Current status of Quasi-Zenith Satellite System

Japan Aerospace Exploration Agency

QZSS Project Team

#4 International Committee on GNSS,

@ Saint-Petersburg, Russian Federation

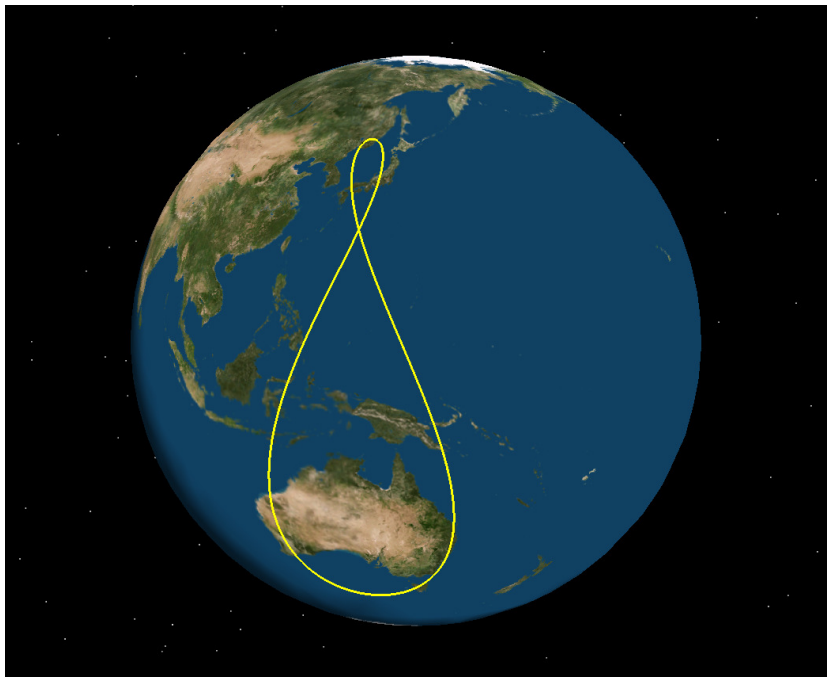
14-18 September 2009

Contents

Concept of the QZSS (1/2)

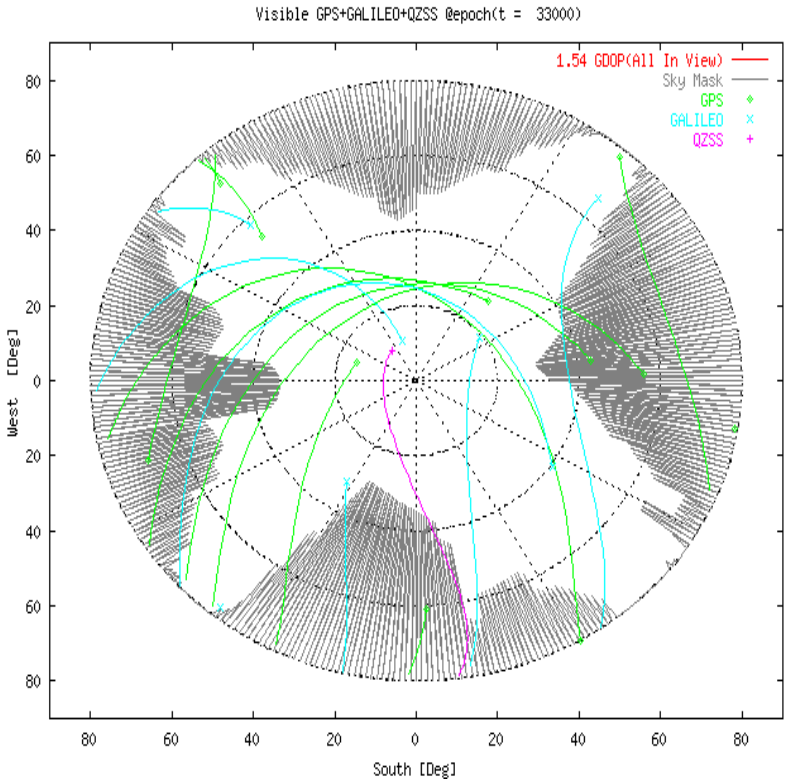
- QZSS is designed so that at least one satellite out of three satellites exists near zenith over Japan.
- Three satellites are in elliptical and inclined geosynchronous orbits in different orbital planes to pass over the same ground track.

(a=42,164km, e=0.06-0.09, i=39-47deg, Ω = 120deg apart)

