Approach to the era of Multi-GNSS
(GEONET by GSI : part2)

Tetsuro IMAKIIRE

（Geospatial Information Authority of Japan)

Contents

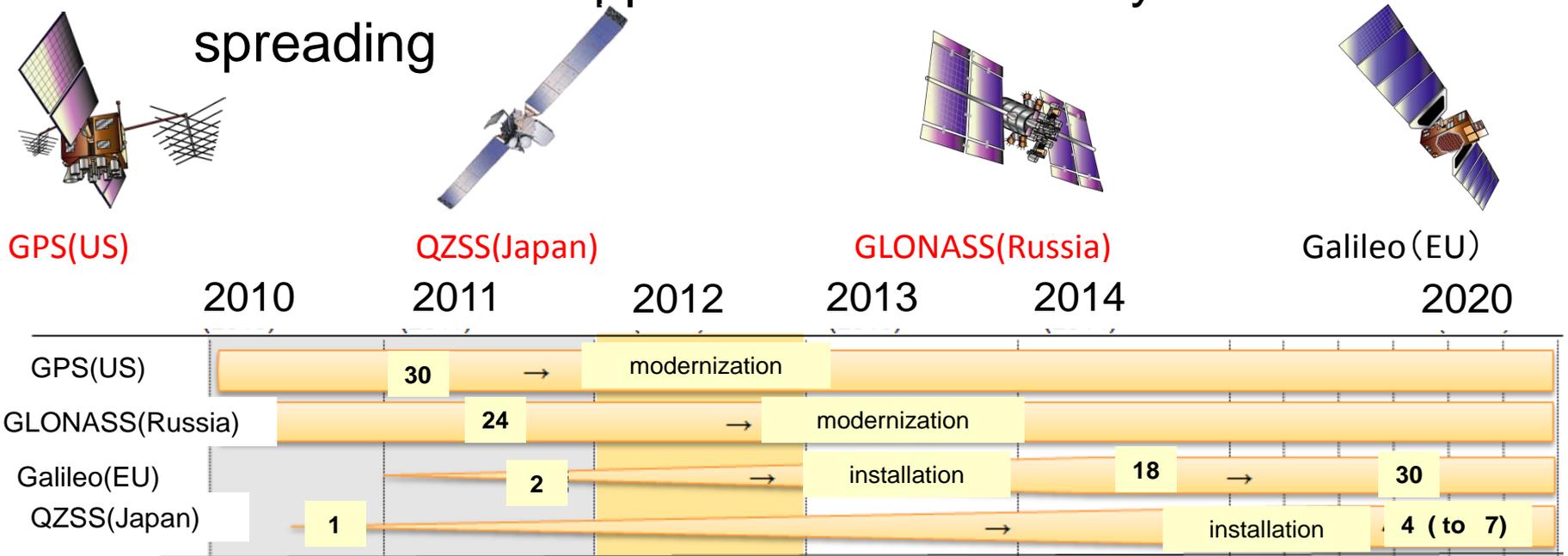# 1. Multi GNSS environment

- ## GNSS other than GPS are now usable

 - Receivers and applications for those systems are spreading

GPS(US)   QZSS(Japan)   GLONASS(Russia)   Galileo（EU）

	2010	2011	2012	2013	2014	2020
GPS(US)		30	→ modernization			
GLONASS(Russia)		24		→ modernization		
Galileo(EU)		2		→ installation	18	→ 30
QZSS(Japan)	1				→ installation	4 (to 7)

- ## GEONET is adapted to this multi-GNSS environment

Multi GNSS

GPS   ：US

GLONASS   ： Russia

GALILEO   ： EU

COMPASS（Beidou） ：China

IRNSS   ： India

QZSS（Michibiki）   ： Japan

GPS

COMPASS

QZSS
(C) JAXA

GLONASS

GALILEO

4
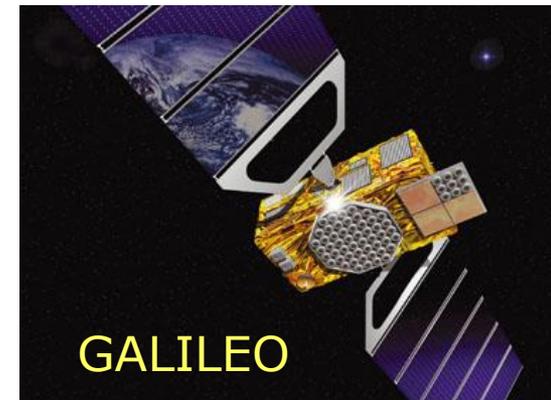
- GPS(US) was only practically usable GNSS in 20th century.
- Now, GLONASS(Russia) is usable with completed constellation.
- Galileo(EU) and BeiDou(China) are partially usable .
- QZSS(Japan) and IRNSS(India) start working as "regional" systems

30 satellites(GPS) $\Rightarrow$ 70(more) satellites(GNSS). improvement of visibility

Signal frequency 2(L1,L2)$\Rightarrow$4(L1,L2,L5,E6) quick solution of the ambiguity
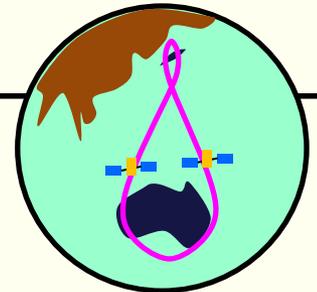

5
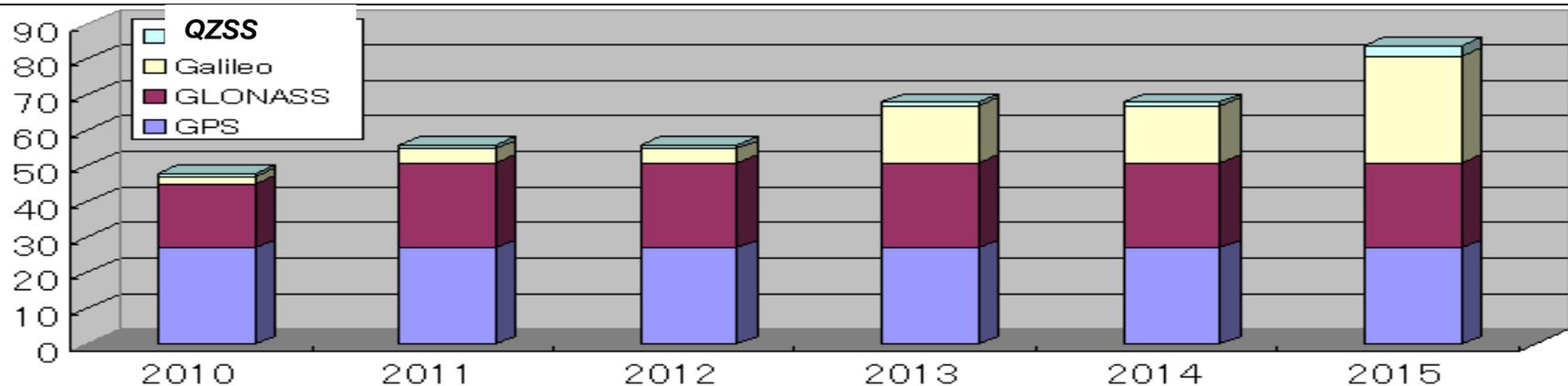
Contribution to multi GNSS environment of Japan

QZSS(Quasi-Zenith Satellite System) GNSS Complimentary / GNSS Augmentation

Schedule

2010   QZO:1 (First Satellite "Michibiki")
2018   4 Satellites Constellation (QZO:3,GEO:1)
Future   7 Satellites Constellation

Coverage Area

Japan, Southeast Asia, Oceania

Signals

L1C/A, L1C, L2C, L5 (Compatibility with GPS)
L1S, L5S, L6 (Augmentation)

GPS and QZSS can be used at one
Synchronize time completely
Compatibility with GPS signals

The number of "visible" GPS group satellites,
above the elevation angle 20 degree

		Total	GPS	QZSS
2013	L1, L2	6-8sat	5-7sat	0.7sat
	L1,L2,L5	2-3sat	1-2sat	
2018	L1,L2	8-10sat	5-7sat	3sat
	L1,L2,L5	6-8sat	3-5sat	
future	L1,L2	10-12sat	5-7sat	5sat
	L1,L2,L5			

Disaster information is created in a government office for disaster, and it distributes to a user through a QZS.

