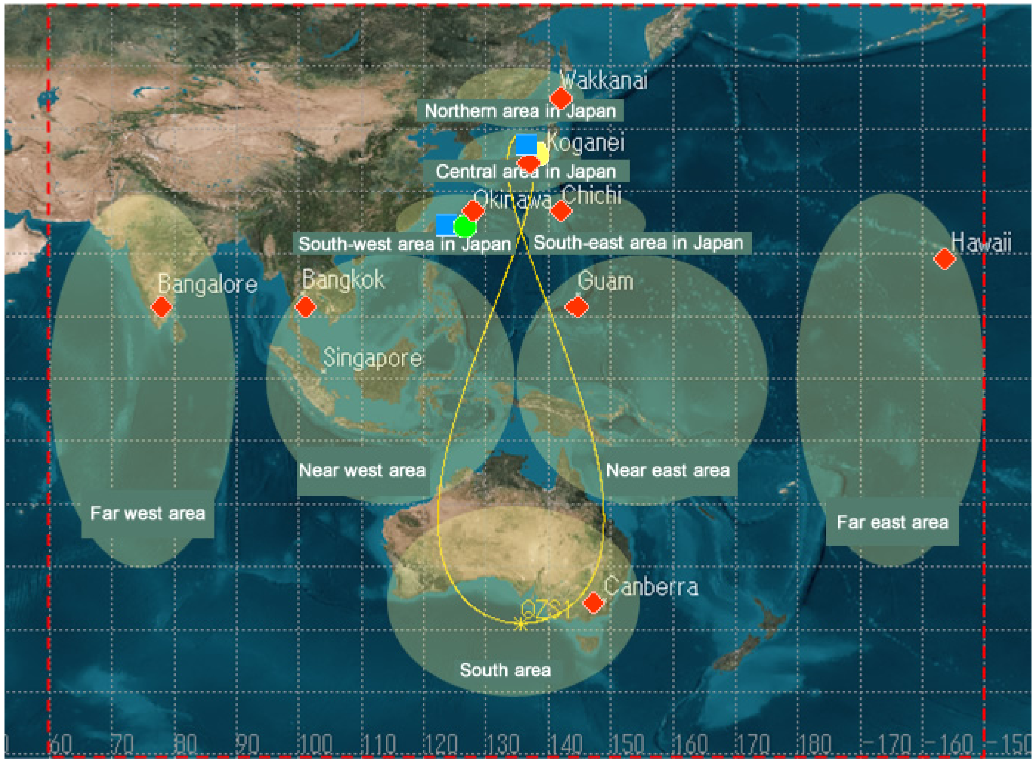
- Nine foreign and domestic monitor test stations receive positioning signals from the MICHIBIKI. Those signals are gathered at the Master Control Station (MCS,) then the tracking and control stations send them to the MICHIBIKI with correction data generated by related organizations.
- The MICHIBIKI receives data for positioning signals from the tracking and control station in Okinawa, and transmit signals to the Earth.

Monitor test station
(9 overseas and domestic stations)

Master Control Station (in Tsukuba)

Time control test station
(in Koganei and Okinawa)

QZS tracking and control station



Post Launch Operation Plan

- Post launch operation plan
  - In about 10 days: completion of the transfer orbit phase
  - In about two weeks: completion of the drift phase, and injection into the quasi-zenith orbit
  - In about three months: completion of the initial function verification to start technical verification experiments and application verification

- QZSS and MICHIBIKI information provision
  - Special site

    http://www.jaxa.jp/countdown/f18/index_e.html

    Latest information including launch preparation status, launch and orbit injection
  - QZSS project site

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

    Mission explanation, orbit and time date during the operation

QZSS and International Cooperation

- Relation with the ICG (International Committee on Global Network Satellite System, GNSS) -

- ICG = International Committee on GNSS
  - A committee for satellite positioning systems established under the United Nations Committee on the Peaceful Uses of Outer Space (UN-COPUOS) in 2006. Voluntary-based activity by countries and organizations who are interested in the satellite positioning system.
- Japan participates in the committee as a GNSS provider.
  - MTSAT (Multi-functional Transport satellite) Satellite-based Augmentation System (MSAS)
  - QZSS
  - Host and chair an ICG meeting (2011 in Tokyo)
  - Participate in the decision making of the ICG as a member
- ICG participants
  - GNSS providers (U.S.: GPS, Europe: Galileo, Russia: GLONASS, China: COMPASS, India: IRNSS, and Japan: QZSS)
  - Member countries (Italy, Malaysia, Nigeria, United Arab Emirates)
  - Related international organizations (Bureau International des Poides et Measure (BIPM,) International Association of Geodesy (IAG,) International GNSS Service (IGS,) and others.)