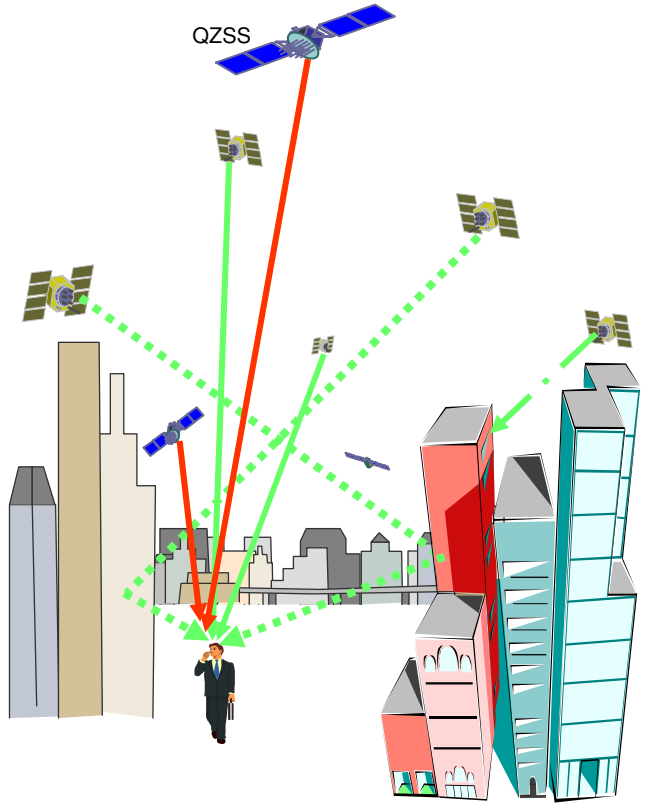


QZSS Ground Track

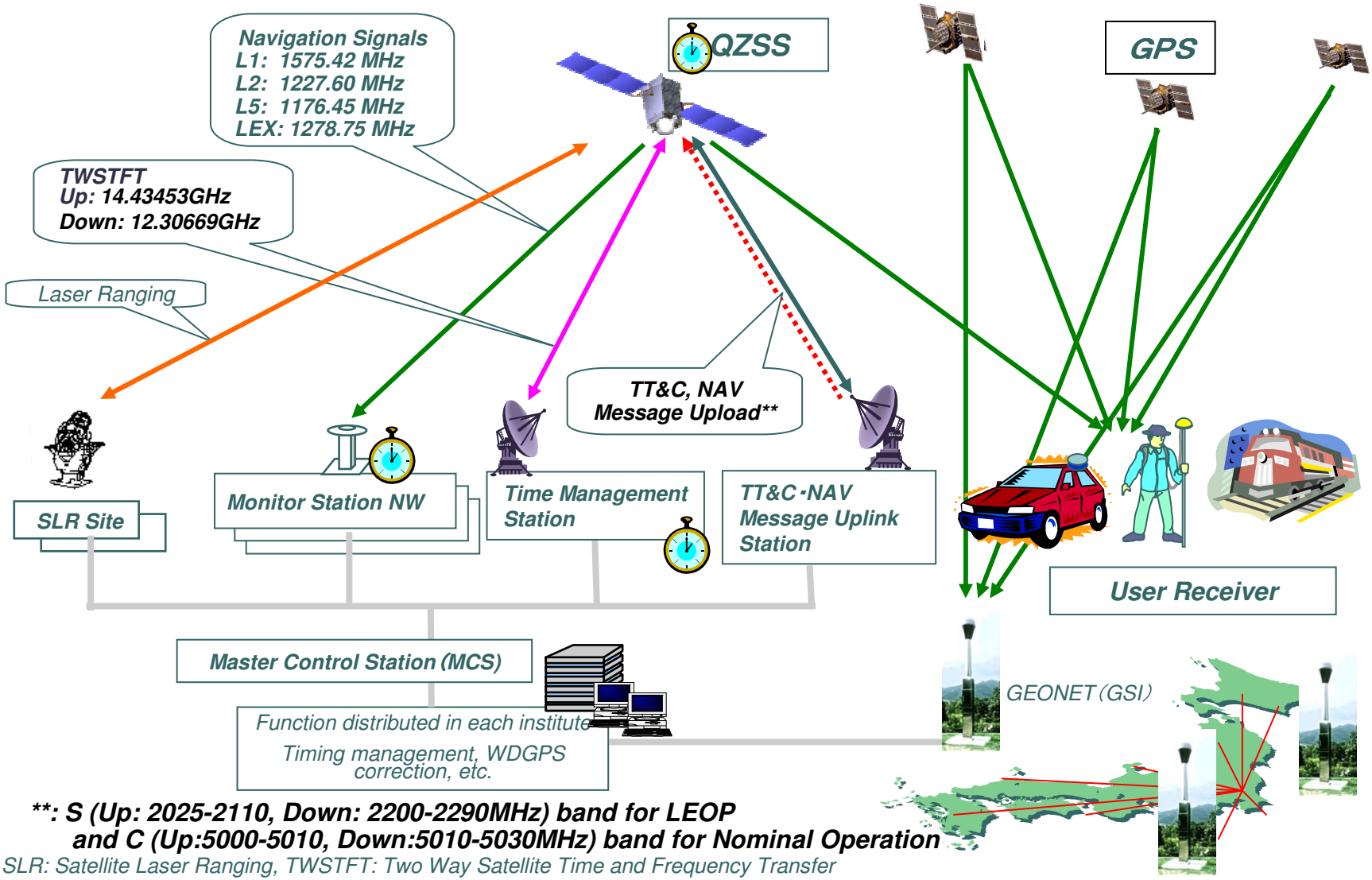
Concept of the QZSS (2/2)



- *QZSS can provide a seamless service from high elevation angle.*
- *Increasing the availability of PNT services in downtown and mountainous areas.*



System Architecture

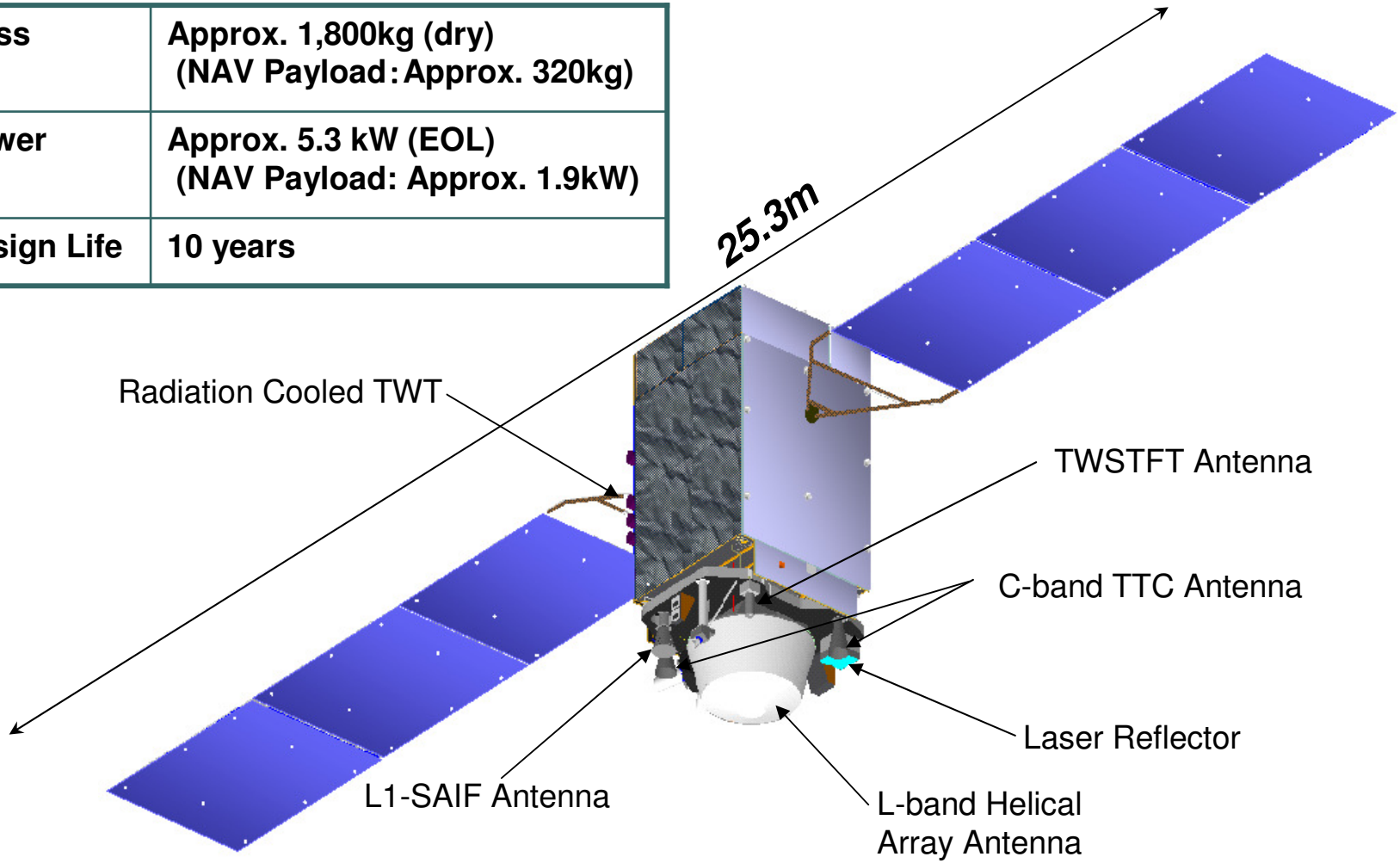


**: S (Up: 2025-2110, Down: 2200-2290MHz) band for LEOP
and C (Up:5000-5010, Down:5010-5030MHz) band for Nominal Operation