It reaches in several seconds after sending a message.
(periodically)

The user can use it also in a mobile phone interruption area.

Government

Control

GSI operates 7 IGS stations
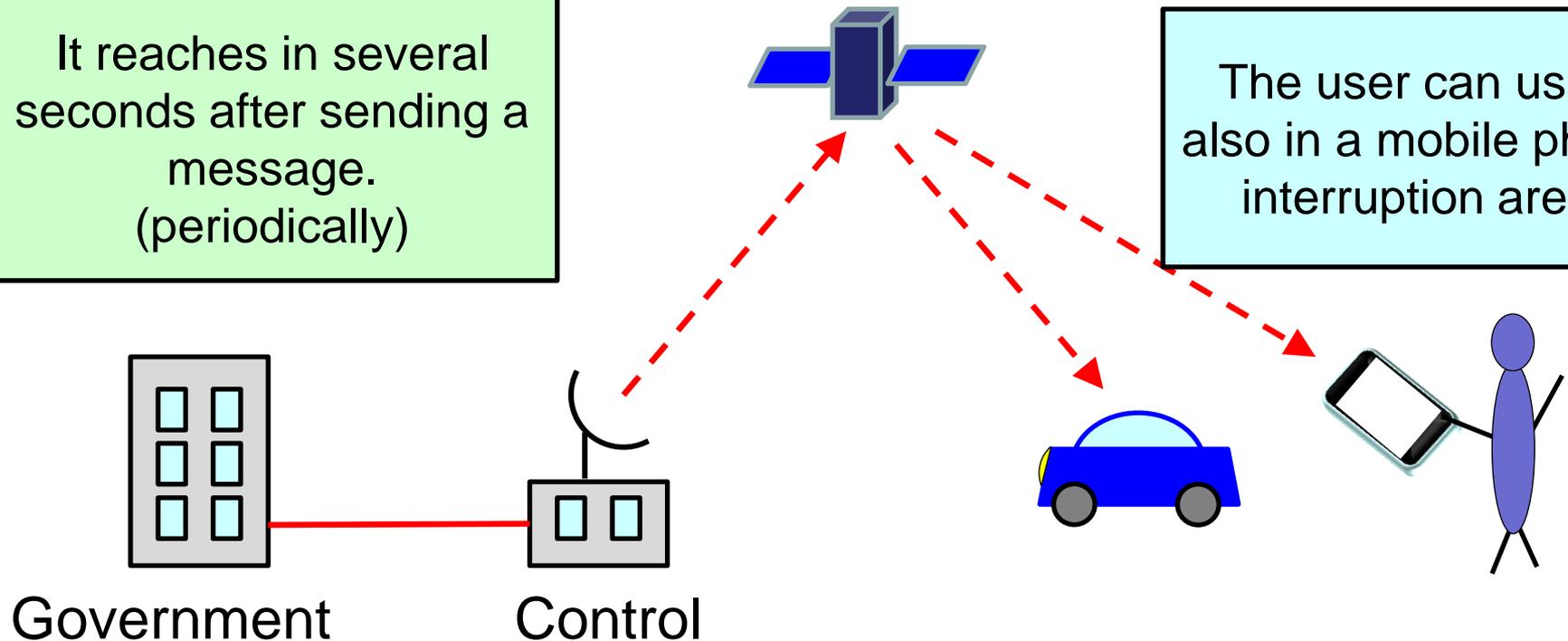
Contributions to the MGM-Net

GSI Registered 4 IGS stations as the MGM-Net stations.

AIRA   STK2   CCJ2   TSK2

Receiver : Trimble NetR9
Antenna : Trimble Choke Ring (TRM59800.00)
Differences from GEONET stations : precise external frequency and radome

GSI has sent the real-time data by Ntrip since last Summer.
The format is BINEX.

2. Utility of Multi GNSS

- Improvement of visibility
  - 30 satellites(GPS) $\Rightarrow$ 70 and more(GNSS).
  - Expanding the opportunity of GNSS survey

- Increase of signal frequency
  - 2(L1,L2) $\Rightarrow$ 4(L1,L2,L5,E6)
  - Quicken the solution of the ambiguity to enhance the real time application
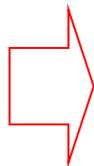
Visibility of the satellites is poor in the very crowded cities

View in Ginza, Tokyo metropolitan area

銀座松屋　　　　　20°

（Image from Google Earth）

Positioning by GNSS is difficult to achieve high accuracy ⟹ Survey by TS is necessary

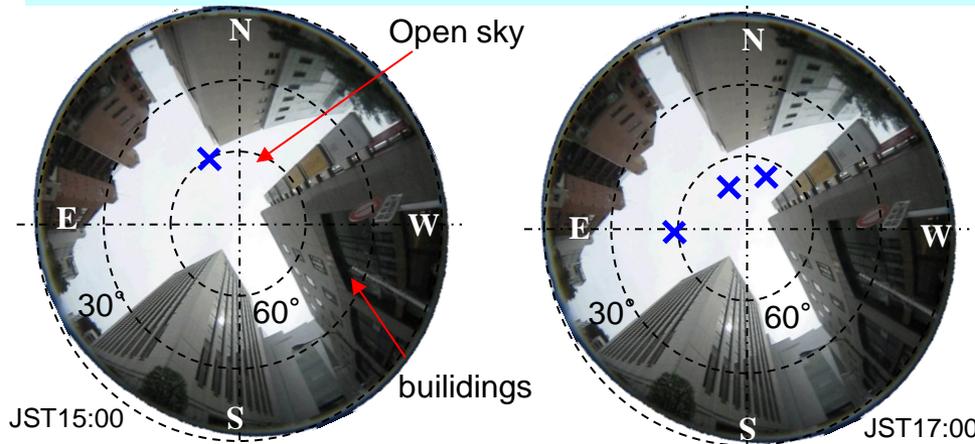Percentage of time; visible 4 or more GPS satellites in Ginza

| Percentage | ■ 0-20. | ■ 20-40. |
| ■ 40-60, | ■ 60-80, | ■ 80-90, | ■ 90-100 % |

（**Based on the document of JAXA**）

Tall buildings block the sight above the observation sites.

