Current Status of Quasi-Zenith Satellite System

Japan Aerospace Exploration Agency

QZSS Project Team

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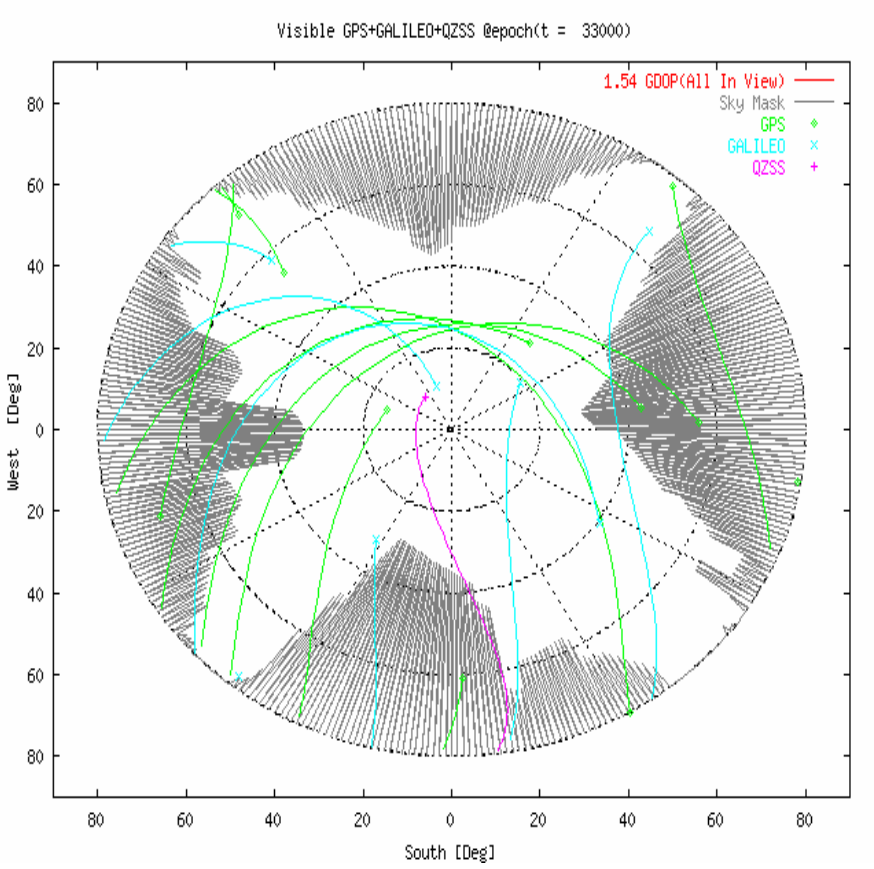
Contents

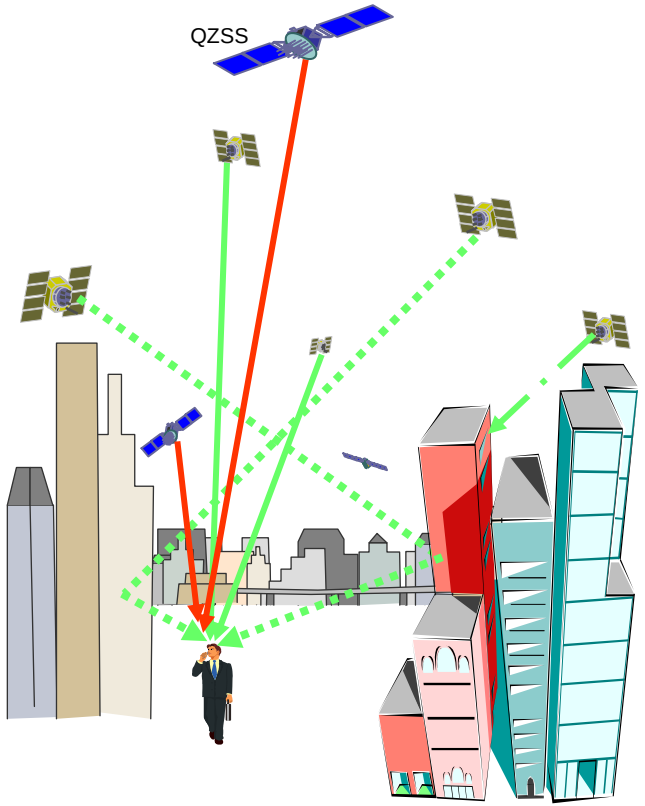
Concept of the QZSS (1/2)

