Yoshihiro Fukuzaki et al.: New Project for Constructing a VLBI2010 Antenna in Japan, IVS 2012 General Meeting Proceedings, p.18–22
http://ivscc.gsfc.nasa.gov/publications/gm2012/fukuzaki.pdf

New Project for Constructing a VLBI2010 Antenna in Japan

Yoshihiro Fukuzaki, Misao Ishihara, Jiro Kuroda, Shinobu Kurihara, Kensuke Kokado, Ryoji Kawabata

Geospatial Information Authority of Japan

Contact author: Yoshihiro Fukuzaki, e-mail: fukuzaki@gsi.go.jp

Abstract

The Geospatial Information Authority of Japan (GSI) has started a new project for constructing a VLBI2010 antenna (radio telescope) in Japan. The basic design of the specifications of the antenna has been investigated. The observation system will be fully compliant with the VLBI2010 concept. The candidate site for the location of the new antenna is near Tsukuba. The antenna will be installed at the site by the end of next fiscal year (March 2013). We briefly report about the results of the investigations for the design of the antenna specifications.

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 observations by using them. As a result, eight sites in Japan were observed and precise positions determined. In addition, Japan–Korea VLBI observations were carried out by using a transportable 3.8-m antenna in 1995. In these observations, the Kashima 26-m antenna, which was removed in 2002, was used as the main station. Next, 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 observations by using the four stations have been carried out. Especially, the Tsukuba 32-m antenna is a main station for not only domestic but also international VLBI observations now.

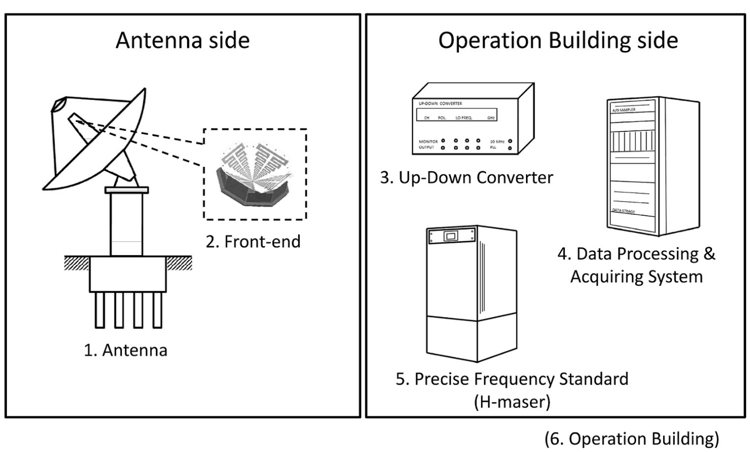

Figure 1. Conceptual design of the new observing facilities.

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 basic design of the specifications of the new antenna.

2. Observing Facilities

In the new project, observing facilities will be constructed. The conceptual design consisting of six components is depicted in Figure 1. The Operation Building will be constructed by the Construction Department of our Ministry.

3. Components

3.1. Antenna

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

Table 1. Design specifications of the new antenna.

Parameter	**Value**
Diameter	12–14 m
RF frequency range	2–14 GHz
Surface accuracy	$\leq$ 0.4 mm (rms)
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	$\geq 3.5°$/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 wide-band feed is necessary to achieve high aperture efficiency over 2–14 GHz. At present the Eleven feed, which has been developed at Chalmers University of Technology in Sweden, is the only practical as a wide-band feed, so it will be employed.

For the design of the antenna optics, employing the Eleven feed is assumed.

The feed and Low Noise Amplifiers (LNAs) are integrated into the cryogenic system, whose physical temperature is less than 20K. The system noise temperature will be less than 40K (excluding atmosphere contribution). The phase and cable calibration system will also be installed. A new type of P-cal unit is under development. In addition, instead of the present D-cal a new cable calibration system is also under development. The design specifications of the front-end are shown in Table 2.

Table 2. Design specifications of the front-end.

