Construction of a VGOS Station in Japan

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Abstract The Geospatial Information Authority of Japan (GSI) began a new project for constructing a VGOS station in Japan. The construction of the antenna (radio telescope) has been completed, and the necessary equipment (Front-end, Back-end, H-maser, and so on) has also been delivered. The name of the new station is Ishioka, which is located 17 km away from the Tsukuba 32-m antenna. We briefly report the current status of the construction of the new antenna.

Keywords VGOS, broadband receiving

1 Introduction

The Geospatial Information Authority of Japan (GSI) has carried out VLBI observations since 1981. In the first period from 1981 to 1994, we developed transportable VLBI systems with a 5-m antenna and a 2.4-m antenna and carried out domestic sessions using them. As a result, eight sites in Japan were observed, and precise positions were determined. In addition, Japan–Korea VLBI sessions were carried out by using a transportable 3.8-m antenna in 1995. In these sessions, the Kashima 26-m antenna, which was removed in 2002, was used as the main station. In the second period from 1994 to 1998, GSI established four permanent stations: the Tsukuba 32-m, Sintotsukawa 3.8-m, Chichijima 10-m, and Aira 10-m antennas. Up to the present, regular VLBI sessions using the four stations were carried out. The Tsukuba 32-m antenna is a main station for not only domestic but also international VLBI sessions now.

In 2011, GSI started a project for constructing a new antenna following the VLBI2010 concept, which is recommended by the International VLBI Service for Geodesy and Astrometry (IVS) as the next-generation VLBI system. This paper gives the outline of the project and the current status of the construction of the new antenna.

Geospatial Information Authority of Japan

2 Observing Facilities

In the new project, observing facilities are now being constructed. The conceptual design of the facilities consisting of six components is depicted in Figure 1. The Operation Building will be constructed by the Construction Department of Ministry of Land, Infrastructure, Transport, and Tourism a few years later than the original plan.

3 Components

3.1 Antenna

The antenna (radio telescope) is the main part of the observing system. Since a single antenna is employed, very high slew rates are specified in order to be compliant with the VLBI2010 concept. The specifications of the antenna are listed in Table 1. The photo of the new antenna is shown in Figure 2.

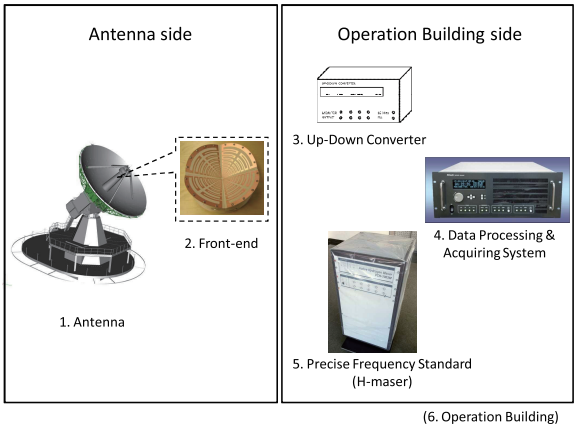

Fig. 1 Conceptual design of the new observing facilities.

Table 1 Specifications of the new antenna.

Parameter	Value
Diameter	13.2 m
RF frequency range	2–14 GHz
Surface accuracy	$\leq$ 0.08 mm (RMS) (at EL 45°)
Aperture efficiency	$\geq$ 50%
Antenna noise temperature	$\leq$ 10K (excluding atmospheric contributions)
System G/T	$\geq$ 45.882 dB (at 14 GHz) [T is the system noise temperature (Tsys), and Tsys excluding antenna noise temperature should be assumed as 30K.]
AZ maximum slew rate	$\geq$ 12°/sec
EL maximum slew rate	$\geq$ 6°/sec
AZ maximum acceleration rate	$\geq$ 3°/sec^2
EL maximum acceleration rate	$\geq$ 3°/sec^2
Cable for signal transfer	Optical fiber cable from antenna to building
Special feature	Reference point should be measured directly from the ground for co-location.