- Designed so that at least one satellite can be observed near zenith over Japan.
- Three satellites are in elliptical and inclined GSO in different orbital planes to pass over the same ground track.

Concept of the QZSS (2/2)

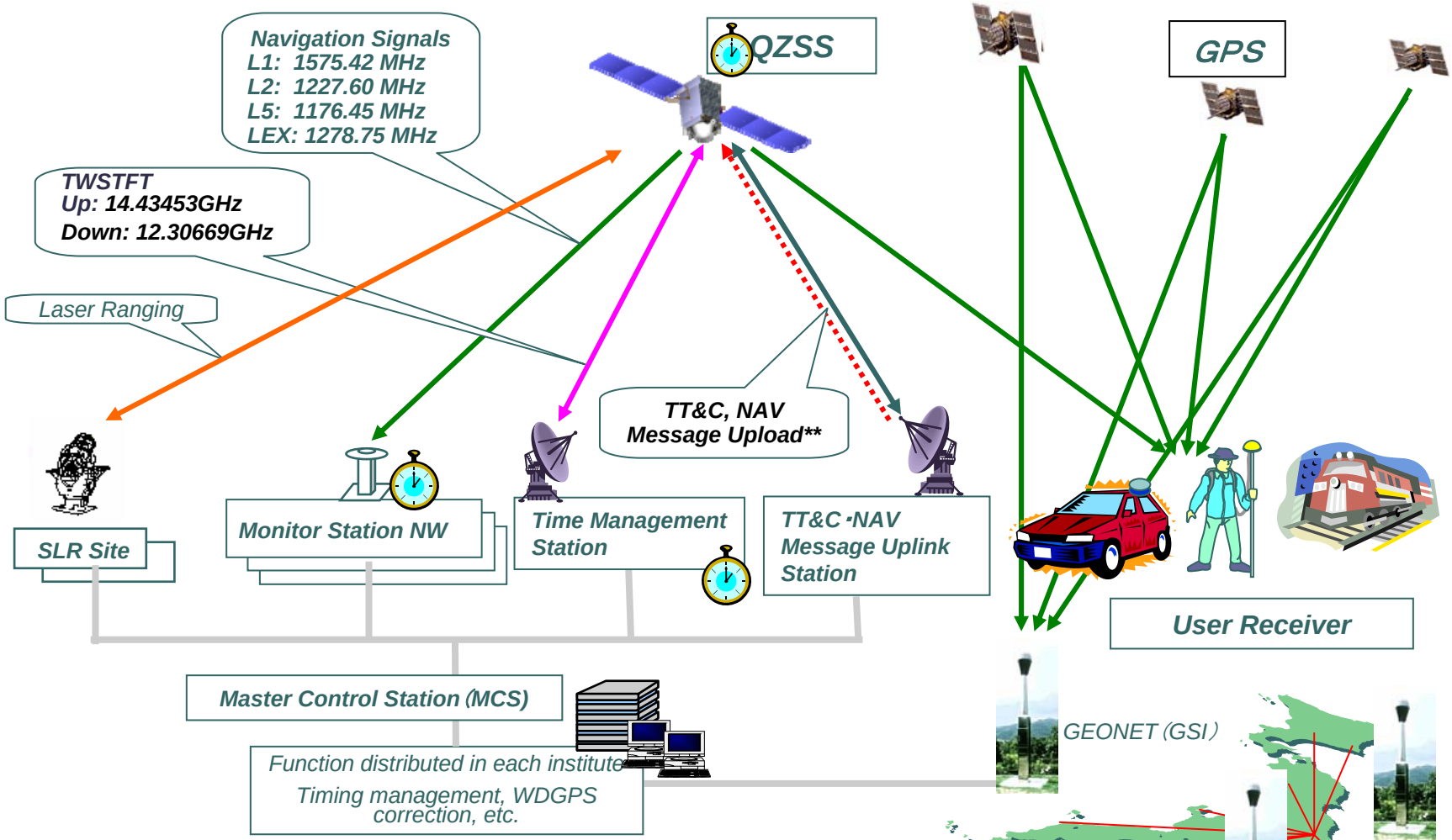
- QZSS can provide a seamless service from high elevation angle.
- Increasing the availability of PNT services even in downtown and mountainous areas.