Simulation images for the visibility of GPS and other GNSS

GPS only 1-3 satellite(s) ⇒ unable to survey

Open sky

buildings

JST15:00

JST17:00

GPS＋QZSS◇＋GLONASS○＋Galileo△ 7-10 satellites ⇒ able to survey

JST15:00

JST17:00

Visibility in Ginza, Tokyo on 2013 July 21

• At least, 4 satellites should be visible from the observation point to carry out static or kinematic positioning for GNSS survey.
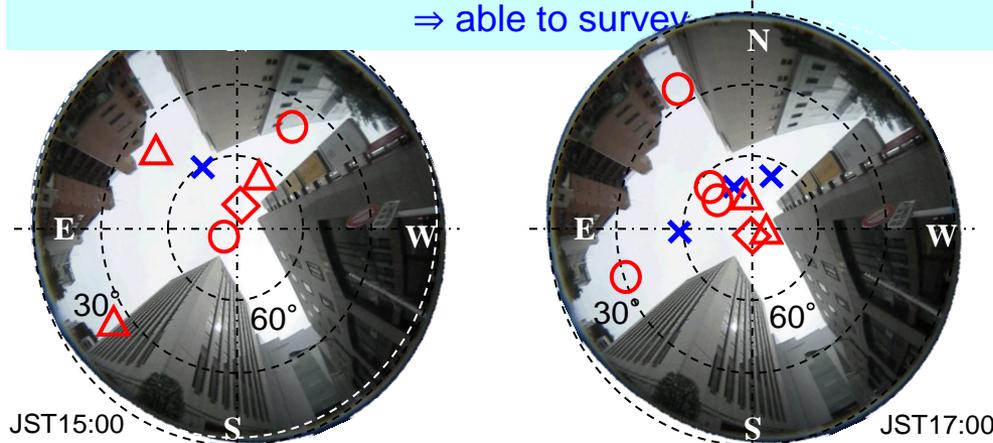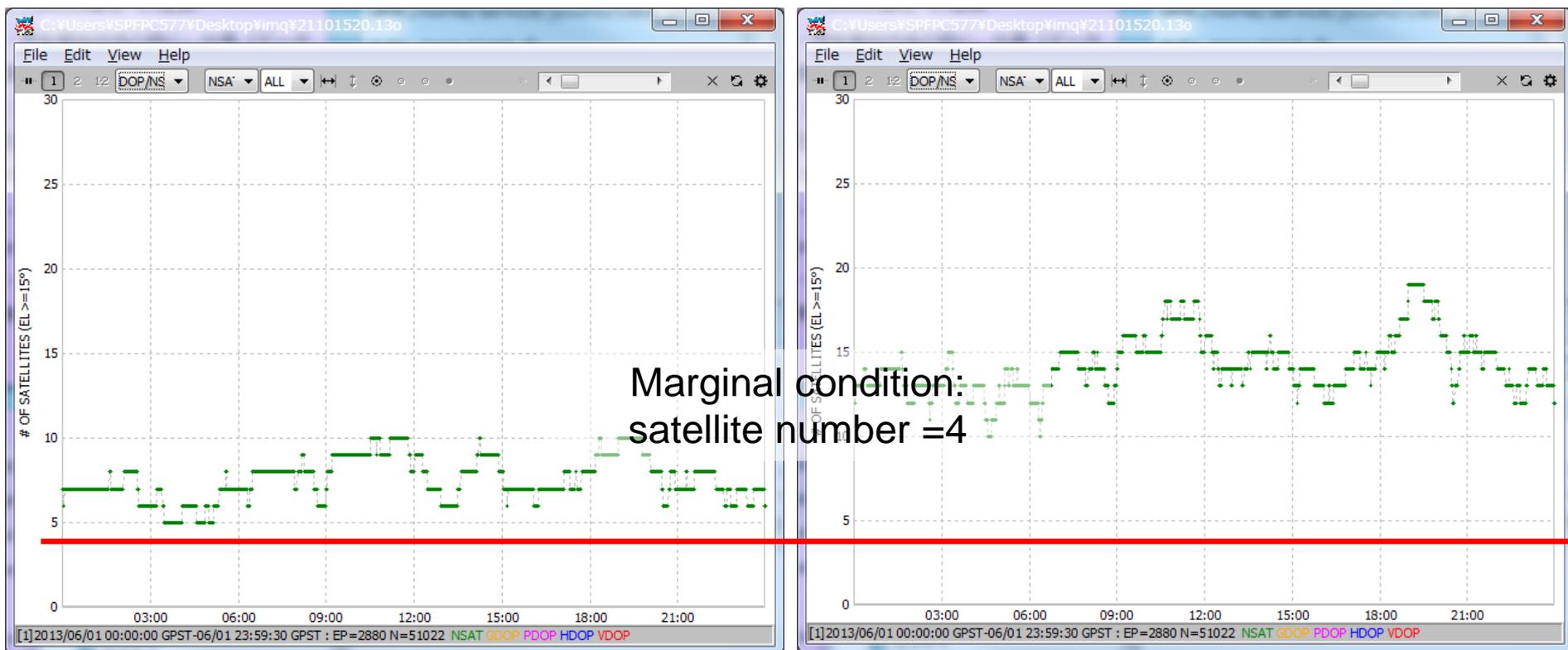
• In the crowded city like Tokyo, multi GNSS environment is necessary to fulfill the condition of visibility of the satellites.
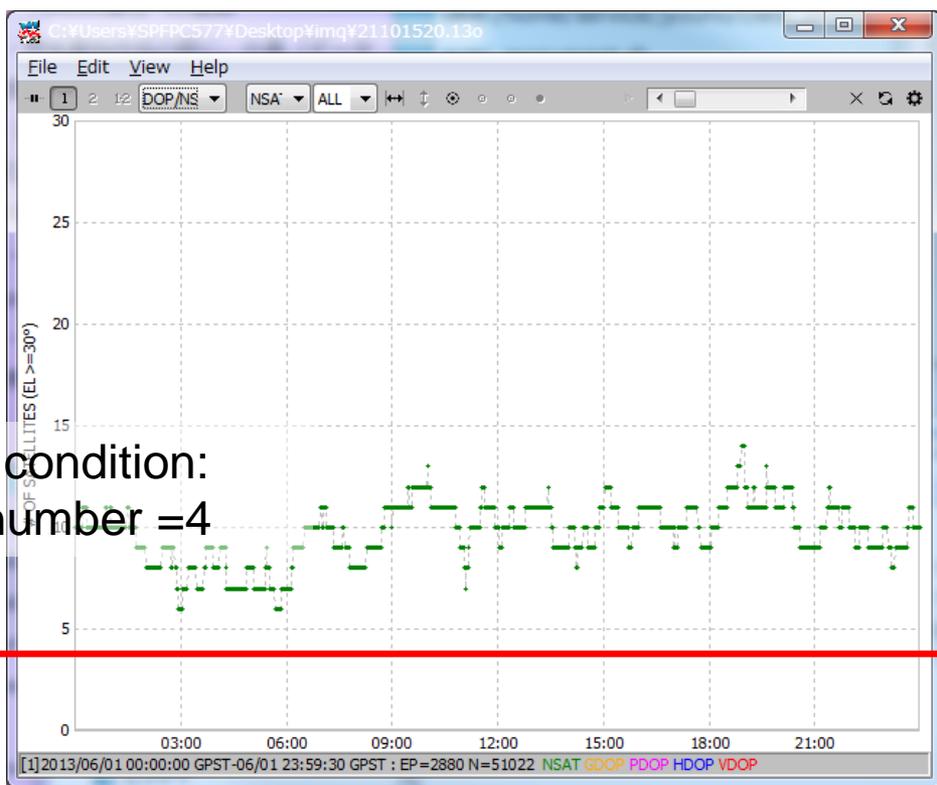
Left: GPS only / Right : GPS+GLONASS+QZSS
Cut-off angle: 15 degree

Marginal condition:
satellite number =4

Visibility of GNSS satellites in Tsukuba site on June 1, 2013
estimation by RTKLIB program