SLR: Satellite Laser Ranging, TWSTFT: Two Way Satellite Time and Frequency Transfer

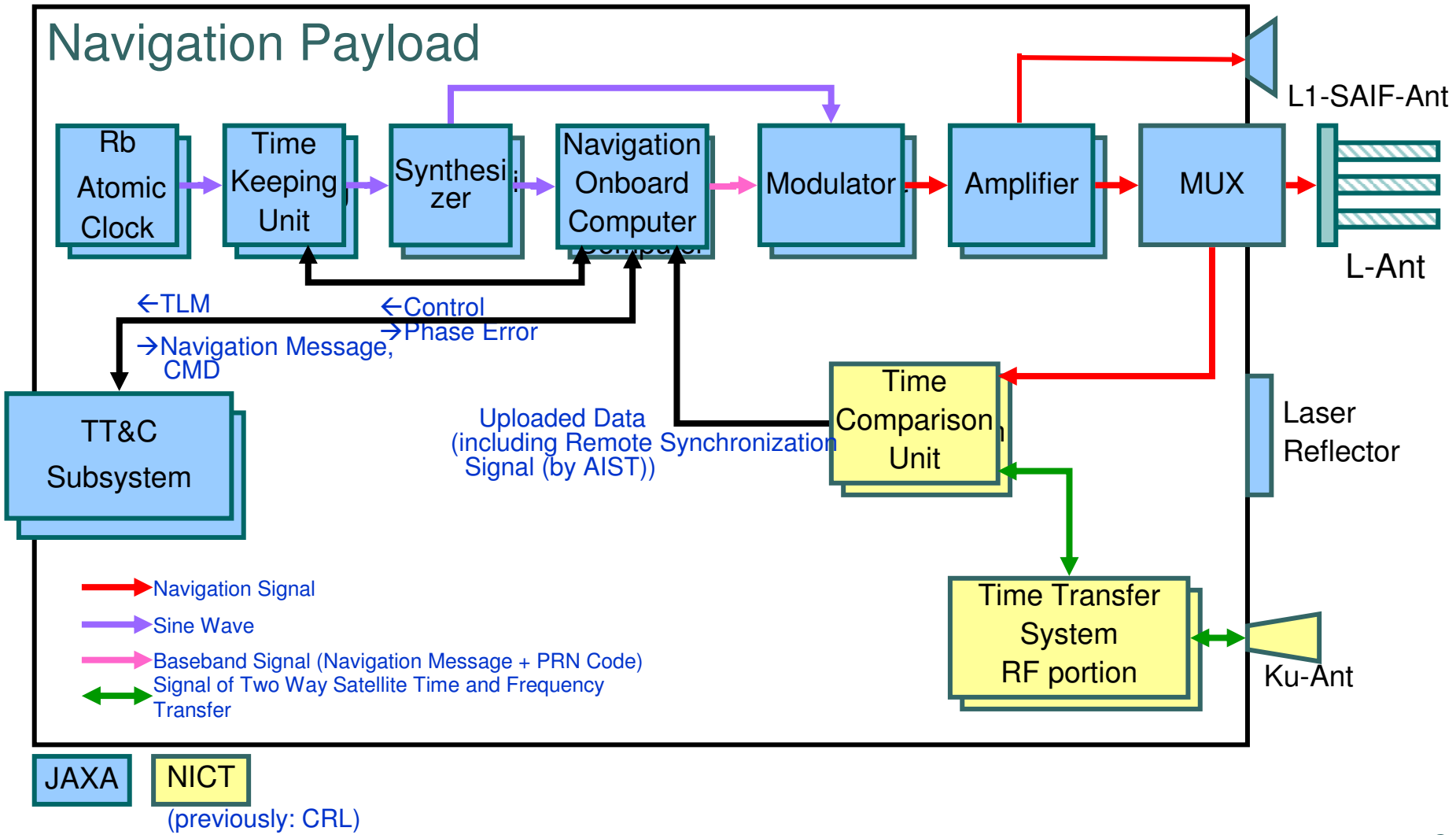
Space Segment - QZS-1 -

Mass	**Approx. 1,800kg (dry)** **(NAV Payload : Approx. 320kg)**
Power	**Approx. 5.3 kW (EOL)** **(NAV Payload: Approx. 1.9kW)**
Design Life	**10 years**