3.2 Front-end

According to the VLBI2010 concept, a broadband feed is necessary to achieve high aperture efficiency over 2–14 GHz. At present the Eleven feed, which was developed at Chalmers University of Technology in Sweden, and the Quadruple-Ridged Flared Horn (QRFH), which was developed at California Institute of Technology (Caltech), were practical as a broadband feed, so both feed systems were purchased. For the design

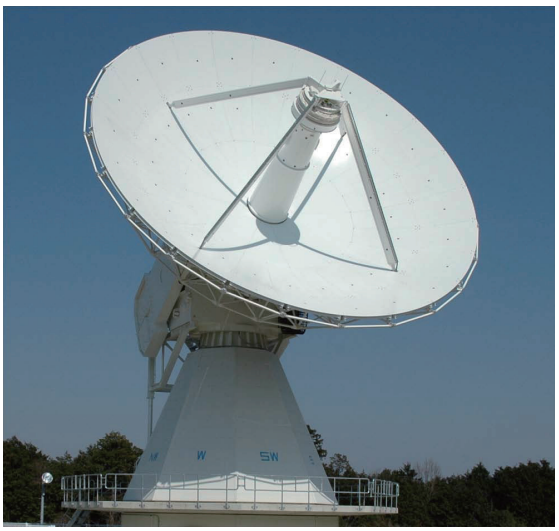

Fig. 2 Photo of the new antenna.

of the antenna optics, employing the Eleven feed was assumed.

In both cases, the feeds and the Low Noise Amplifiers (LNAs) are integrated into each cryogenic system, whose physical temperature is less than 20 K. The measured receiver noise temperatures for a QRFH system are less than approximately 30 K (see Figure 3). The specifications of the front-end are shown in Table 2.

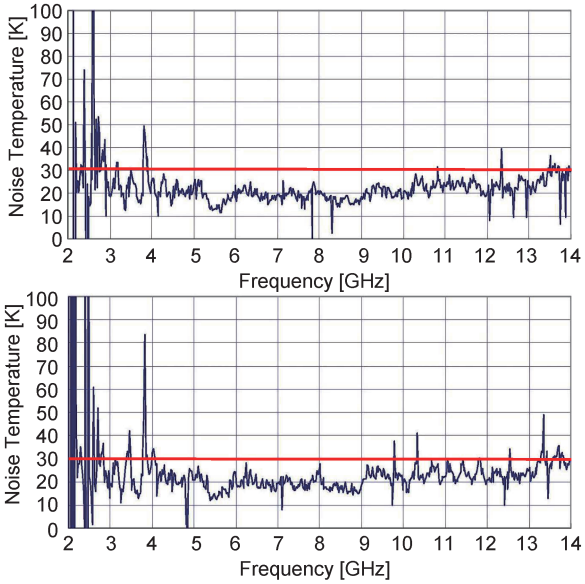

Fig. 3 Receiver noise temperature for QRFH system (upper: horizontal polarization, lower: vertical polarization).

Table 2 Specifications of the front-end.

Parameter	Value
RF frequency range	2–14 GHz
Polarization	Dual linear polarization
Feed	Eleven feed or QRFH
Dewar	Feed, LNAs, and other devices should be included and cooled by cryogenic system.
Physical temperature	$\leq$ 20 K (1st stage)
System noise temperature	$\leq$ 30 K (excluding antenna noise temperature)
Total gain	$\geq$ 45 dB
Output frequency range	2–14 GHz
Number of outputs	2 (for dual linear polarization)
Phase and delay calibration	New-type P-cal unit New cable calibration system developed by NICT
Injection of P-cal/noise-source	In the front of the feed or LNAs

3.3 Up-Down Converter

In order to convert the observed analog signal to digital data, the frequencies should be downconverted. For this purpose, a new Up-Down Converter is under development. The output signal frequencies are 1–2 GHz. The Lower Side Band (LSB) and the Upper Side Band (USB) need to be selectable in the Up-Down Converter, because the second Nyquist zone will be used in the sampler (see Section 3.4). The specifications of the Up-Down Converter are given in Table 3.