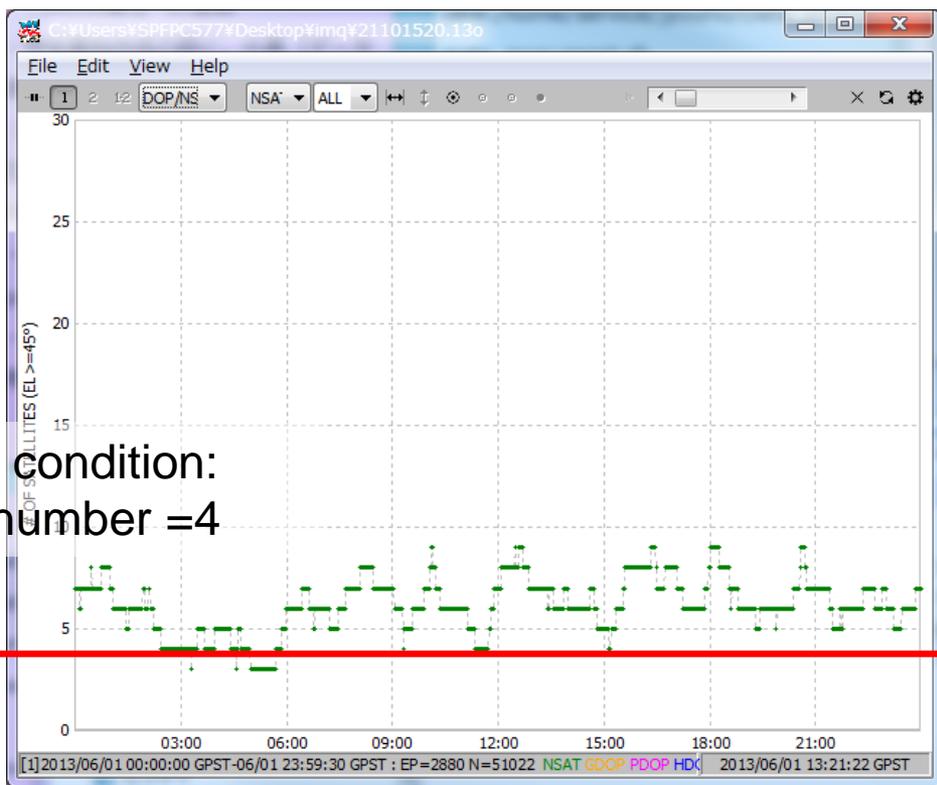## Left: GPS only / Right : GPS+GLONASS+QZSS
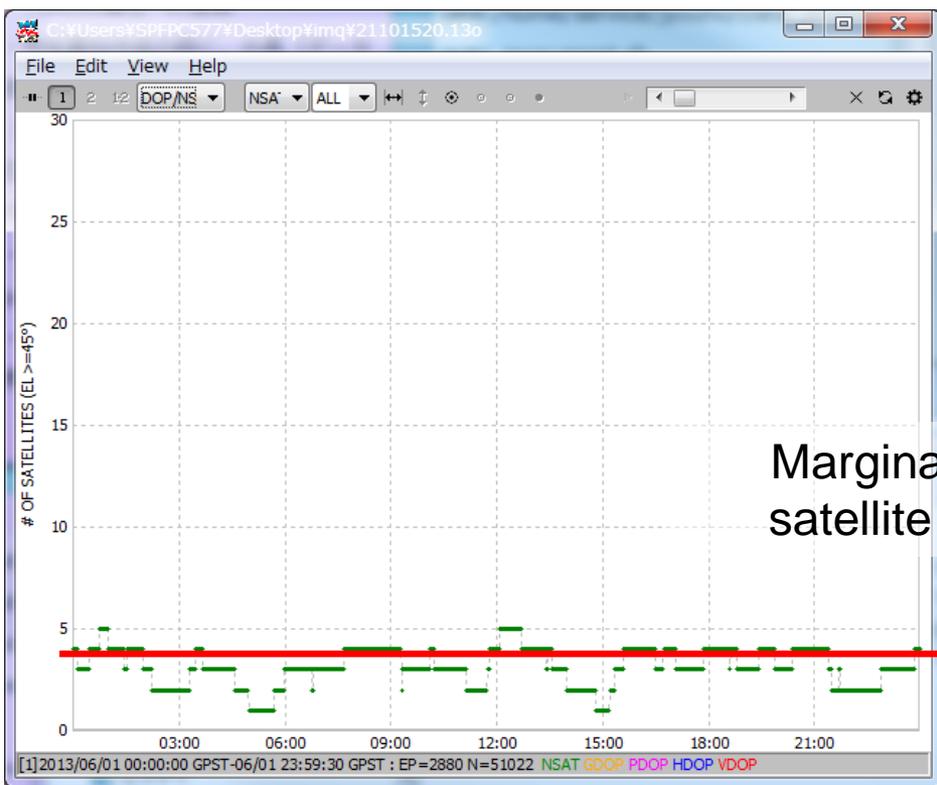## Cut-off angle: 30 degree

Marginal condition:
satellite number =4

Visibility of GNSS satellites in Tsukuba site on June 1, 2013
estimation by RTKLIB program

Left: GPS only / Right : GPS+GLONASS+QZSS
Cut-off angle: 45 degree

Marginal condition:
satellite number =4

Visibility of GNSS satellites in Tsukuba site on June 1, 2013
estimation by RTKLIB program

Single < Dual < Multiple

- Dual frequency GNSS receivers have some advantage compared to single frequency receivers

  - Ionosphere delay correction

  - RTK(real time kinematic) survey

    - time for ambiguity fix is much shorter than single frequency receivers

- Multiple frequency enhance the advantage described above

Multiple frequency allows the more sophisticated ambiguity resolution program for positioning
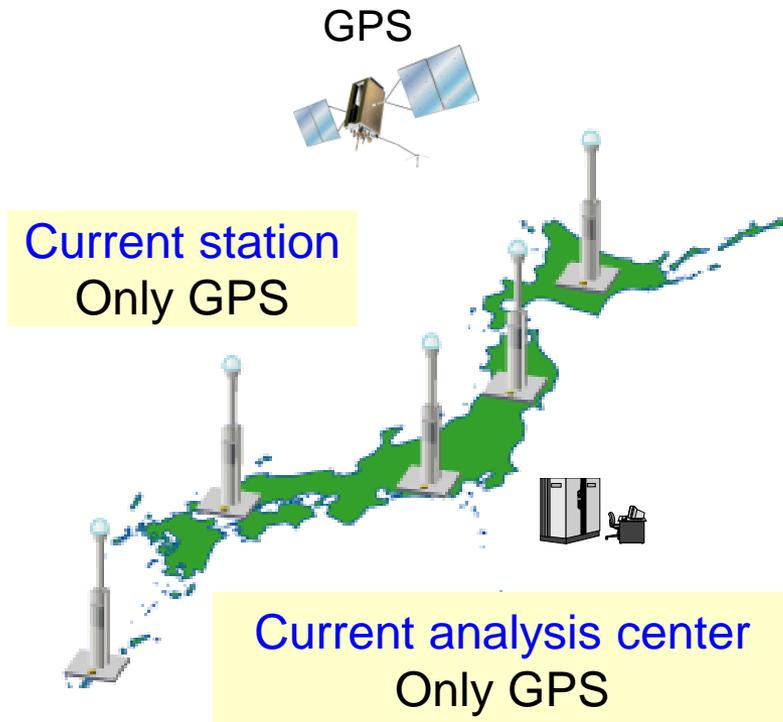

present   new generation
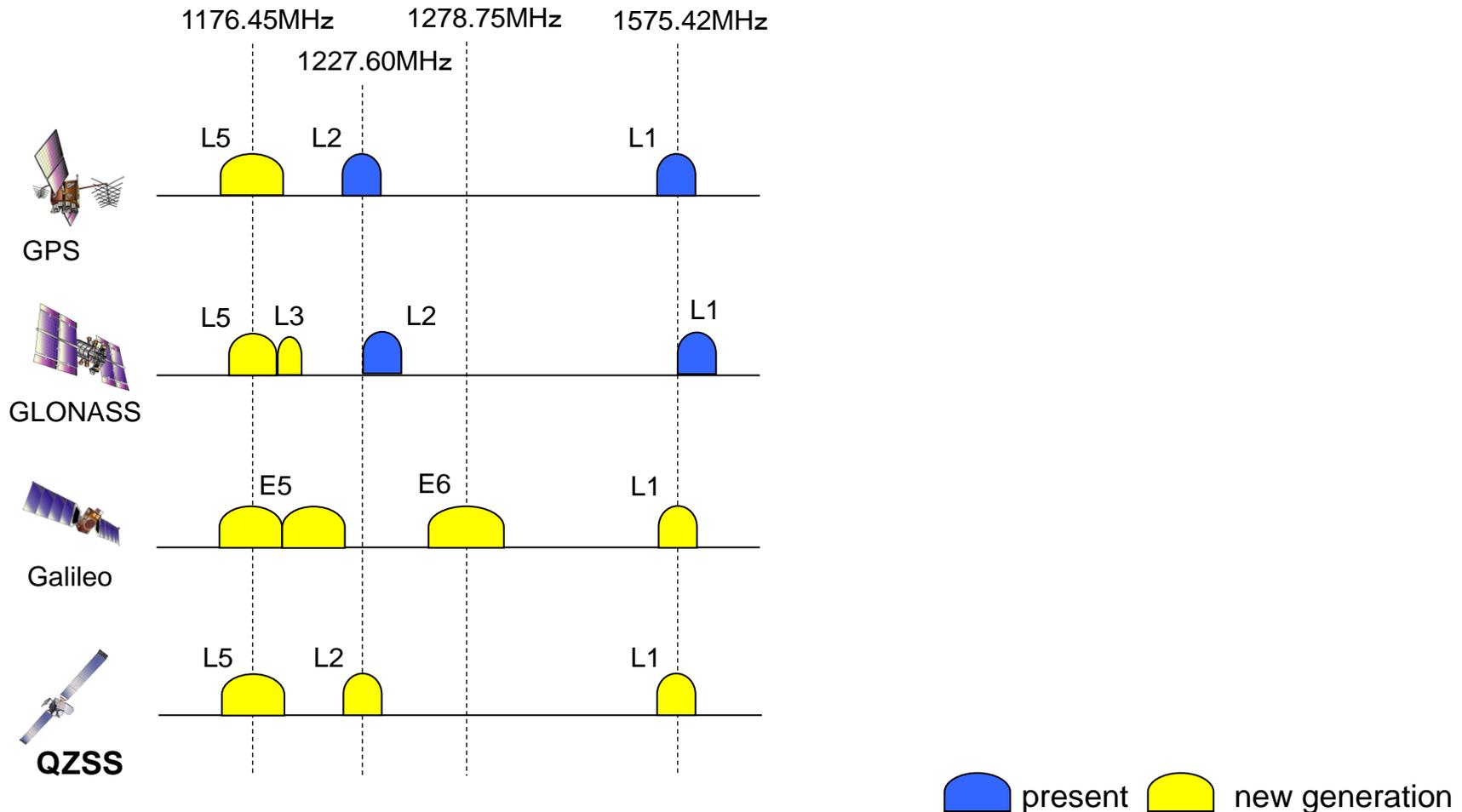
Signal frequencies of GNSS

