Kashima and Koganei 11-m VLBI Stations

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Abstract

Two 11-m VLBI antennas at Kashima and Koganei used to be stations of the Key Stone Project VLBI Network. The network consisted of four VLBI stations at Kashima, Koganei, Miura, and Tateyama. Since the Miura and Tateyama stations have been transported to Tomakomai and Gifu, the Kashima and Koganei 11-m stations remain as IVS Network Stations. After the regular VLBI sessions with the Key Stone Project VLBI Network terminated in 2001, these stations have been mainly used for the purposes of technical developments and miscellaneous observations. In 2008, a series of geodetic VLBI experiments were performed between the Kashima and Koganei 11-m VLBI stations to evaluate the capability of the VLBI technique for precise time transfer between Time and Frequency laboratories to construct Coordinated Universal Time. Other series of experiments were also carried out for the development of e-VLBI by using the high speed network connection between the sites.

1. Introduction

The Key Stone Project (KSP) was a research and development project of the National Institute of Information and Communications Technology (NICT, formerly Communications Research Laboratory) [1]. Four space geodetic sites around Tokyo were established with VLBI, SLR, and GPS observation facilities at each site. The locations of the four sites were chosen to surround Tokyo Metropolitan Area to regularly monitor the unusual deformation in the area (Figure 1).

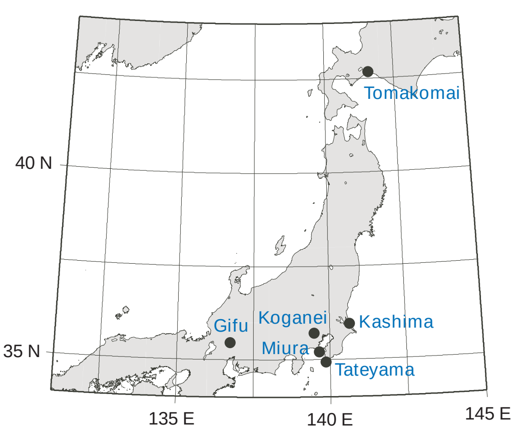

Figure 1. Geographic locations of four KSP VLBI stations and two stations at Tomakomai and Gifu.

Therefore, the primary objective of the KSP VLBI system was to determine precise site positions of the VLBI stations as frequently and quickly as possible. To realize this objective, various new technical advancements were attempted and achieved. By automating the entire process from the observations to the data analysis and by developing a real-time VLBI system using the high speed digital communication links, unattended continuous VLBI operations were made possible. Daily continuous VLBI observations without human operations were actually demonstrated, and the results of data analysis were made available to the public users immediately after each VLBI session. Improvements in the measurement accuracies were also accomplished by utilizing fast slewing antennas and by developing higher data rate VLBI systems operating at 256 Mbps.

11-m antennas and other VLBI facilities at Miura and Tateyama stations have been transported to Tomakomai Experimental Forest of the Hokkaido University and to the campus of Gifu University, respectively. As a consequence, two 11-m stations at Kashima and Koganei (Figure 2) are remaining as IVS Network Stations. After the regular VLBI sessions with the Key Stone Project VLBI Network terminated in 2001, the 11-m VLBI stations at Kashima and Koganei have mainly been used for the purposes of technical developments and miscellaneous observations.

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

2. Activities in 2008

Since 2007, we have been performing special purpose geodetic VLBI experiments between the Kashima (11-m or 34-m) and Koganei (11-m) stations to evaluate the capability of geodetic VLBI for precise time and frequency transfer and comparison. Currently, the International Bureau of Weights and Measures (BIPM) is maintaining and evaluating Coordinated Universal Time (UTC) by assembling more than 300 atomic clocks operated at many laboratories around the world. Common view GPS measurements and two-way satellite time and frequency transfer methods are mainly used to compare the signals from time and frequency standard systems located at different laboratories. It is necessary to perform the comparisons over long distances, and the current accuracy of the time comparison measurements is typically a few hundreds of picoseconds by using conventional methods. On the other hand, clock offsets between observing stations are usually estimated from geodetic VLBI experiments, and their uncertainties are typically on the order of a few tens of picoseconds. In the future, it is expected to achieve 4 picoseconds of uncertainties for time delay by using the so-called broadband delay method under development for VLBI2010 by using a wider frequency range than the current S/X configuration. At Koganei, a set of Cesium