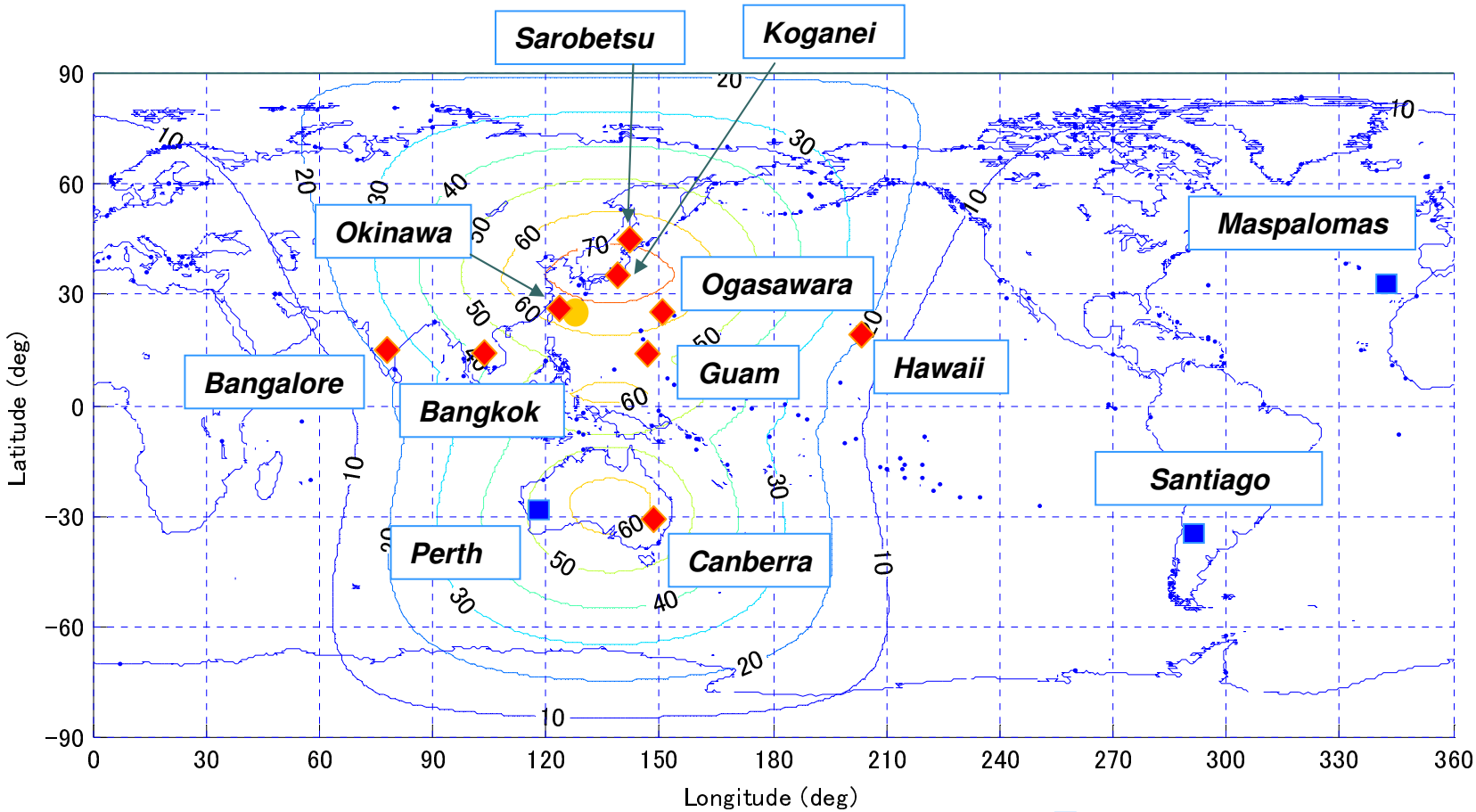


Satellite Configuration on Orbit

Navigation Payload on the QZS-1

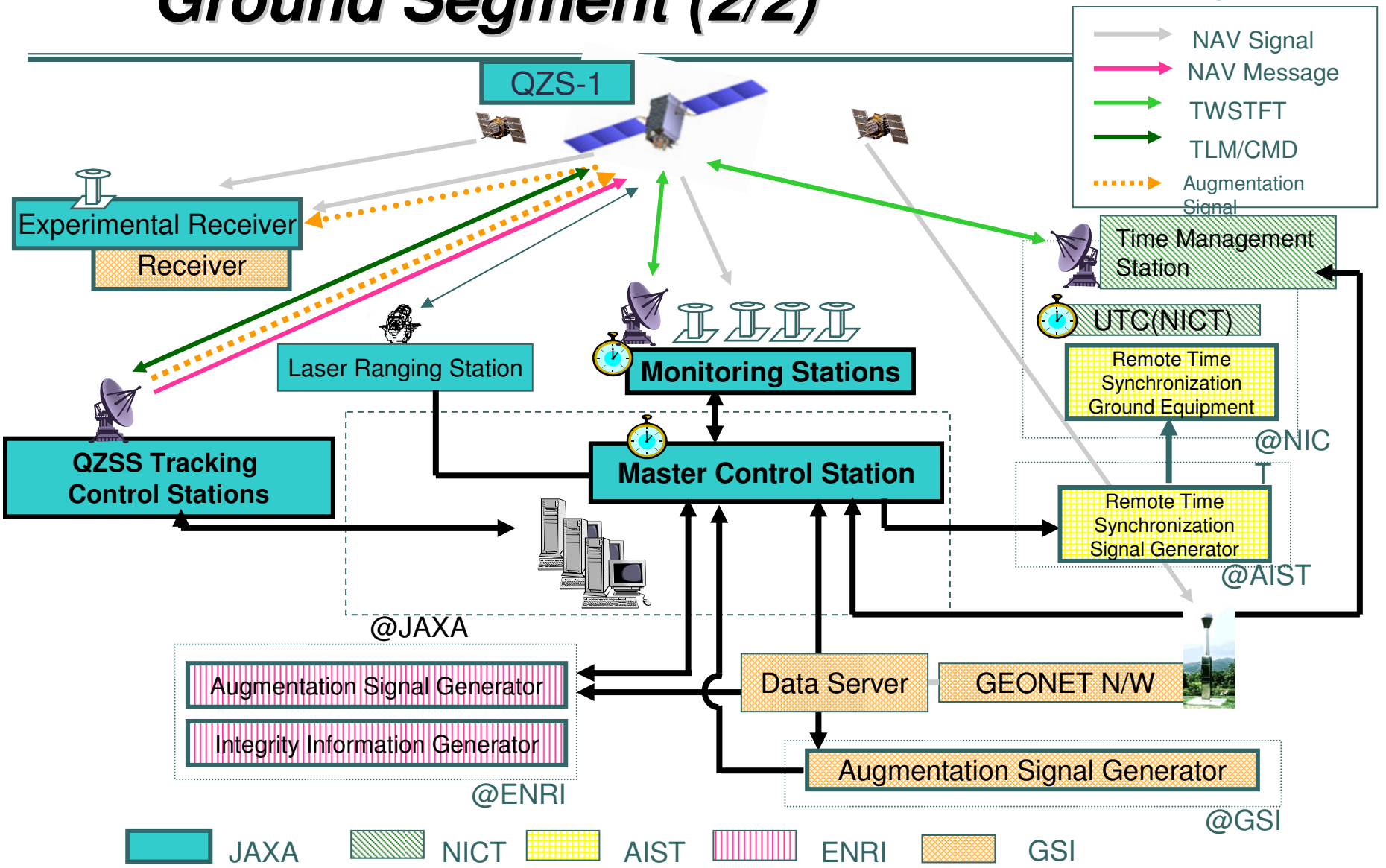


Ground Segment (1/2)



Okinawa is primary TT&C station for nominal operation.
LEOP operation is to be conducted by using JAXA Ground TT&C Network

Ground Segment (2/2)