3. GEONET and Multi GNSS

- GEONET routine analyses have been based only on GPS data
  - Reliable and well known GPS data has been preferable for highly precise crustal deformation monitoring
- Practical users need multi GNSS data for RTK
  - GEONET should be updated for application users

Current GEONET

Next generation GEONET

GPS

Current station
Only GPS

Current analysis center
Only GPS

Galileo   GLONASS   QZSS   GPS

Next generation station
Renewal to GNSS

Next generation analysis system
Renewal to GNSS
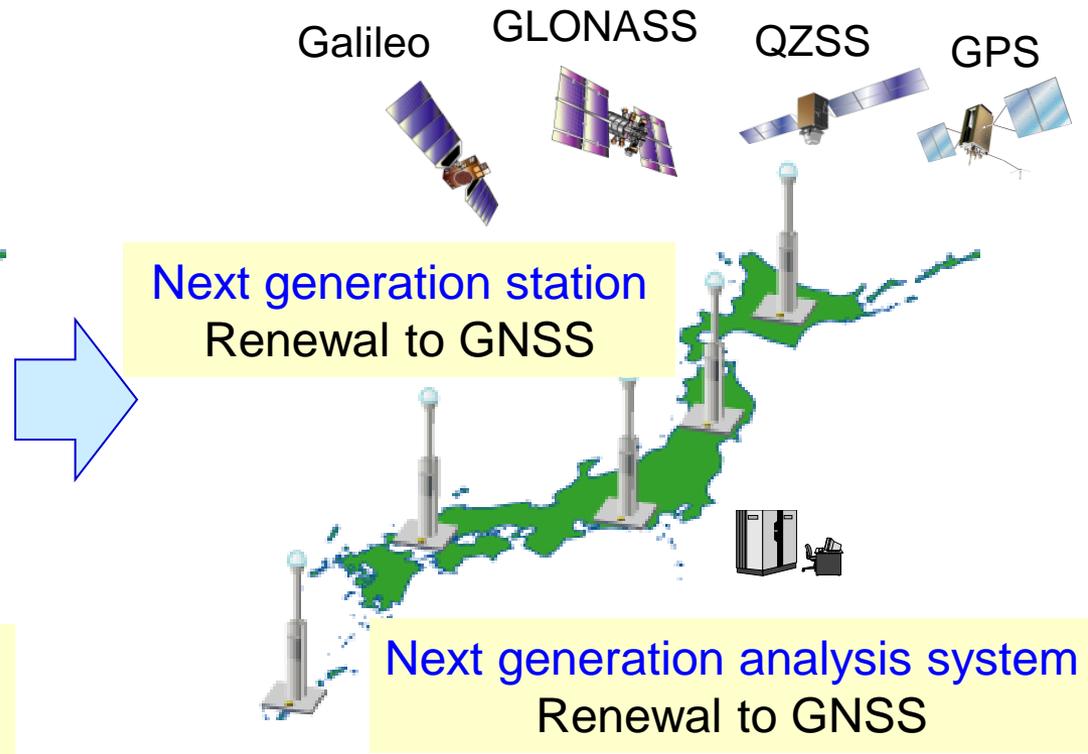
GEONET stations and analysis system update schedule

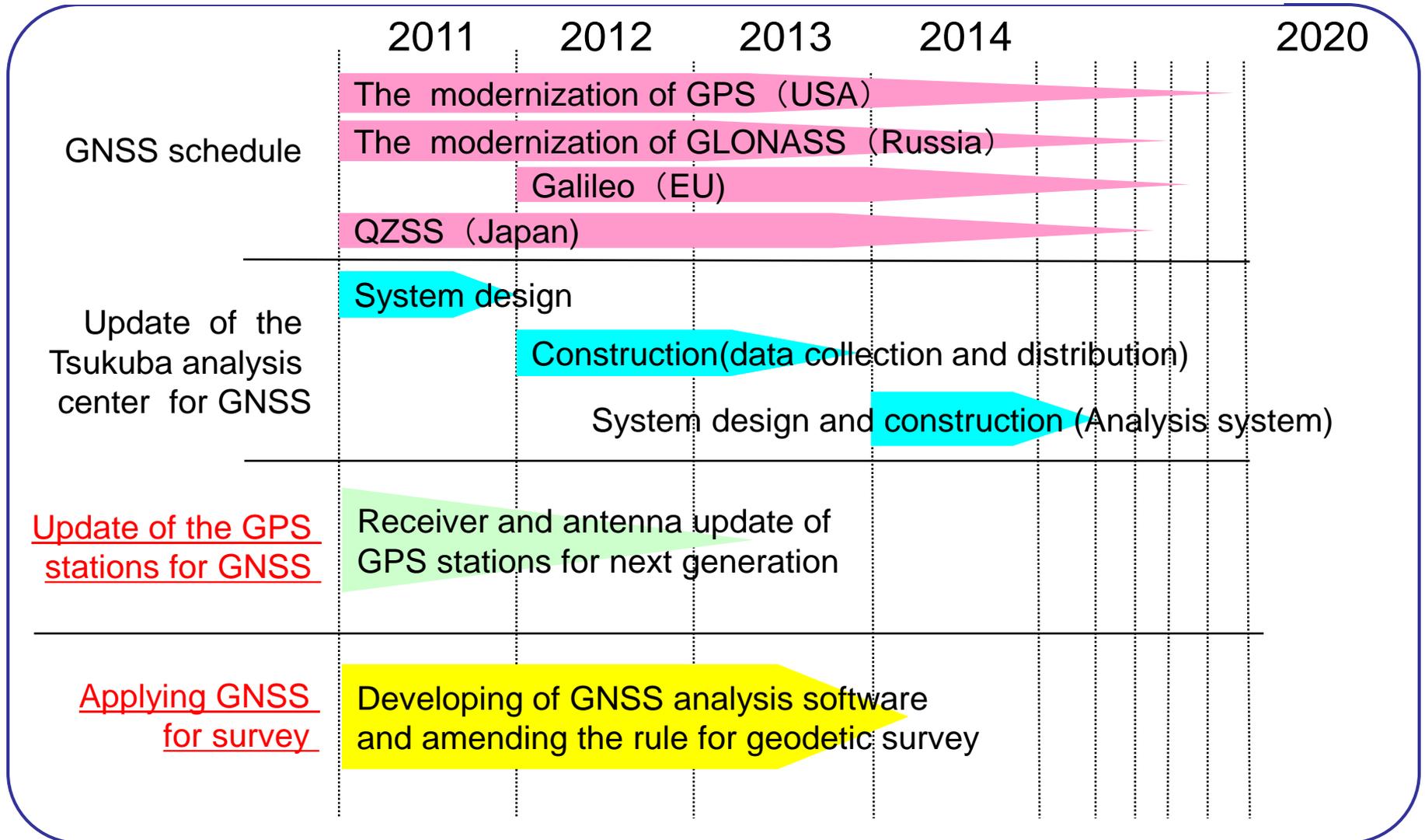|	2011	2012	2013	2014	2020

GNSS schedule

The modernization of GPS（USA）

The modernization of GLONASS（Russia）

Galileo（EU）

QZSS（Japan）

Update of the Tsukuba analysis center for GNSS

System design

Construction(data collection and distribution)

System design and construction (Analysis system)

Update of the GPS stations for GNSS

Receiver and antenna update of GPS stations for next generation

Applying GNSS for survey

Developing of GNSS analysis software and amending the rule for geodetic survey

Most stations have multi GNSS receivers, now.