1. System description

System architecture

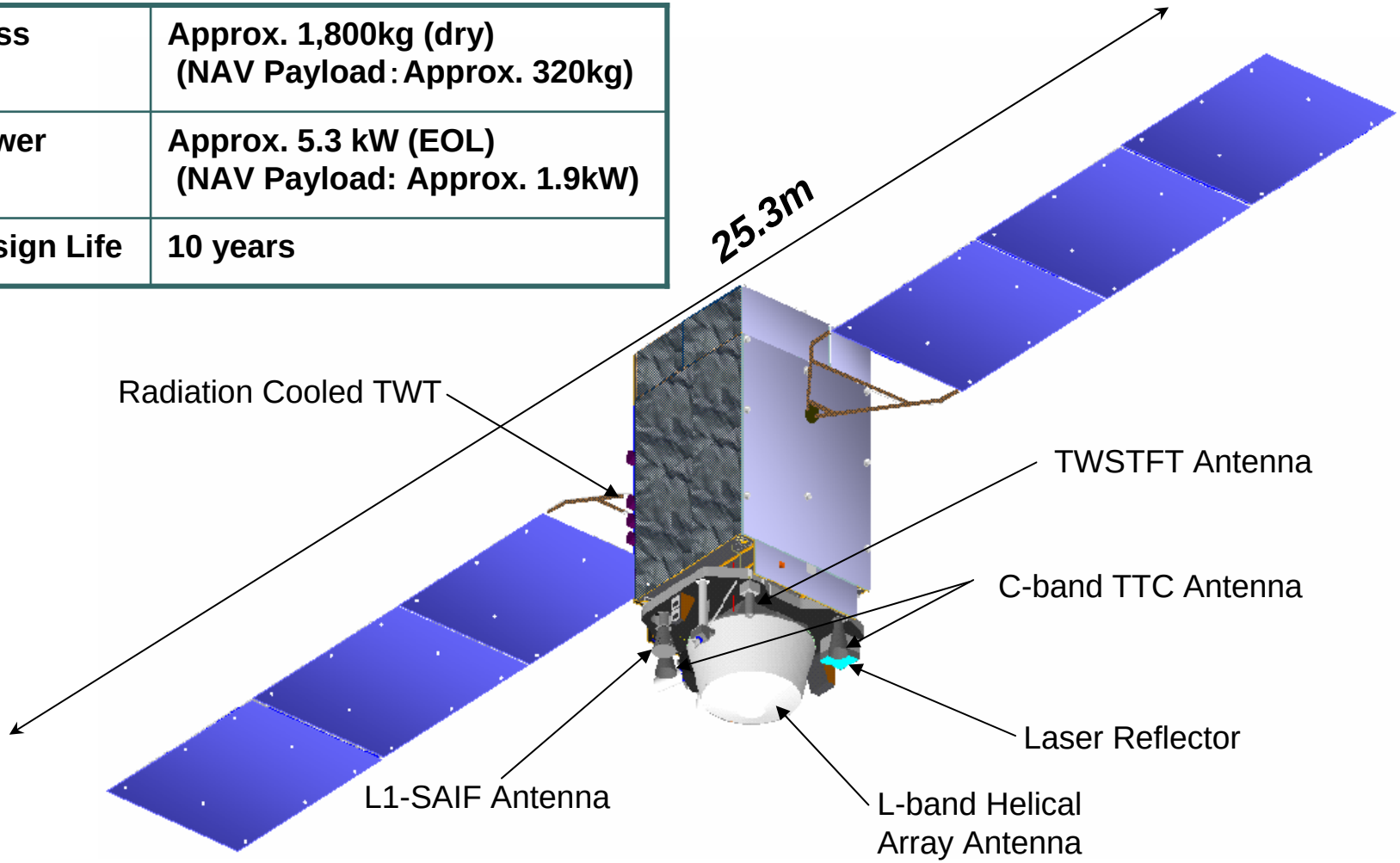


**: S (Up: 2025-2110, Down: 2200-2290MHz) band for LEOP
and C (Up:5000-5010, Down:5010-5030MHz) band for Nominal Operation

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