Planned Signals

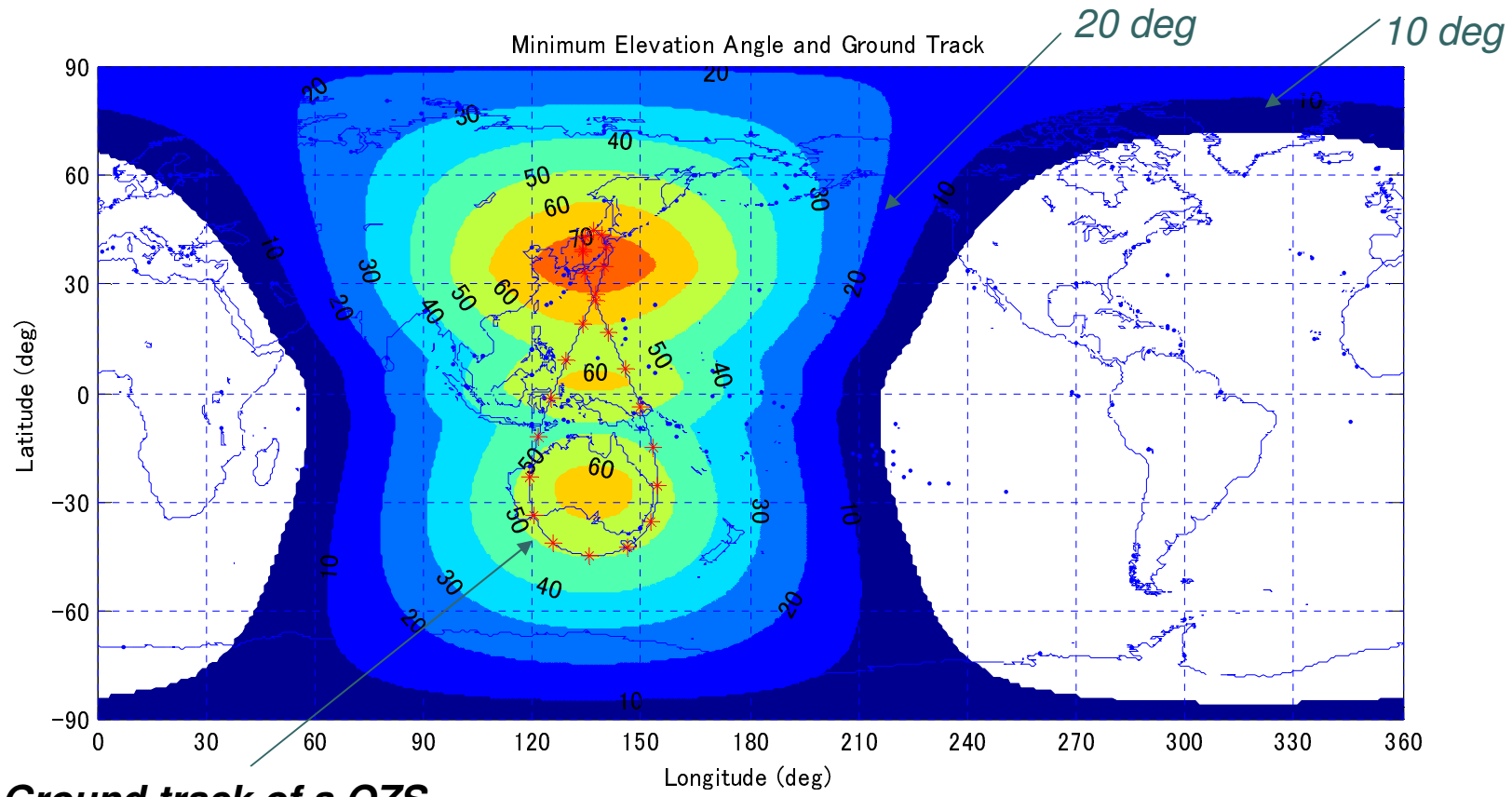
	Frequency	*Notes*
L1-C/A	*1575.42MHz*	➢ *Complete compatibility and interoperability with existing and future modernized GPS signals* ➢ *Differential Correction data, Integrity flag, Ionospheric correction* ➢ *Almanac & Health for other GNSS SVs*
L1C		
L2C	*1227.6MHz*	
L5	*1176.45MHz*	
*L1-SAIF**	*1575.42MHz*	➢ *Interoperability 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**

System Time and Geodetic Reference Frame Standards

- **Time scale: 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%).**
- **Coordinate System: 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].**