GNSS data have been provided
since July 13th, 2012.
The number of stations is 1,220.

- GPS, GLONASS, QZSS

- signals : GPS (L1 and L2),
  GLONASS (L1 and L2),
  QZSS (L1, L2, L5)

- format : RINEX v2.12
  qzss_extension

O provided since July 13th, 2012
O provided since April 1st, 2013
O provided since May 10th, 2013
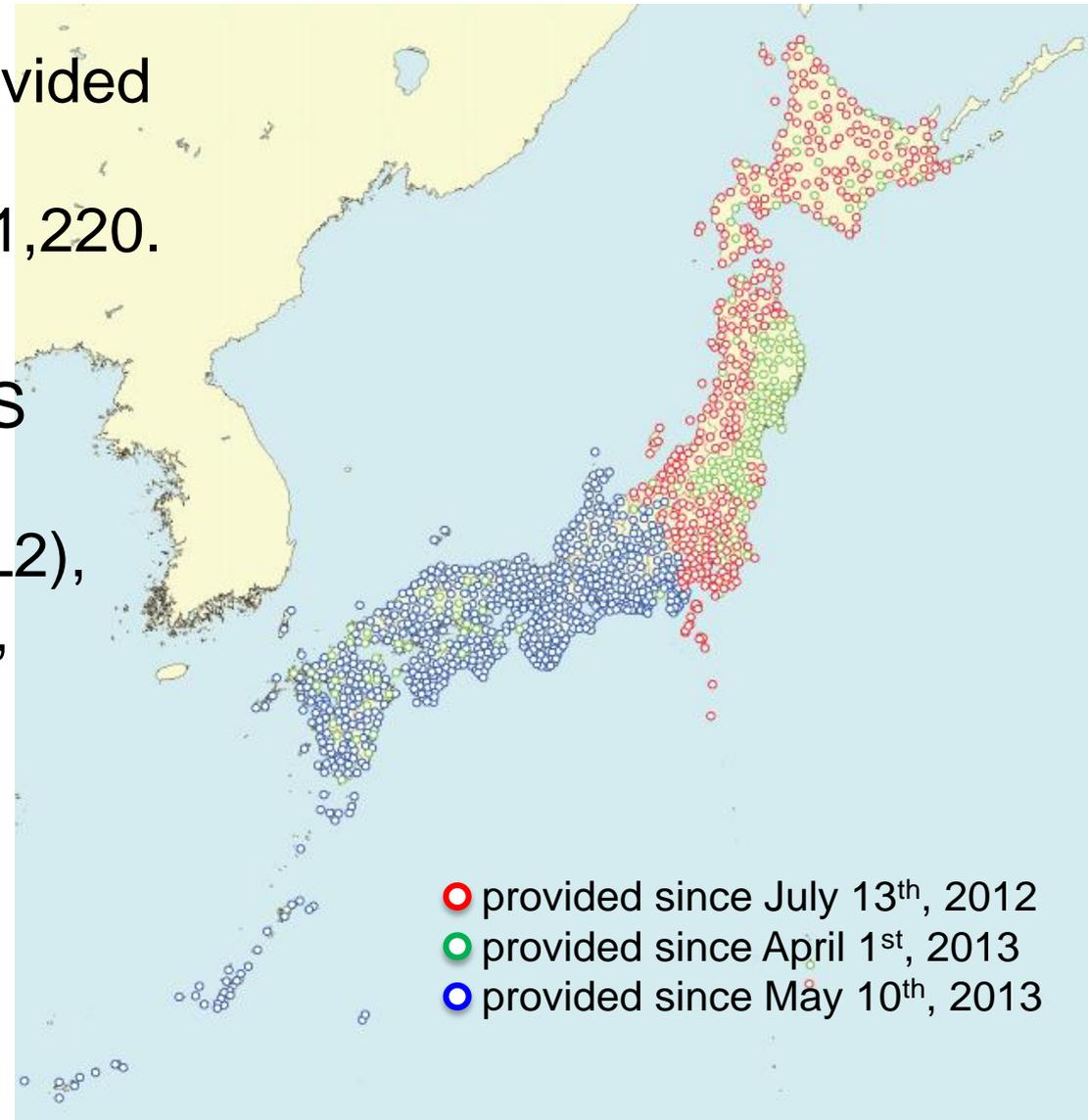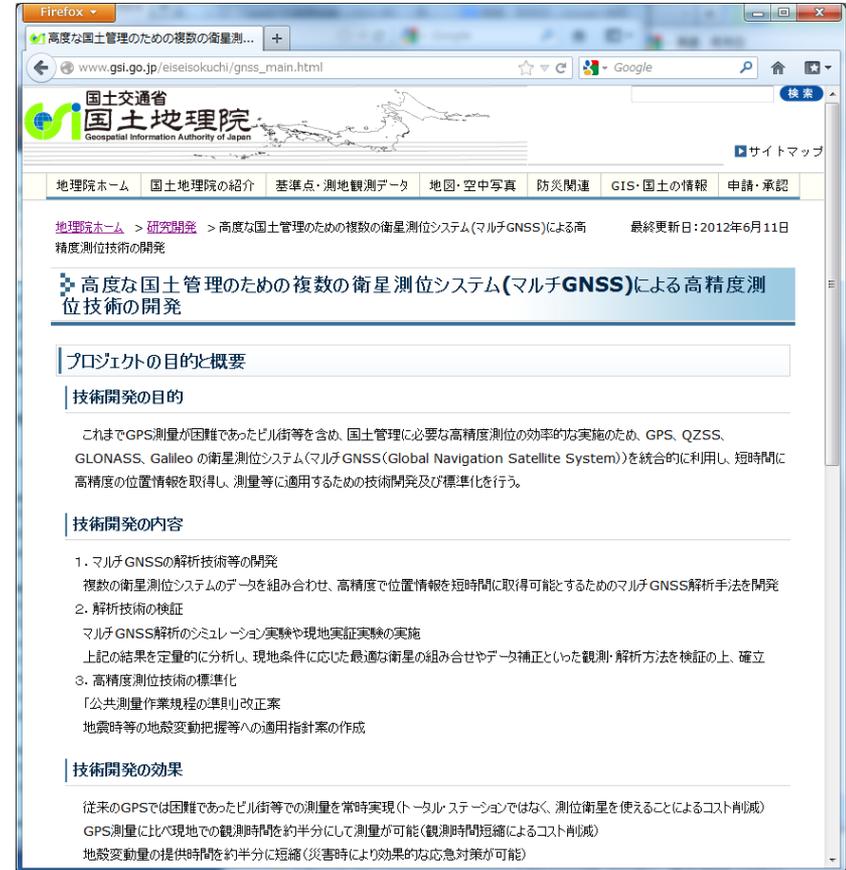
Applying GNSS for survey

GSI is developing new analysis software.

<targets>

Satellites : GPS, GLONASS, QZSS, Galileo
Signals : L1, L2, L5
Corrections : Inter Frequency Bias, Inter System Bias, L2C quarter cycle shift …