Space Segment - QZS-1 -

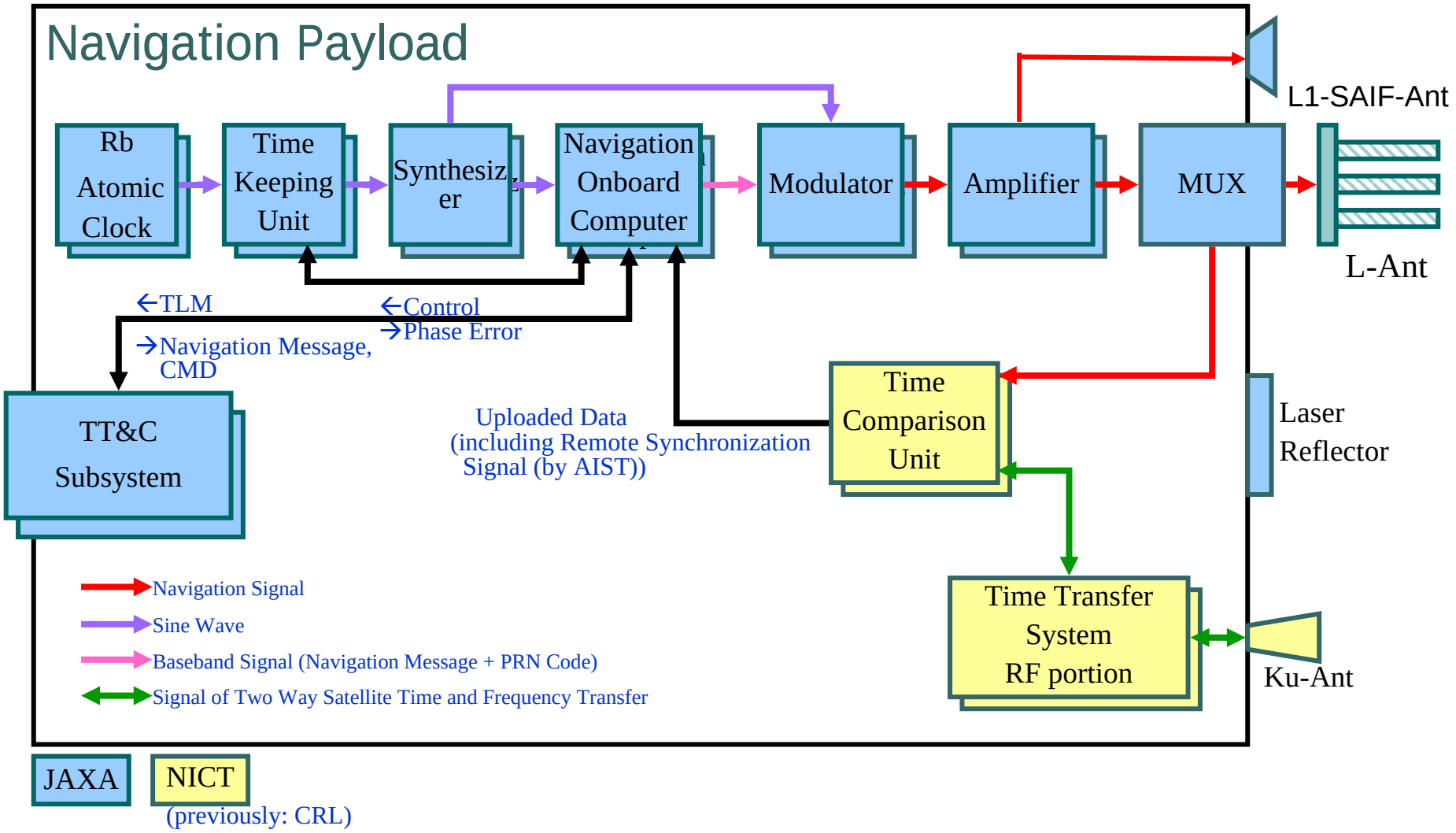
Mass	**Approx. 1,800kg (dry)** **(NAV Payload：Approx. 320kg)**
Power	**Approx. 5.3 kW (EOL)** **(NAV Payload: Approx. 1.9kW)**
Design Life	**10 years**



