Kashima 11 m and Koganei 11 m VLBI Stations
Report for 2017-2018

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Abstract The Kashima 11-m and Koganei 11-m stations have been participating in R1, T2, CRF, APSG, and AOV sessions conducted by the IVS and AOV. In addition to these regular sessions, the Kashima 11-m antenna has participated in CONT17. In recent years, the S-band receiver of the Koganei 11-m station has suffered from radio frequency interference, and we found sensitivity degradation. The Kashima and Koganei sites are designated as a member of the GGOS Space Geodetic Network. Co-location is an important subject for GGOS; thus, local survey information on co-location among the VLBI 11-m antenna, GPS, and SLR reference points in 1996—1999 and an additional survey conducted in 2013 are briefly described as a reminder.

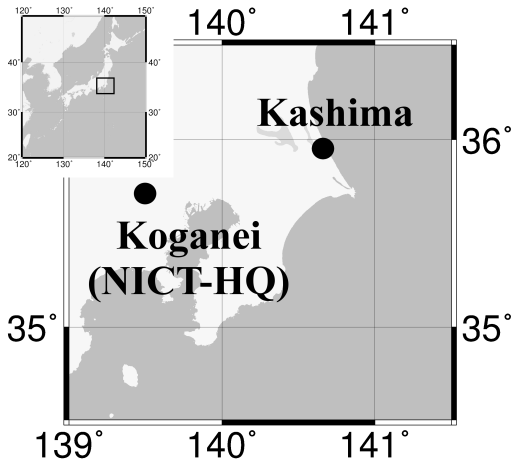

Fig. 1 Location of NICT-Koganei Headquarters and Kashima.

1 General Information

A pair of 11 m diameter antennas are operated by the VLBI group of the Space-Time Standard Laboratory (STSL) of the National Institute of Information and Communications Technology (NICT). The Kashima 11-m antenna is located at the Kashima Space Technology Center (KSTC), on the east coast of the Japanese main island. The 11-m antenna is in the same campus as the Kashima 34 m diameter radio telescope [1] at a 240 m distance. The Koganei 11-m diameter antenna is located at the headquarters of the NICT in Koganei Tokyo (Figure 1). These 11-m VLBI antennas at Kashima and Koganei (Figure 2) were built together with two other VLBI stations for the Key Stone Project (hereafter referred to as KSP). The aim of the KSP [2] was monitoring of crustal deformation around the Tokyo metropolitan area by using multiple space geodetic techniques; VLBI, GPS, and SLR. That project was operated in the period between 1995 and 2001. After the KSP project was terminated in 2001, two other 11 m diameter antennas were transferred to Gifu University and Hokkaido University, respectively, for astronomical research and education. The Kashima and Koganei 11-m stations remained at NICT, and they have been used for technology development and geodetic observations. Participation in the IVS sessions of these two stations on a regular basis started after the "Great East Japan Earthquake" occurred in March 2011. Post-Seismic Deformation (PSD) mod-

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Fig. 2 11-m VLBI antennas at Kashima (left panel) and Koganei (right panel).

els for Kashima 11 m and Koganei are included in ITRF2014.

2 Component Description

2.1 Kashima 11-m Antenna

The antenna parameters of Kashima-11 and Koganei-11 are summarized in Table 1. The receiving frequency bands are the S and X bands, and room temperature LNAs are used. Then the signal is converted to three intermediate frequency (IF) signals, which have a frequency range of 500-1000 MHz. The X-band signal is divided into two IFs, which are XL for 7.7-8.2 GHz and XH for 8.1-8.6 GHz.

Bandpass filters for S-band (2212-2360 MHz) were additionally installed in 2010 at both stations for mitigation of radio frequency interference (RFI) from cell phone stations.

The local oscillator (LO) frequency for XH at the Kashima 11-m station has been changed from 7600 MHz to 7680 MHz since 2008, so that the observing frequency range changed from 8100–8600 MHz to 8180–8680 MHz.

Table 1 The antenna parameters of the 11-m antennas.

		Kashima	Koganei
Antenna Type		Cassegrain type	
Diameter		11 m	
Mount Style		Az El mount	
Latitude		N 35° 57' 19.46"	N 35° 42' 37".89
Longitude		E 140° 39' 26.86"	E 139° 29' 17".06
Altitude		62.4 m	125.4 m
Rx Freq. [MHz]	S band	2212 ∼ 2360	2212 ∼ 2360
	X Low band	7700 ∼ 8200	7700 ∼ 8200
	X High band	8180 ∼ 8680	8100 ∼ 8600
Local Freq. [MHz]	S band	3000	3000
	X Low band	7200	7200
	X High band	7680	7600
SEFD [Jy]	X-band	5700	9500
	S-band	3300	5500