Expected Performance - Service Area -



Minimum Elevation Contour for 3 QZS over 24 hours

** for maximum elevation of visible satellites*

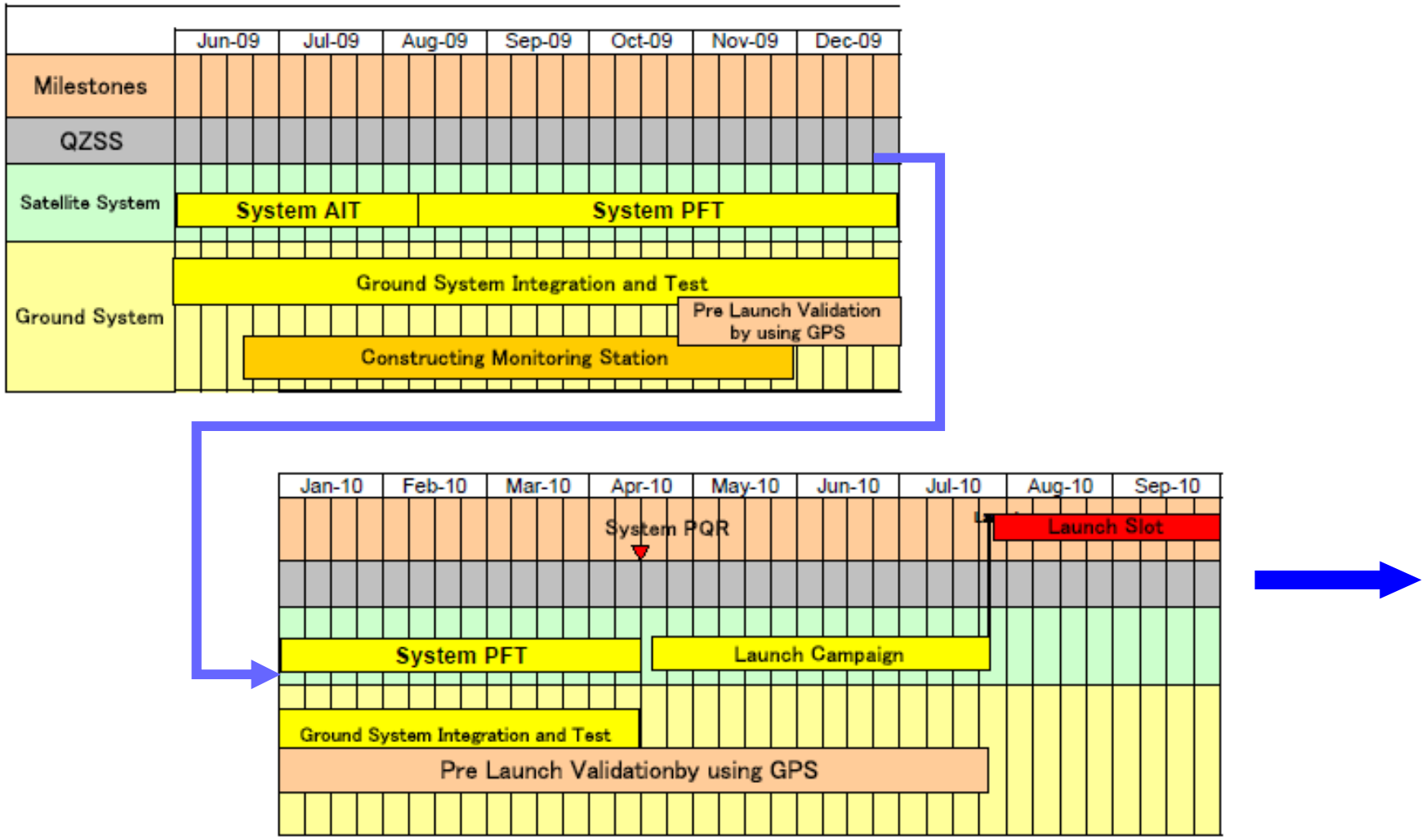
Expected Performance - Accuracy -

- 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%)

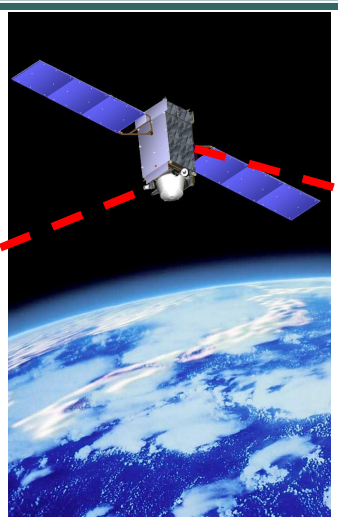
  - L1-SAIF signal can provide WDGPS correction data, its positioning accuracy is 1m (1 sigma rms) except in cases of large multipath error and large ionospheric disturbance.

Timetable for System Development & Operation

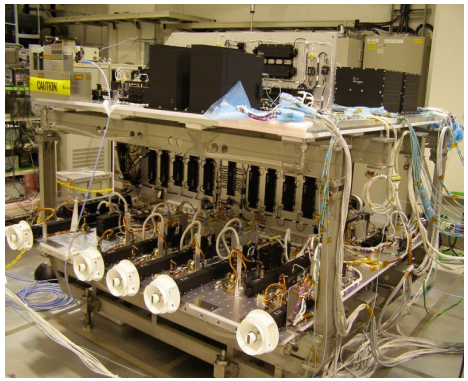


3 months later from the launch (for 1 year) : In Orbit Validation

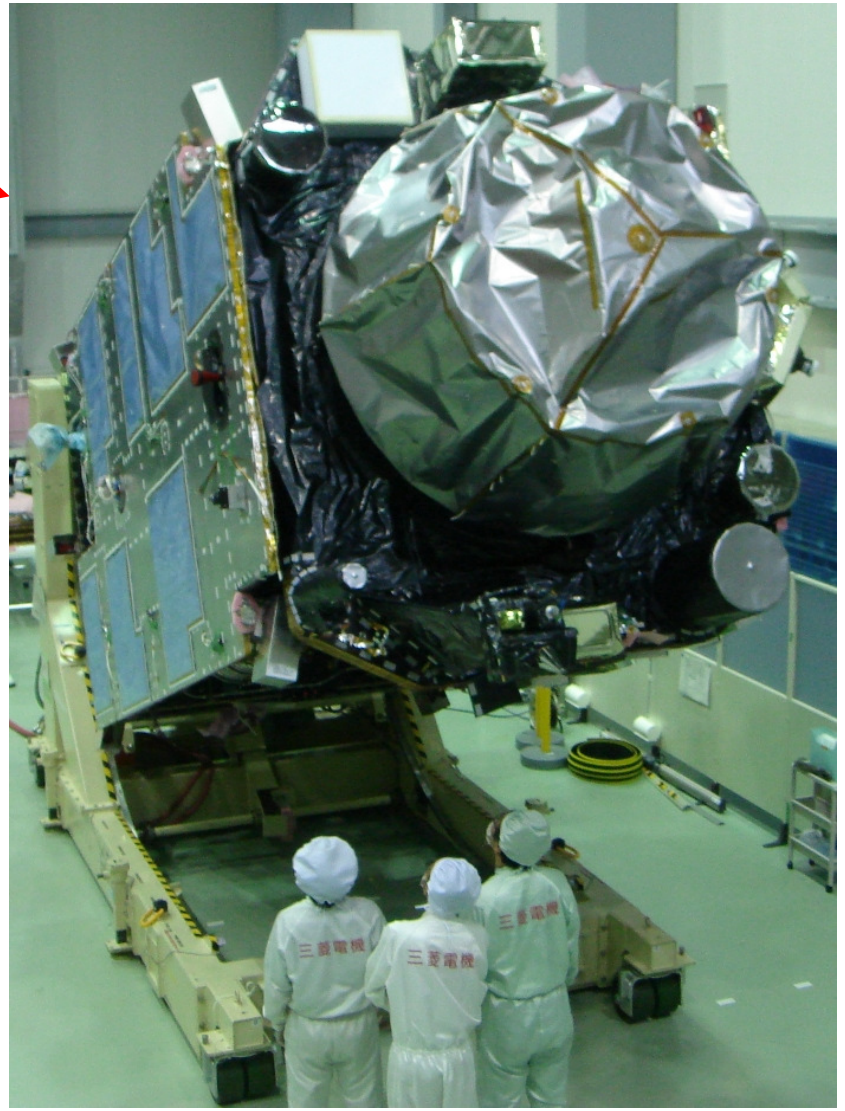
Development Status - Space Segment -



L-band Antenna Pattern Test
Proto-Flight Model (July 2008)



NAV Payload PFM TVT
(Jan 2009)



Satellite System (Aug 2009)

Development Status - Ground Segment -

Agreements for hosting QZSS MSs.