Parameter	**Value**
RF frequency range	2–14 GHz
Polarization	Dual linear polarization
Feed	Equivalent for Eleven feed or more
Dewar	Feed, LNAs, and other devices should be included and cooled by cryogenic system.
Physical temperature	$\leq$ 20K
System noise temperature	$\leq$ 30K (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

3.3. Up-down Converter

In order to convert the observed analog signal to digital data, the frequencies should be down-converted. For this purpose, a new Up-Down Converter will be developed. The output signal frequencies are 1–2 GHz. The Lower Side Band (LSB) and 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 design specifications of the Up-Down Converter are given in Table 3.

3.4. Data Processing & Acquiring System

The data processing & acquiring 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 compatibility with the legacy observation system. Huge data storage of more than 400 TByte will be installed. The design specifications of the data processing & acquiring system are given in Table 4.

Table 3. Design 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)
First local oscillator	Programmable with 0.4-MHz step
Second local oscillator	two fixed LOs for LSB and USB
Total noise figure	$\leq$ 25 dB
Phase stability	$\leq 4°$ with $\pm$ 2°C temperature change

Table 4. Design specifications of the data processing & acquiring 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 will be installed as the frequency standard. In addition, a GPS time receiver and clock comparison system will also be installed. The design specifications of the precise frequency standard are given in Table 5.

Table 5. Design 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: $\leq 3.2 \times 10^{-15}$
Digital back-end	IVS recommended type
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 will be installed at the new site in order to establish a high-speed data link for data transmission. Initially, the transmission rate will be 10 Gbps; then it will be increased to 32 Gbps and more in the future.

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

4. Candidate Site

The candidate site for a new station is near Tsukuba (about a 50-minute drive by car). The location is shown in Figure 2. According to the results of a soil investigation of the site, there is bedrock very close to the surface (at less than 3-m depth).

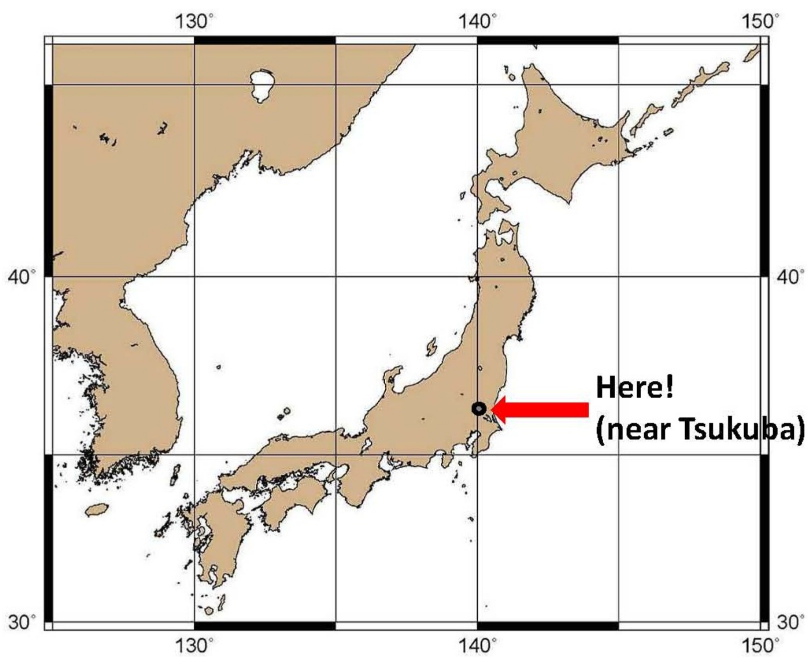

Figure 2. Location of the candidate site of the new observing facilities.

5. Summary

A new project for constructing a new antenna in Japan has started. The basic definition of the specifications has been accomplished. The new station will be fully compliant with the VLBI2010 concept. The construction of the station will be complete by the end of March 2013. After completion of the station, it will play an important role as a main station in the Asian region.