Satellite Configuration on Orbit

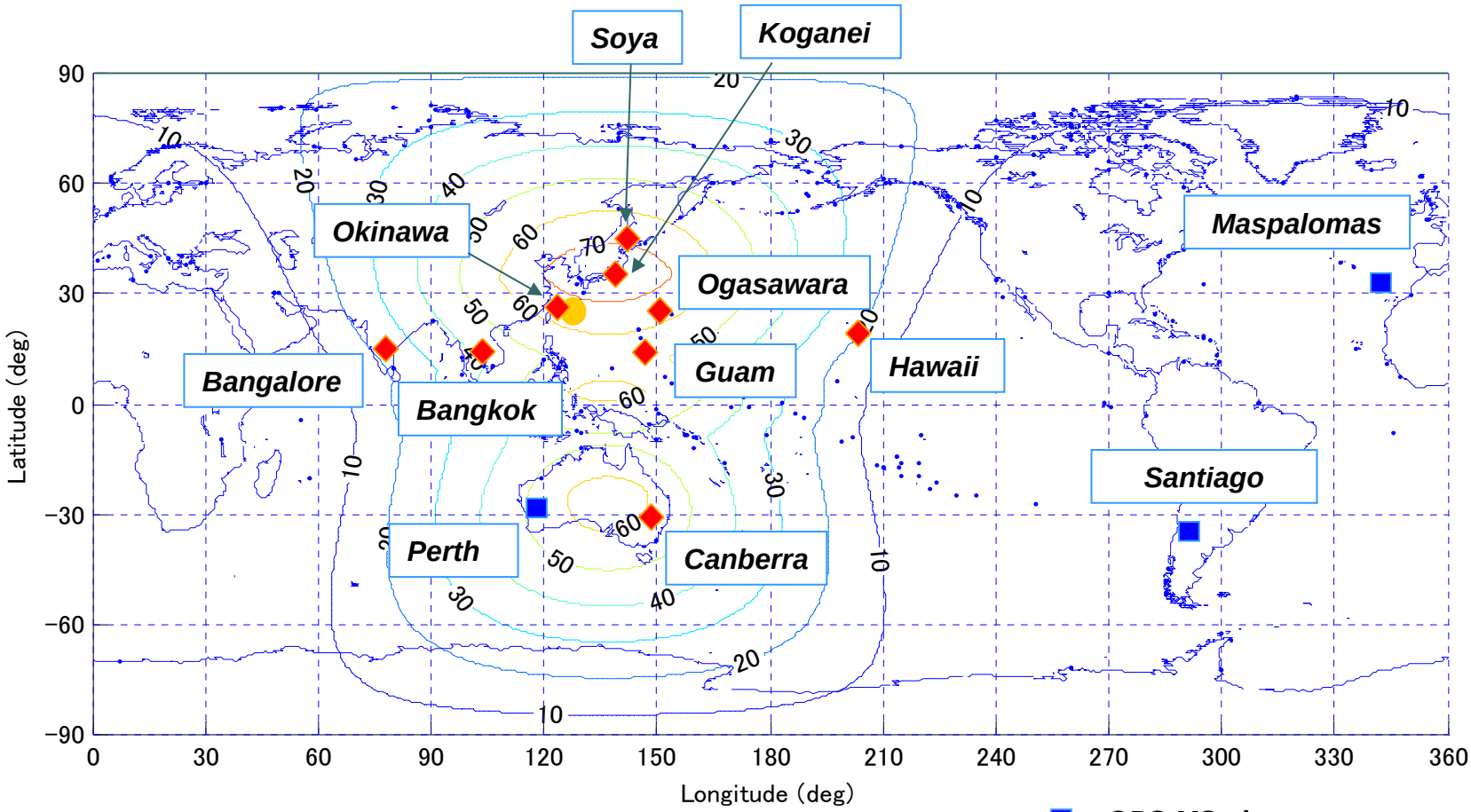
1. System description

Navigation Payload on the QZS-1



1. System description

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

Planned signals

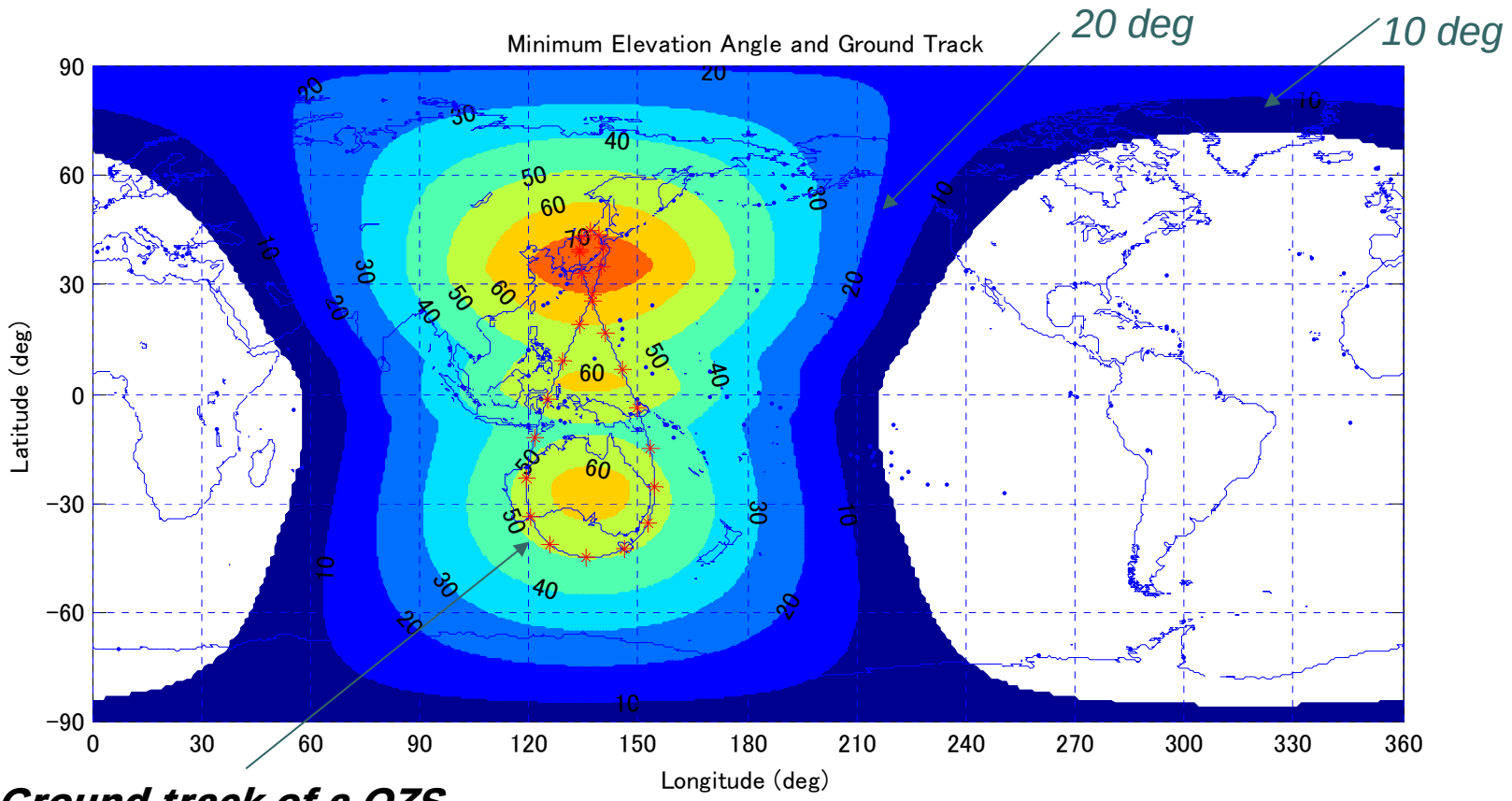
	Frequency	*Notes*
L1-C/A	*1575.42MHz*	➢ *Complete compatibility and interoperability with existing and future modernized GPS signals* ➢ *Differential Correction data, Integrity flag, Ionospheric correction* ➢ *Almanac & Health for other GNSS SVs*
L1C		
L2C	*1227.6MHz*	
L5	*1176.45MHz*	
*L1-SAIF**	*1575.42MHz*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