2.2 Koganei 11-m Antenna

The Kashima and Koganei 11-m stations have been participating in IVS sessions with a frequency of about once in a month. In recent years, we have received a series of warnings from IVS correlator reports that the S-band fringe detection rate is getting lower at the Koganei 11-m station. The cause of the issue was clearly recognized by monitoring of the first low noise amplifier (LNA) output. In February 2018, we checked the S-band LNA output of the Koganei 11-m station for all the azimuthal antenna directions in 30-degree steps with the elevation angle at 5 degrees. Strong RFI

at 2.1 GHz and 2.6 GHz (hereafter referred to as f_1, and f_2 for these frequencies) was received at +3dBm as the peak level. Higher order inter-modulations of these two frequencies ($f_2-f_1, f_1+f_2, 2f_2-f_1, 2_f2-f_1, 2f_1+f_2, 2f_2+f_1$) were detected for the majority of all directions, and they were stronger in the direction of Az=270 $\sim$ 360. These data indicate that LNA gain is saturated by the RFI. Figure 3 shows the radio frequency spectrum of the LNA output obtained by Maxhold measurement for 30 seconds with 3 MHz resolution bandwidth. The bandwidth of the RFI signal was about 60 MHz. From these measurement data, power levels of each RFI (f_1, f_2) are estimated to be around +16dBm. The receiver system of the KSP 11-m station is composed of an S/X-band dual frequency waveguide system equipped with a high gain (50dB) waveguide type room temperature LNA. Then the input power level to the LNA is estimated to be no less than -34dBm per signal. A possible counter measure to this problem would be replacement of the receiver system by a cooled LNA with a superconductor filter in front of it; however, it is not allowed due to the budgetary condition.

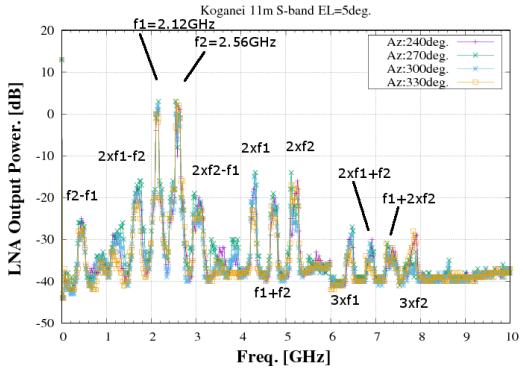

Fig. 3 Frequency spectrum of receiving power at the S-band first LNA output of the Koganei 11-m station. The antenna was pointing to the west direction with the elevation angle at 5 degrees. Maxhold measurement was made for 30 seconds with 3 MHz resolution bandwidth. Higher order harmonics and inter-modulation of strong RFI at 2.1 GHz (f_1) and at 2.6 GHz (f_2) indicate saturation of the first LNA.

Table 2 VLBI data sampler/DAS systems equipped at the Kashima 11 m and Koganei 11 m stations.

System	K5/VSSP32 (4 units)	ADS3000+(K5/VSI)
Video Converter	K4/KSP 16ch	not necessary
# of Input Channels	4 /unit x 4 units	1 or 2
# of Output Channels	16	1, 2, 16
Input Freq. Range	0 - 300 MHz	0 - 2 GHz
Sampling Rate [Msps]	0.04,0.1,0.2,0.5,1, 2,4,8,16,32,64	128, 256, 1024, 2048,4096
Quantization bit	1,2,4,8 bit	
Max. data rate [Mbps]	256/unit x 4	4096
Output Interface	USB 2.0	VSI-H

2.3 Data Acquisition Systems

The K5/VSSP32 [3] has four channels of video band signal input per unit. Four units of K5/VSSP32 constitute one geodetic VLBI terminal with 16 video channels. This system is constantly used for geodetic VLBI observations including IVS sessions. This K5/VSSP32 sampler has digital filter functionality inside. The input video signal is digitized with 8-bit quantization with 64 MHz sampling. Then the signal is shaped for the recording bandwidth by a digital filter. The data come out from a USB 2.0 interface at the data rate corresponding to the observation mode. The data stream is recorded on a standard Linux file system in K5/VSSP32 format[1]. Data format conversion from K5/VSSP32 to Mark IV, VLBA, and Mark-5B are available with conversion tools[2].

Another sampler ADS3000+ [4, 5] and PC-VSI data recording system are available at the Koganei station (Table 2); however, geodetic VLBI observing has been mostly done by using the K5/VSSP32. The ADS3000+ is used only at the Kashima 34-m station [1] but not used at the 11-m stations yet.

2.4 Network for e-Transfer

VLBI observation data recorded in the K5/VSSP32 format is converted to Mark5B before submission to a cor-

[1] Please see `http://www2.nict.go.jp/sts/stmg/K5/VSSP/vssp32_format.pdf`

[2] Observation and data conversion software for K5/VSSP are freely available from `http://www2.nict.go.jp/sts/stmg/K5/VSSP/index-e.html`