QZSS and International Cooperation

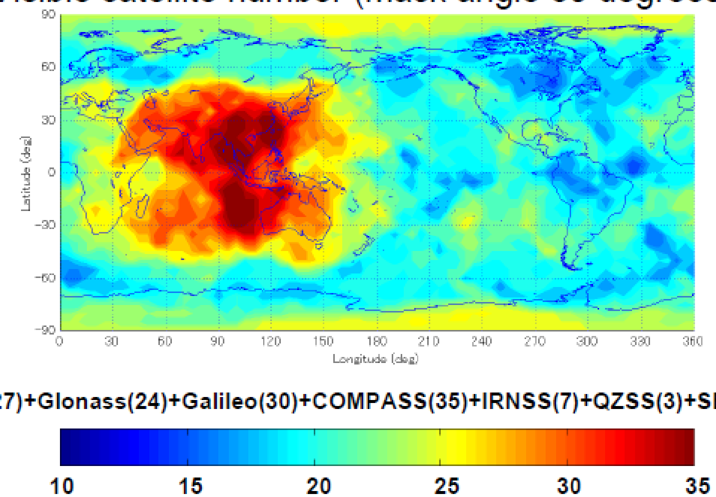
- Verification experiment on the Asia/Oceania regional multi GNSS -

Multi-GNSS Demonstration Campaign

- The MICHIBIKI's orbit is in a shape of the figure "eight (8)" with its center at the equator over Japan and Australia. Therefore, its signals can be received not only in Japan, but also in South Korea, Australia, and South-Eastern Asian countries.
- The Asia and Oceania regions are the first areas that can enjoy the benefits of the multi-GNSS (GPS, Glonass, Galileo, Compass, QZSS, IRNSS) in the world.

- We would like to set up a framework to promote cooperative experiments for application verification in order to facilitate the use of the multi-GNSS in Asia and Oceania.

Visible satellite number (mask angle 30 degrees)



2020:

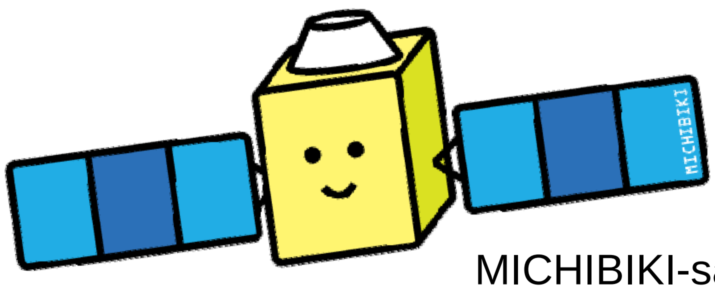
GPS(27)+Glonass(24)+Galileo(30)+COMPASS(35)+IRNSS(7)+QZSS(3)+SBAS(7)

The first Asia/Oceania regional workshop
In Bangkok, Thailand, on January 25 and 26
195 participants from 18 countries and 95 organizations

The second meeting is scheduled to be held within Japan Fiscal Year 2010

Nickname 'MICHIBIKI'

- The nickname "MICHIBIKI," meaning "guiding" or "showing the way," was selected as a nickname through a campaign conducted between October and December, 2009. (Total of 11,111 participants in the campaign)
- Reason for the selection
  Many godparents of "MICHIBIKI" explained their selection reason as the QZS-1 is to show us correct locations using its highly accurate positioning information, and to guide us toward a futuristic society by establishing the next generation satellite positioning technology in Japan. The name was chosen as it precisely illustrates the QZS mission.



MICHIBIKI-san

Mission Logo

- Mission Logo
  - The mission log design shows the unique footprint of a quasi-zenith satellite orbit, which looks like the figure "eight (8)." The English acronym "QZSS" is also on the logo.
- Decal on the H-IIA Launch Vehicle No. 18
  - A decal with MICHIBIKI's mission logo and logo marks of related organizations will be attached to the body of the H-IIA Launch Vehicle No. 18.

The decal that will be attached to the H-IIA (4.2 x 3.0 m)