Table 3 Specifications of the Up-Down Converter.

Parameter	Value
Input frequency range	2–14 GHz
Output frequency range	1–2 GHz
Type of output signal	LSB or USB (selectable)
Number of units	4
Number of channels per one unit	2 (for dual linear polarization)
1st local oscillator	Programmable with 0.4-MHz step
2nd local oscillator	2 fixed LOs for LSB and USB
Total noise figure	$\leq$ 25 dB
Phase stability	$\leq$ 4° with $\pm$2°C temperature change

3.4 Data Processing and Acquisition System

The data processing and acquisition system includes samplers, a Digital Back-end (DBE) function, and huge data storage. The sampling rate is 2048 Msample/sec, and the quantization is 1/2/4/8 bits (selectable). The second Nyquist zone will be used. The DBE function is equipped for the compatibility with the legacy observation system. Huge data storage of more than 400 TByte is installed. The specifications of the data processing and acquisition system are given in Table 4.

Table 4 Specifications of the data processing and acquisition system.

Parameter	Value
Sampling rate	2048 Msample/sec
Quantization	1/2/4/8 bits (selectable)
Digital Back-end	IVS recommended type
Data Storage	$\geq$ 400 TB

3.5 Precise Frequency Standard

Two hydrogen masers are installed as a frequency standard. In addition, a GPS time receiver and a clock comparison system are also installed. The specifications of the precise frequency standard are given in Table 5.

Table 5 Specifications of the precise frequency standard.

Parameter	Value
Number of hydrogen masers	2
Frequency stability	1 sec: $\leq 2.0 \times 10^{-13}$ 10 sec: $\leq 3.0 \times 10^{-14}$ 100 sec: $\leq 7.0 \times 10^{-15}$ 1000 sec: $\leq 3.2 \times 10^{-15}$
Output signal	5 MHz, 10 MHz, 100 MHz, and 1.4 GHz 1PPS
Other equipment	GPS time receiver Clock comparison system

3.6 Additional Facilities

Optical fiber cables are installed at the new site in order to establish a high-speed data link for data transmission. The initial transmission rate is 10 Gbps; then it can be increased to 32 Gbps and more in the future.

Two Global Navigation Satellite System (GNSS) continuous observation systems are installed at the new site to be registered as an IGS (International GNSS Service) station.

4 Site Information

The site name is Ishioka, which is near Tsukuba (about 40 minutes by car). The location is shown in Figure 4.

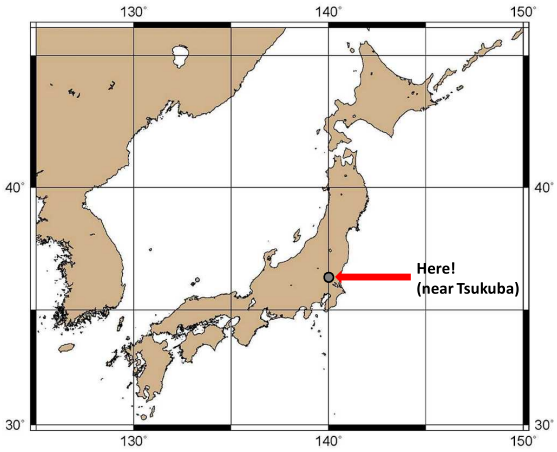

Fig. 4 Location of the site of the new observing facilities.

According to the results of a soil investigation of the site, there is bedrock very close to the surface (at less than 3 meter depth).

5 Summary

A new project for constructing a new antenna in Japan has started. The contract for the new antenna is complete, and the other components (front-end, back-end, and so on) were delivered. By integrating the whole set of components, the new station will be fully compliant with the VLBI2010 concept. In 2014, set-up and test observations will be carried out to make regular observing possible. After completion of the station, it will play an important role as a main station in the Asian region.