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 (WGS84) is less than 0.02 [m].

Expected Performance - Service Area -



Ground track of a QZS

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.

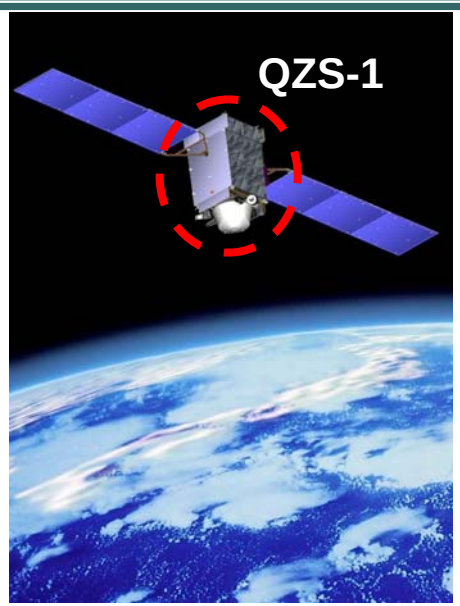
Timetable for system deployment and operation

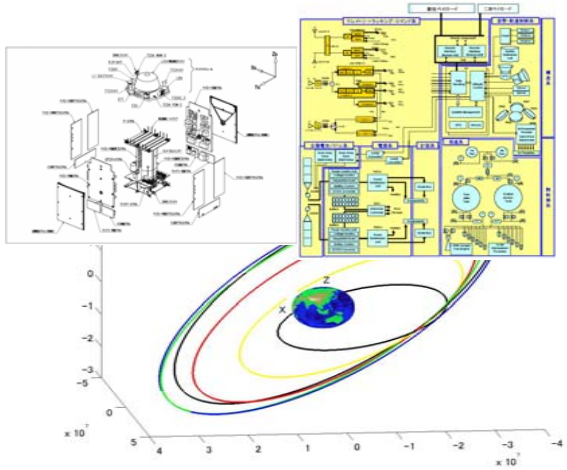
- 2005~6: Phase B (August 2007 PDR)
- 2007~8: Phase C (August 2008 CDR)
- 2008~10: manufacturing, assembly, integration and test
- 2010 Summer : Launch of QZS-1