Atomic Clocks, Hydrogen Maser Frequency Standard systems, and primary frequency standard systems are operated to contribute to UTC. In addition, optical frequency standard systems are being developed by using ion trap method of Calcium ions and optical lattice clock using Strontium atoms. It is expected to achieve frequency stability (Allan Standard Deviation) in the order of 10^{-16}. If such highly stable optical frequency standard systems are realized, it will become necessary to perform precise time transfer with the other time and frequency laboratories, and we expect to use the geodetic VLBI technique to improve the current time and frequency transfer uncertainties. We are currently developing small wide-band antenna systems with apertures of 1.6 m and 1.5 m in diameter, and we would like to demonstrate the capability of the geodetic VLBI technique for precise time transfer. In 2008, series of VLBI sessions were performed in February, April, August, and December. Each time, S/X-band geodetic VLBI observations were performed continuously from four to 13 days. To compare the results from various time comparison methods, GPS observations were performed at the same time as all the sessions, and Two Way Satellite Time and Frequency Transfer observations were performed in December.

For technical developments, baselines between the Kashima and Koganei stations are also used to perform real-time VLBI observations based on the Internet Protocol (IP). These stations used to be connected by a high speed Asynchronous Transfer Mode (ATM) network in collaboration with the NTT Laboratories until July 2003. From April 2004, NICT started to operate a high speed research test-bed network called JGNII, and both the Kashima and Koganei stations were connected to the JGNII backbone with an OC-192 (10 Gbps) connection. In 2008, the JGNII network was upgraded to JGN2+, and the network between Kashima and Koganei was replaced by 10GbE. Under cooperation with National Astronomical Observatory (NAO), we have installed a 10GbE interface unit at the Kashima 34-m station and the Koganei 11-m station. These interface units are the developments of NAO and are equipped with four VSI-H ports and one 10GbE port. The maximum data rate of the VSI-H ports is 2 Gbps (64 MHz clock rate with 32 parallel data streams). At Kashima 34-m and Koganei 11-m stations, four ADS1000 A/D data samplers are connected to the interface units, and it has become possible to transfer observation data from Koganei to Kashima at the maximum data rate of 8 Gbps (1024 Msps, 2 bits/sample, 4 channels). The transferred data are then correlated at Kashima by a high speed real-time correlator developed by NAO. By using this capability, NICT and NAO performed a series of observations of radio variable stars in S-band and X-band from May until August 2008.

Apart from the VLBI sessions, the Space Environment Group of NICT started to use the 11-m antenna at Koganei to download data from the STEREO spacecraft. Two STEREO spacecraft were launched by NASA in October 2006 to investigate the solar terrestrial environment and to provide 3D images of the Sun and solar storms. The Koganei 11-m antenna is therefore operated every day even if there are no VLBI sessions to perform.

3. Staff Members

The 11-m antenna stations at Kashima and Koganei are operated and maintained by the Space-Time Standards Group at Kashima Space Research Center, NICT. The staff members of the group are listed in Table 1. The operation and maintenance of the 11-m VLBI station at Koganei is also greatly supported by Space-Time Standards Group, Space Environment Group and Space Communications Group at Koganei Headquarters of NICT. We are especially thankful to Jun Amagai and Tadahiro Gotoh for their support.

Table 1. Staff members of Space-Time Standards Group, KSRC, NICT

Name	Main Responsibilities
KOYAMA Yasuhiro	Administration
KAWAI Eiji	Antenna Systems
ICHIKAWA Ryuichi	Meteorological Sensors, IGS Receivers
AMAGAI Jun	Antenna System and Timing Systems at Koganei 11m station
SEKIDO Mamoru	Field System, Calibration and Frequency Standard Systems
HASEGAWA Shingo	System Engineer

4. Future Plans

In 2009, we plan to continue precise time transfer VLBI experiments and e-VLBI developments. In addition to the VLBI observations and developments, the data downlink from two STEREO spacecrafts will be continued.

References

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