http://www.gsi.go.jp/eiseisokuchi/gnss_main.html
Sorry, currently Japanese only…

GSI is going to release the developed software including the source codes and the documents of analysis algorithms on our web site. GSI expects that they are referred to improve the other software.
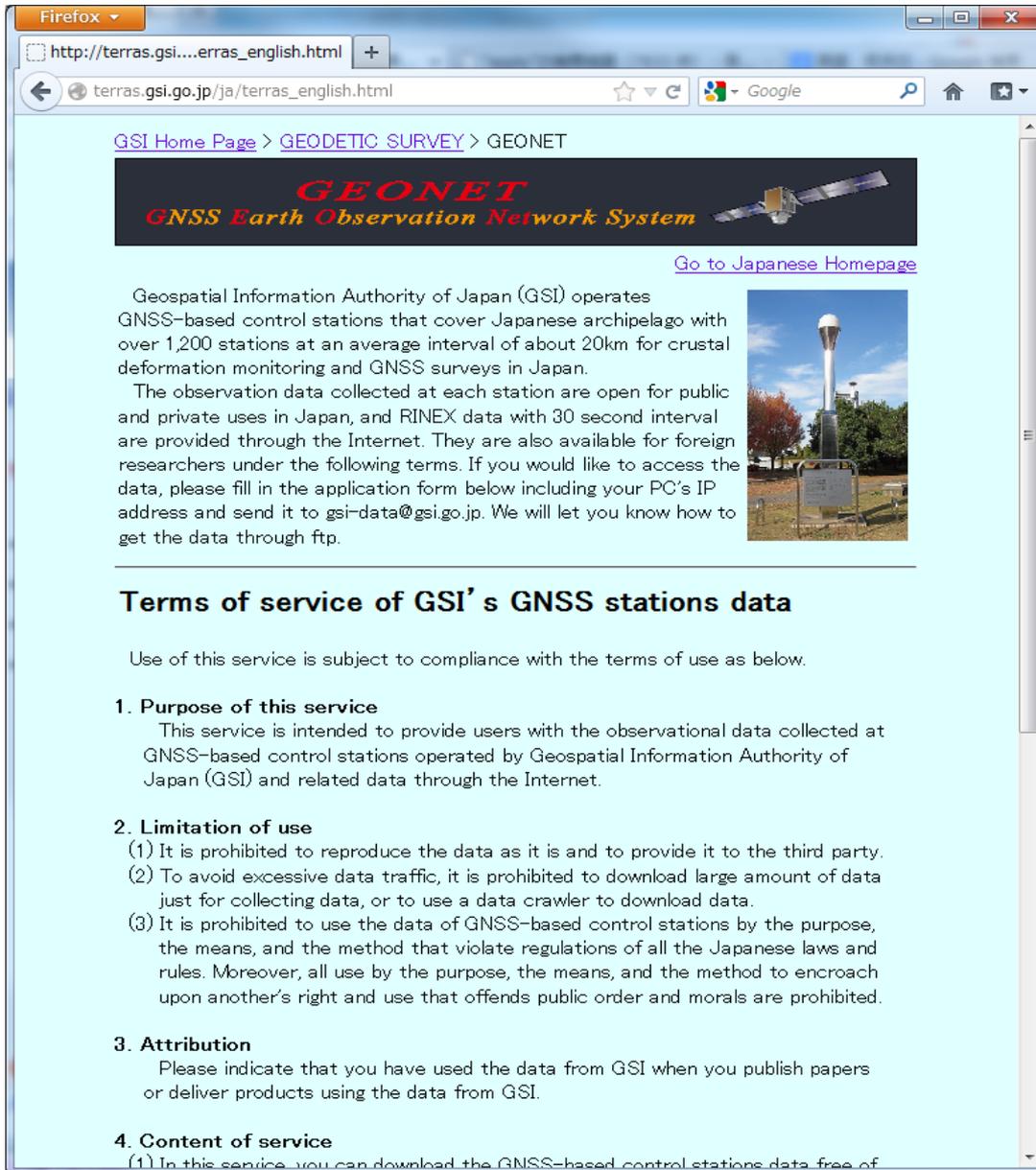
How to get the data

- Fill in the application form and send it to gsi-data@gsi.go.jp

- The application form is posted on our Web site. http://terras.gsi.go.jp/ja/terras_english.html

**http://terras.gsi.go.jp/ja/terras_english.html**

- Real time data (1 second epoch) of GEONET is sent to the end users by private companies through NPO distributor

- Main purpose is RTK(network RTK) survey and positioning for ITC construction works

- GLONASS and QZSS real time data are now usable (from May 10, 2013) for almost all the sites of GEONET

Real time data service scheme

GEONET real time data service: system diagram

GSI:Tsukuba

KDDI:Shinjuku

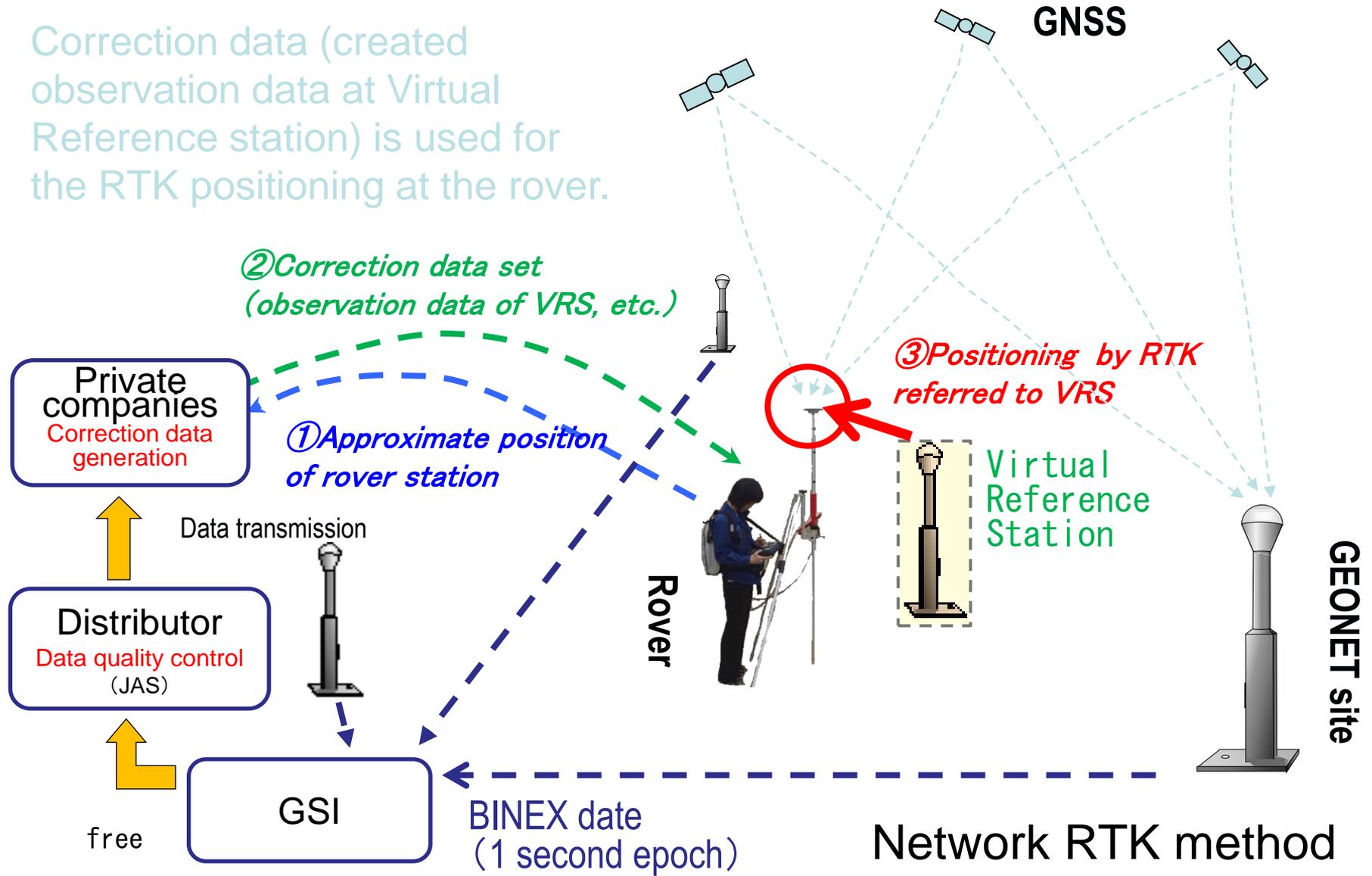Japanese Association of Surveyors: Itabashi, Tokyo