- ***NOAA***
  National Weather Forecast Office (WFO)
  MOU (30/09/2008)
- ***NASA***
  Kokee Park Geophysical Observatory (KPGO)
  LOA (10/10/2008)
- ***Indian Space Research Organisation (ISRO)***
  MOU (24/07/2008)
- ***Geoscience Australia (GA)***
  MOU (TBD)
- ***Asian Institute of Technology (AIT)***
  MOU (18/03/2009)

Monitoring Station @Guam (Aug 2009)

TT&C-NAV Message Uplink Station @Okinawa

Political Back Ground of the QZSS (1/2)

- *Basic Act on the Advancement of Utilizing Geospatial 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 issue 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*

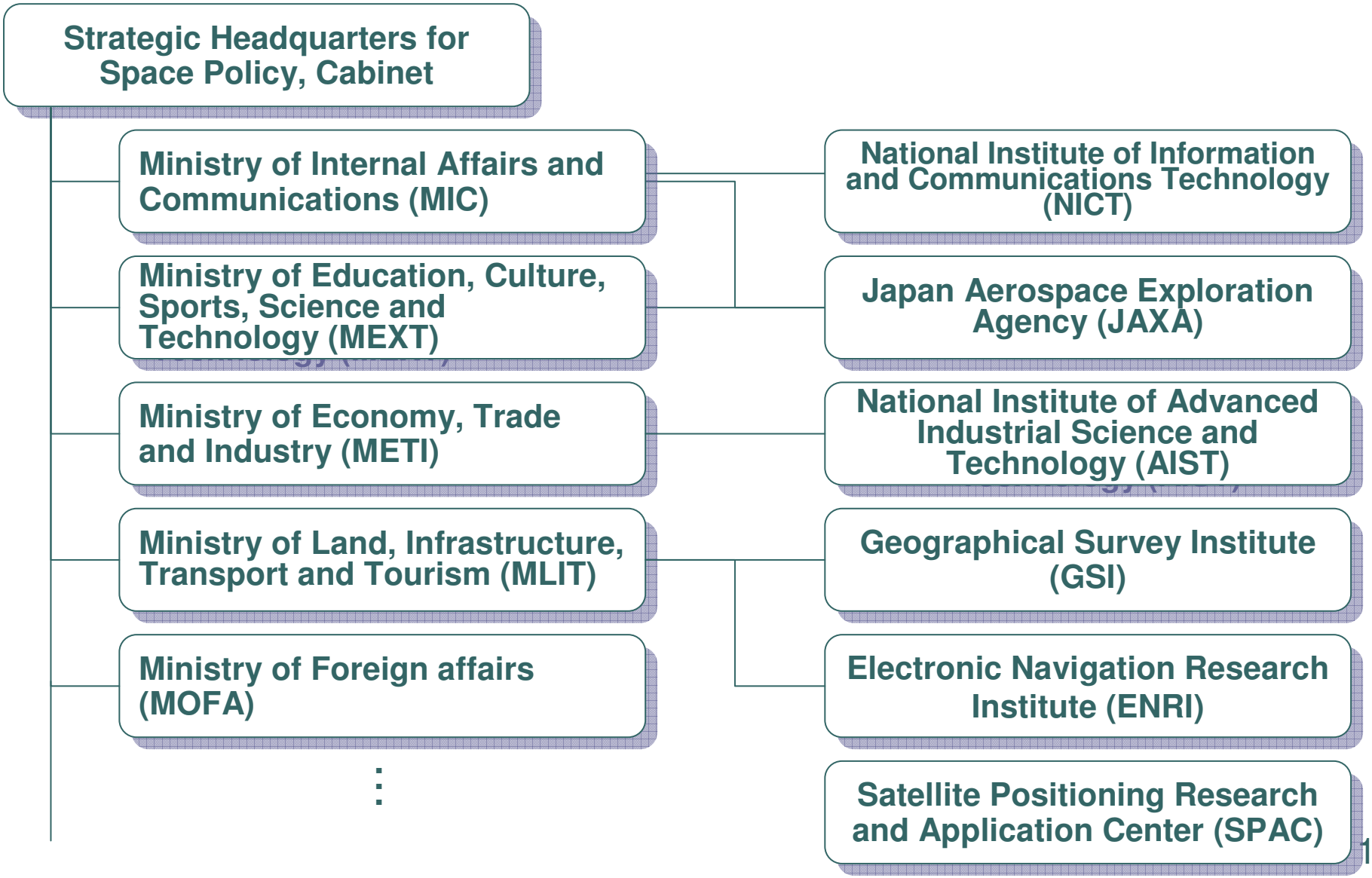
Political Back Ground of the QZSS (2/2)

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

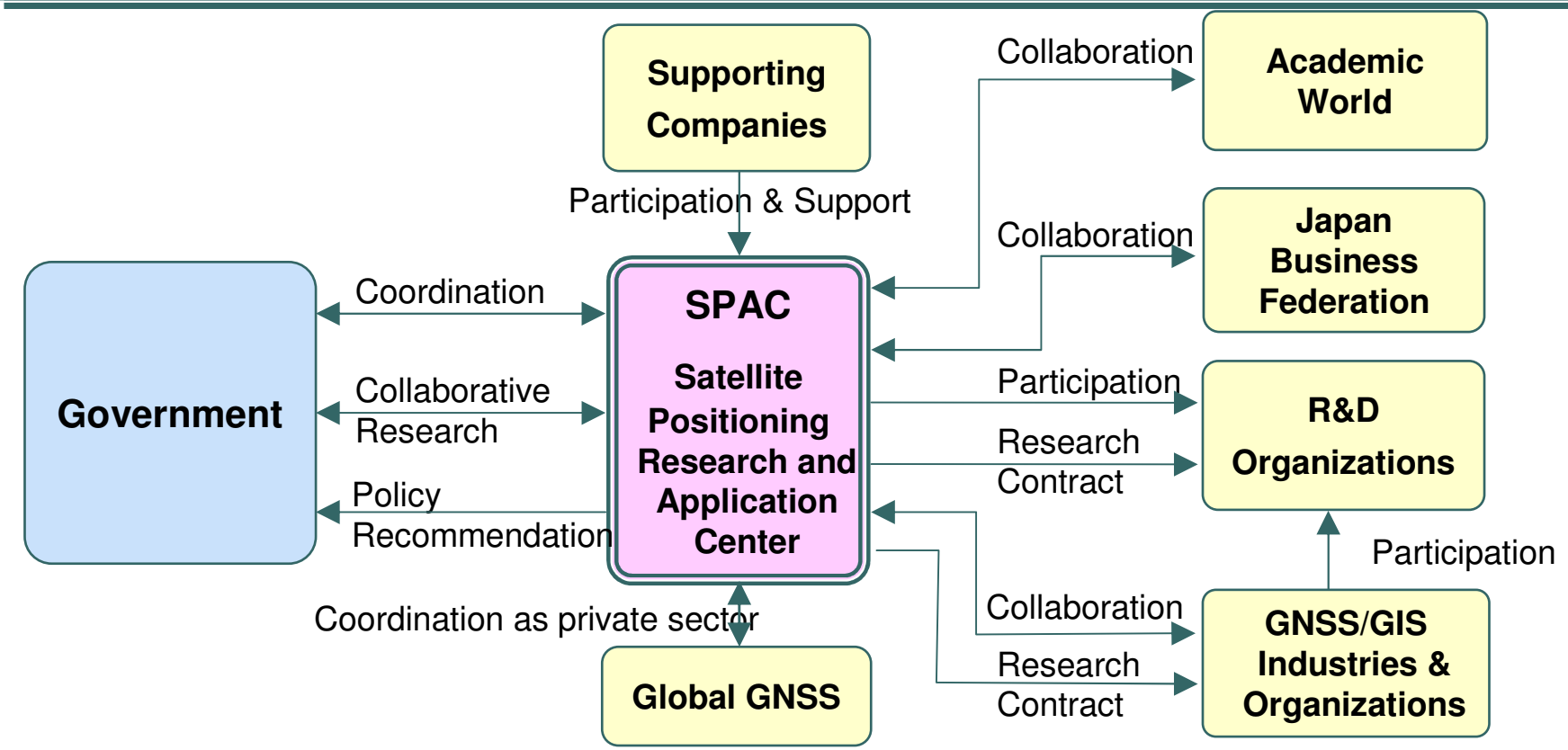
    (chaired by the Prime Minister, based on Article 25 of the Basic Space Law)