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

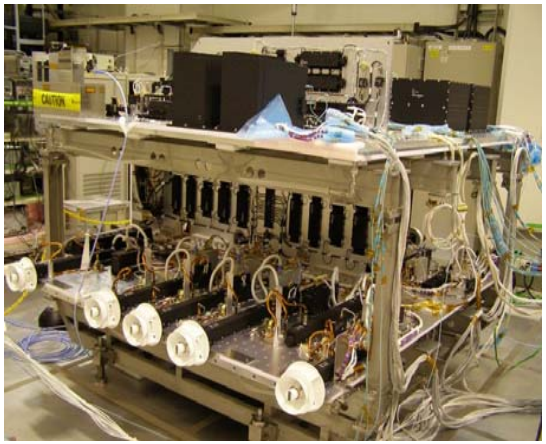
Development status - Space segment -

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





Completion of satellite system Critical design / CDR （August 2008)



NAV Payload PFM TVT （Jan 2009)

Time Comparison Unit (TCU) PFM （March 2008）【MIC】

Main Structure of QZS-1 PFM

(September 2008) 【METI】

Development status - Ground segment -

Site Survey for installing monitoring Station (2007-2008)

Constructing TT&C-NAV Message Uplink Station (2008-2009)

Agreements for hosting QZSS MSs.

- ***NASA***
  Kokee Park Geophysical Observatory (KPGO)
- ***NOAA***
  National Weather Service Forecast Office (WFO)
- ***Indian Space Research Organisation (ISRO)***
- ***Geoscience Australia (GA)***
- ***Asian Institute of Technology (AIT)***

Political Back Ground of the QZSS

- *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*
- *Private Sector-Government Relation Ship is established*
  - ***Satellite Positioning Research and Application Center (SPAC)** was established in 5 February 2007 to promote navigation satellite technology application and consequential geo-spatial information utilization*

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. 1.0 is available on following web site.

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

3. Perspective on compatibility and Interoperability (1/2)

- *GPS*
  - *GPS-QZSS Technical Working Group (TWG) established to achieve compatibility and technical interoperability between QZSS and current and future configurations of GPS in 2002.*
  - *QZSS and GPS success in designing "common" signals*
    - *Five of six QZSS signals use same signal structures, frequencies, spreading code families, data message formats as GPS or SBAS signals*
  - *US-Japan Joint Statement, January 27, 2006 :*
    - *The Technical Working Group concluded that GPS and QZSS are designed to be fully interoperable and compatible.*
- *Galileo*
  - *JAXA-EU Galileo signal task force have had six coordination meetings to secure RF compatibility between QZSS and Galileo.*
  - *QZSS and Galileo have same spectrum of L5–E5a, LEX-E6, and almost close in L1C-E1OS.*

3. Perspective on compatibility and Interoperability (2/2)

- *COMPASS*
  - *RF compatibility coordination between QZSS and COMPASS has just started since July 30, 2007.*

- *Other RNSS systems*
  - *Need bi-lateral coordination for Indian filing for IRNSS if current frequency plan would be changed and L5 signal adopted.*
  - *No frequency overlapping with current GLONASS system. Additional GLONSS CDMA signals on L1 and L5 band request the further bi-lateral coordination with QZSS in future.*

4. 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 JFY 2010*
- *Development of QZS-1 and NAV system is under going.*
  - *NAV payload PFM testing is almost completed and will be delivered to satellite bus system for integration*
- *The User Interface document, IS-QZSS has been established in June 2008 and available on* http://qzss.jaxa.jp/is-qzss/index_e.html*.*