Users
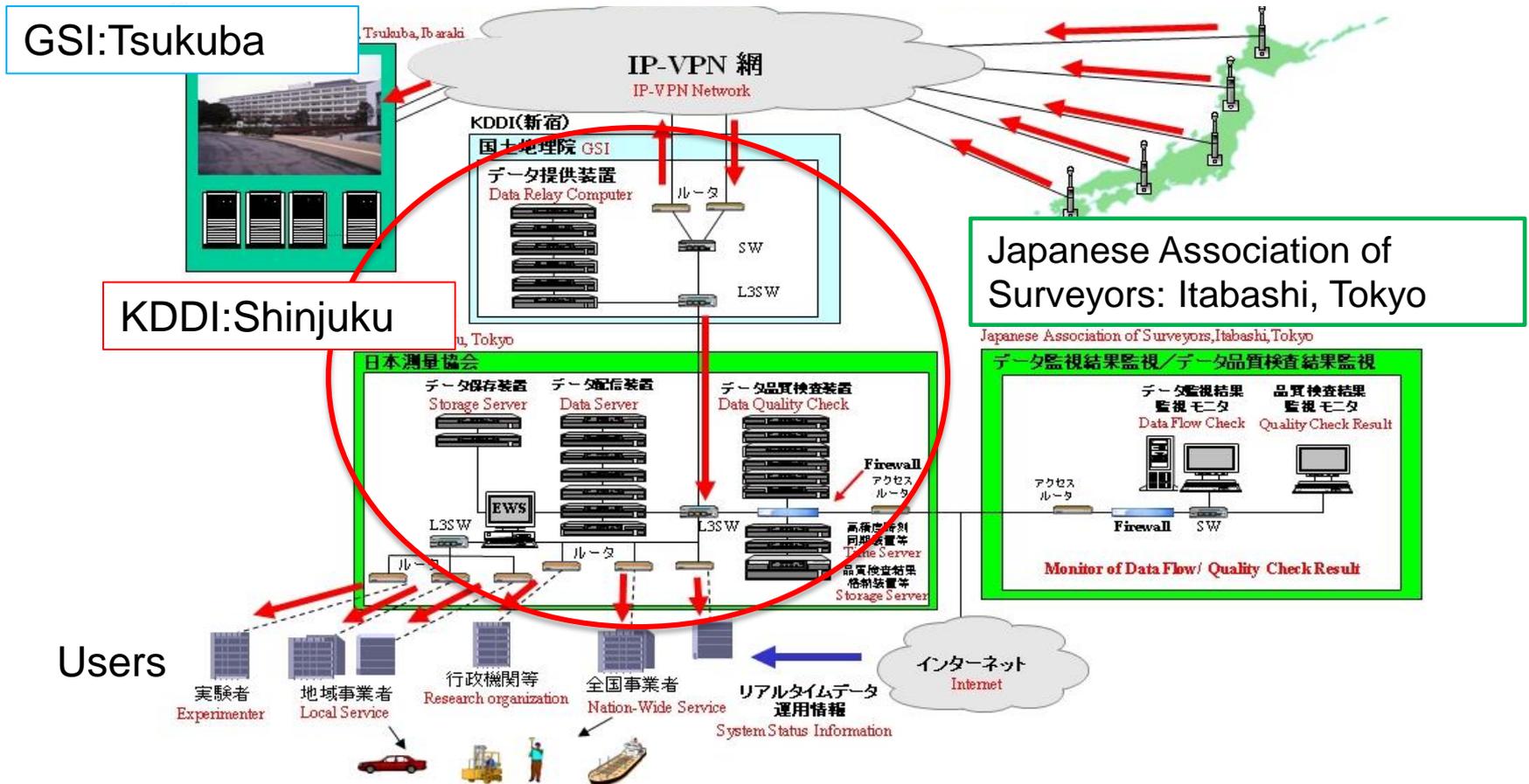
Real time data is distributed through JAS(non-profitable organization) to private sectors. Two private companies are operating commercial data service .
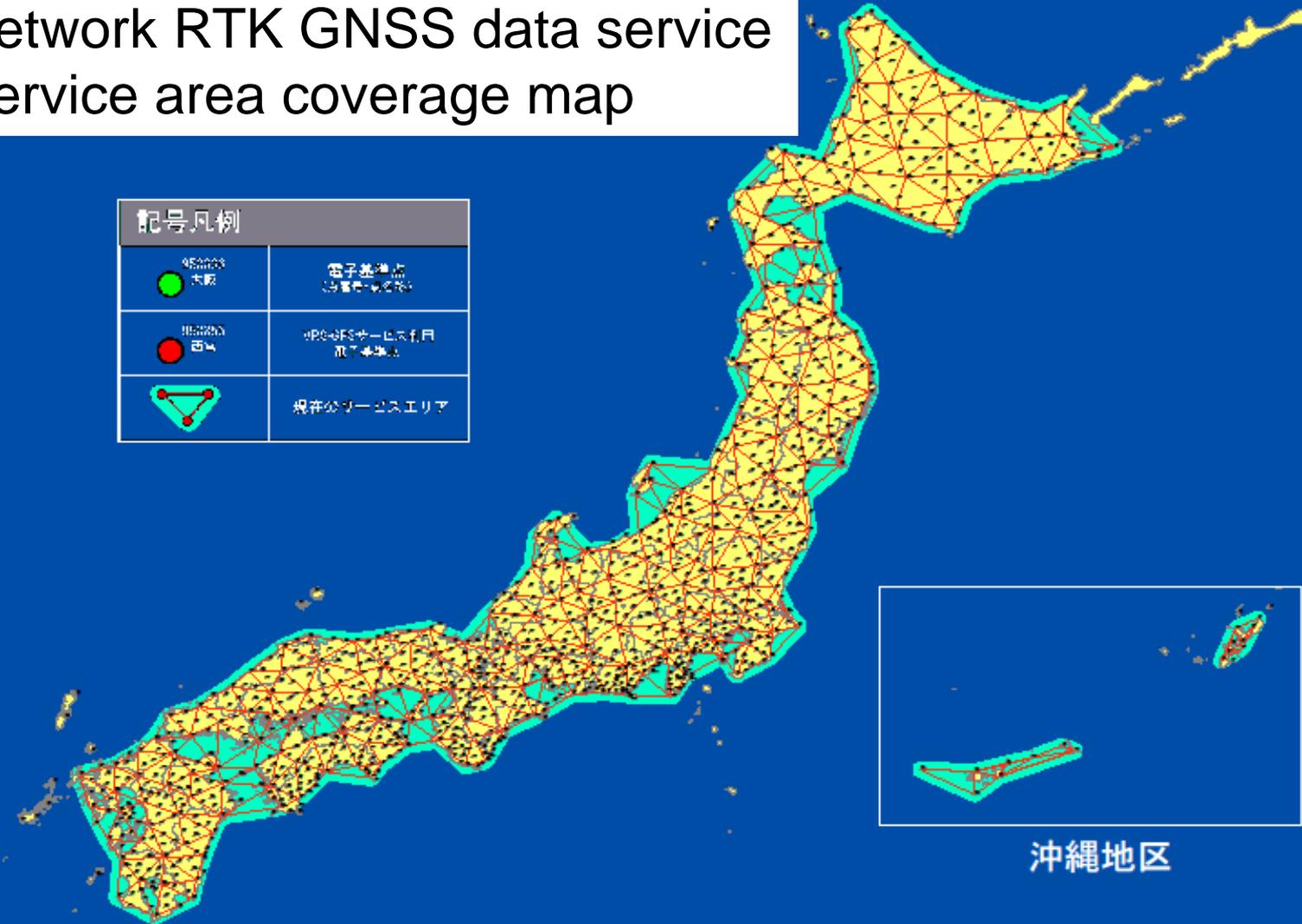
Network RTK Survey(VRS)

Correction data (created observation data at Virtual Reference station) is used for the RTK positioning at the rover.

GNSS

②Correction data set
(observation data of VRS, etc.)

③Positioning by RTK referred to VRS

Private companies
Correction data generation

①Approximate position of rover station

Data transmission

Distributor
Data quality control
（JAS）

Virtual Reference Station

Rover

GEONET site

free

GSI

BINEX date
（1 second epoch）

Network RTK method

Example of network RTK service in Japan

Network RTK GNSS data service
Service area coverage map

沖縄地区

Mainland, Okinawa and coastal sea area are covered
(based on the document of Jenoba）

Automatic operation of bulldozer using RTK positioning

GNSS
Antenna

4. Summary

- Multi GNSS environment enhances the utility of GNSS survey and positioning for the various aspects, especially for real time usages
  - Improvement of visibility
  - Shortening of the ambiguity fix time
- GEONET is updated to be usable for multi GNSS (now for GPS, GLONASS, QZSS)
- Multi GNSS data service is now on practical use in Japan

Thank you for your attention !