- *Space-based PNT in the Basic Plan for Space Policy*
  - *Support six basic Pillars in the Plan*
  - *Promote highly accurate system such as QZSS and MSAS*
  - *Create new services in our daily life such as personal navigation systems, with private sector*

Organization Structure of QZSS Development & Utilization



Establishment of New Private Sector Organization



Satellite Positioning Research and Application Center (SPAC) was established in 5 February 2007 approved by the Ministers associated with QZSS research and development (MEXT, MIC, METI and MLIT) to promote navigation satellite technology application and consequential geo-spatial information utilization （*http://www.eiseisokui.or.jp/en/*）

II. Service Provided and 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.*

Interface Specification for QZSS

- *Describes Not only SIS ICD but also SPS, CONOPS for design of receiver and applications*
  - *System architecture of whole QZSS*
  - *Signal structure and specifications*
  - *Service performance properties*
- *Close relationship with GPS IS Documents*
- *All users can download **freely** from JAXA's web site*
  - *Both Japanese and English versions are available.*
- *Ver. 1.0 was released in June 2008.*
  - *IS-QZSS ver. 1.1 has been released in August 2009.*
  - *It is available on following web site.*

http://qzss.jaxa.jp/is-qzss/index_e.html

Views on Compatibility

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

- *QZSS complies with the international rule and consensus.*
  - *ITU Radio Regulation*
  - *ICG definition*

Views on Interoperability

- *Interoperability is **NOT mandatory**, but **highly desirable** in the users' point of view.*
- *There exists some levels for the interoperability among GNSS depending on each application.*
  - *Each applications have different allowable levels.*
    - *For instance, High end precise positioning users can allow combining usage of CDMA and FDMA signals.*
- *QZSS will try to achieve as higher levels of interoperability as possible, 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*

Requirements for Securing High Level Interoperability

- *Same RF properties*
  - *Center Frequency, Bandwidth, Spectrum*
  - *PRN code family*
- *Same Message structures*
  - *Message rate, Error Correction method, Frame length, Message contents and their definitions*
- *Same Time and Geodetic reference*
- *Same Max/Min User Receiving Power*
  - *need for better availability and geometry without increasing noise floor, i.e. degrading ranging accuracy.*
  - *QZSS may have some exemption due to its eccentricity.*
  - *It can be accepted with the direction or general principal, but appropriate and achievable URP range for each system are to be investigated.*
- *The above requirement should be provided in open technical descriptions for users such as;*
  - *Interface Specification*
  - *Performance standard*

Commitment of Service Performance

- *Performance standard will be described in IS-QZSS document after enough evaluation through actual operation will be implemented.*
  - *Moderate specification values are to be written in the document during the first step, followed by the appropriate values during the next step, obtained from operation's experience.*
- *JAXA will monitor the performance of the QZSS and report periodically in web site, as to whether the described performance is matched.*
- *As for providing commitment, careful discussion is to be requested.*

Asia Oceania Regional Workshop on GNSS
January 25-26 2010, Thailand

- ***To discuss future joint development and experiment for multi GNSS use in Asia Oceania region***
- ***To feed back the experiment result to discussion on interoperability***
- ***Official announcement will be issued soon at***
  - ***http://www.multignss.asia***

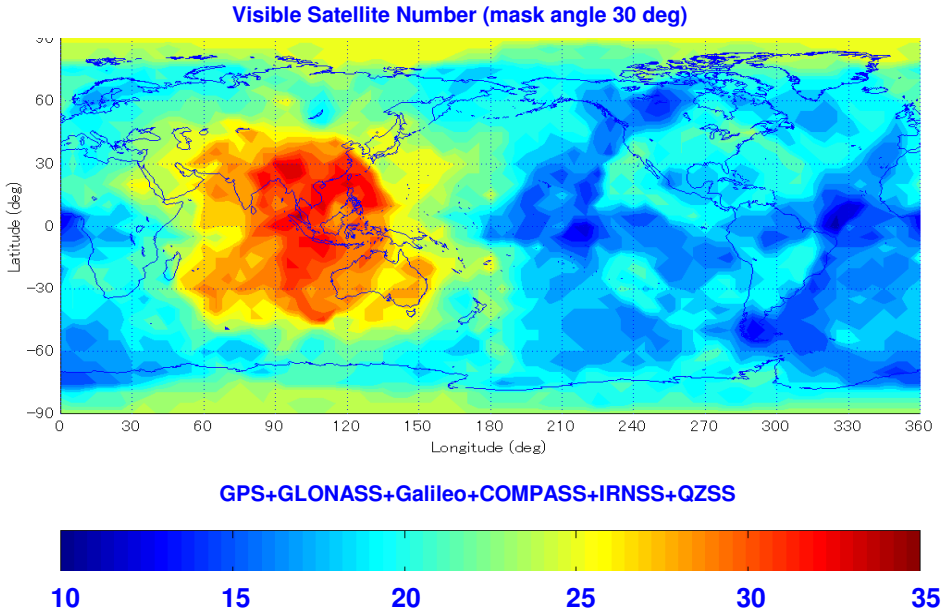
- Multi-GNSS
  - More Stars, Signals, Frequencies

⇩

- Increasing coverage, availability
- Better Geometry
- Higher accuracy
- More reliable, robust performances

⇩

New Applications



IV. Summary

- *QZSS is a Japanese regional Space-based PNT System*
  - *Enhance GPS capability*
  - *High level interoperability with GPS*
- *QZSS Is being developed by step by step manner*
  - *First satellite (QZS-1) will be launched in Summer of 2010*
- *Proto-Flight test of QZS-1 has been conducted.*
- *The User Interface document, IS-QZSS ver. 1.1 is available on http://qzss.jaxa.jp/is-qzss/index_e.html.*