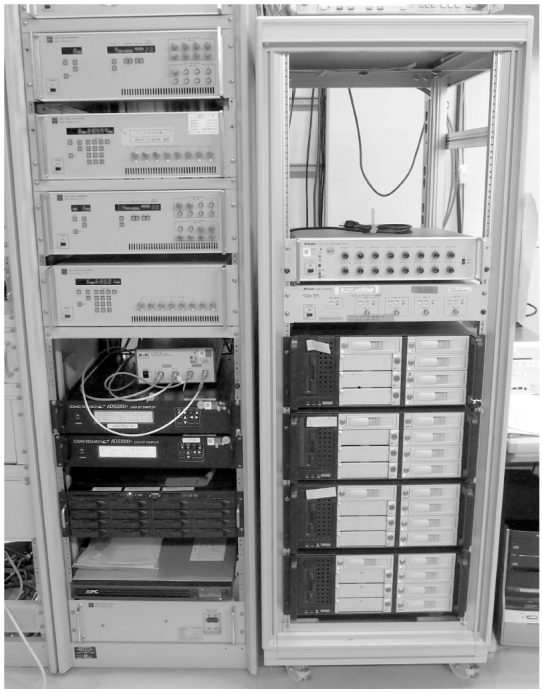

Fig. 4 Data acquisition terminal (K5/VSSP and K5/VSI).

relation center if necessary. All the VLBI data in NICT are transported to correlation centers by e-transfer from the data server at Kashima. The 10 Gbps network connection is provided by the High Speed R&D Network Testbed JGN. All the VLBI stations of NICT (Kashima 11 m, Koganei 11 m, and the Kashima 34 m) share the same 10 Gbps network. Figure 5 shows the schematic diagram of the local network connection and outbound network.

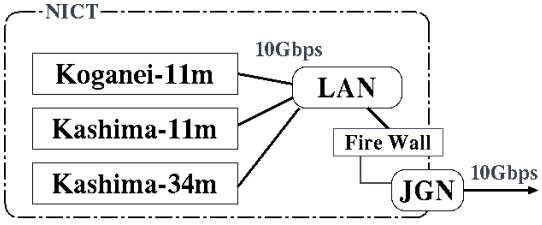

Fig. 5 Network environment of the VLBI stations at NICT (Kashima 11 m, Kashima 34 m, and Koganei 11 m). The nominal network speed is 10 Gbps. The data transfer rate available in practice is 5 Gbps at maximum.

Fig. 6 The Kashima 11-m antenna and GNSS receiver pillar of the IGS tracking station KSMV.

2.5 GNSS Station and Co-location of VLBI, SLR, and GPS

GPS receivers had been installed at the Kashima and Koganei sites in the Key Stone Project. Currently, the GNSS stations 'KSMV00JPN' at Kashima (Figure 6) and 'KGNI00JPN' at Koganei are operated in the observation network of the International GNSS Service (IGS). Their observation data is routinely submitted to the IGS Data Center. The importance of the local ties of the different space geodetic techniques has been recognized in the KSP. A local survey to link SLR, VLBI, and GPS stations has been conducted in the project for the period 1996–1999. Measurement precision of 1.5 mm standard deviation and details of the local survey are summarized by Hasegawa et al. [6] In addition, another local survey was conducted only for the Koganei site in 2013. This survey was triggered by the installation of a new 1.5-m optical telescope, which is for an optical satellite communication experiment of other project. The local survey data of the Kashima and Koganei sites are available from the KSP homepage [3] 'Survey' `http://ksp.nict.go.jp/survey/contents.htm` and 'Supplement' `http://ksp.nict.go.jp/survey/Supplment/KSP-colloc.html`.

[3] `http://ksp.nict.go.jp/`

3 Staff

The following staff members (alphabetical order) contribute to running the Kashima 11-m and Koganei 11-m stations.

Hasegawa Shingo: Supporting staff for IVS observing, operation of data conversion, and maintenance of file servers for e-transfer.

Ichikawa Ryuichi: In charge of GNSS station.

Kawai Eiji: In charge of maintenance of the Kashima 11-m and Koganei 11-m stations.

Kondo Tetsuro: Maintaining the K5/VSSP software package, which is used for data acquisition and conversion from K5 to Mk5B data.

Miyauchi Yuka: In charge of data acquisition software.

Sekido Mamoru: In charge of observation operation and overall activities of the Kashima and Koganei VLBI stations.

Tsutsumi Masanori: In charge of network security and maintenance of computers used in the project.

4 Current Status and Activities during the Past Years

The Kashima and the Koganei 11-m stations are participating in geodetic VLBI IVS-T2, APSG, CRF, and AOV sessions. Kashima 11 m participated in the CONT17 campaign.

Degradation of S-band receiver sensitivity due to RFI at the Koganei 11-m antenna is a serious issue, although there is no plan for a counter measure yet. The Koganei 11-m antenna has been operated under time sharing with the Space Environment Laboratory (SPEL). When the antenna is free from VLBI observing, its X-band receiver is used for receiving down-link signals from the STEREO satellite [4] by the SPEL.

Confirmation of antenna pointing has been made before every session, and no significant error has been reported. The last update of the antenna pointing model was on DOY 36 2017 and DOY 11 2015 for the Kashima 11 m and the Koganei 11 m, respectively.

[4] http://www.nasa.gov/mission_pages/stereo/main/index.html

Acknowledgements

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