Kashima and Koganei 11-m VLBI Stations

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Abstract

Two 11-m VLBI stations at Kashima and Koganei used to be a part of the Key Stone Project VLBI Network. The network consisted of four VLBI stations at Kashima, Koganei, Miura, and Tateyama. Since Miura and Tateyama stations have been transported to Tomakomai and Gifu, Kashima and Koganei 11-m stations are remaining as IVS Network Stations. After the regular VLBI sessions with the Key Stone Project VLBI Network terminated in 2001, these stations are mainly used for the purposes of technical developments and miscellaneous observations. In 2007, a series of geodetic VLBI experiments was performed between 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. In addition, efforts to determine the precise orbit of spacecraft were continued by using Hayabusa and Geotail spacecraft. Another series of experiments was also carried out for developments 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).

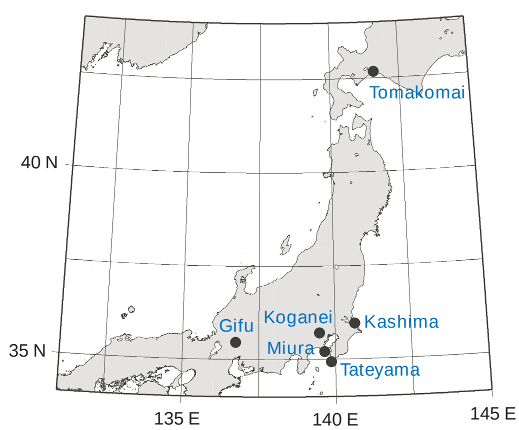

Figure 1. Geographic locations of four KSP VLBI stations and two stations at Tomakomai and Gifu.

Therefore, the primary objective of the KSP VLBI system was to determine precise site positions of the VLBI stations as frequently and fast 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 the 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.

The 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, 11-m VLBI stations at Kashima and Koganei are mainly 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 2007

In 2007, we started to perform special purpose geodetic VLBI experiments between Kashima (11-m or 34-m) and Koganei VLBI stations to evaluate the capability of VLBI for precise time transfer. Currently, the International Bureau of Weights and Measures (BIPM) is maintaining and evaluating Coordinated Universal Time (UTC) by assembling many time and frequency standards operated at Time and Frequency Laboratories around the world. The common view GPS time transfer and bi-directional satellite time transfer are mainly used to compare timing signals of time and frequency standard systems. It is necessary to compare the clocks over a long distance and the current accuracy of the time comparison is typically a few hundred picoseconds by using the bi-directional satellite time transfer technique. On the other hand, the clock offsets between two stations is estimated from usual geodetic VLBI experiments and its typical uncertainty of about a few tens of picoseconds. In addition, it is anticipated to achieve 3 to 4 picoseconds of uncertainty for time delay measurements by using multi-frequency wide band phase delay measurements under the VLBI2010 discussions. At Koganei headquarters of NICT, a set of Cesium Atomic Clocks, Hydrogen Maser Frequency Standard systems, and primary frequency standard systems are operated to contribute to the UTC. In addition, optical frequency standard systems are being developed by using Calcium ion and optical lattice clock techniques. It is expected to achieve frequency stability of down to 10^{-16} of Allen Standard Deviation. If such a highly stable optical frequency standard system is realized, it is necessary to perform precise time transfer with the other time and frequency laboratories and the geodetic VLBI technique is expected to improve the current time transfer limitation. We are currently developing a very small wideband antenna system of the aperture of 1.6m in diameter and we would like to demonstrate the capability of the geodetic VLBI technique for precise time transfer. At first, two 24-hours sessions were performed on January 11th and on 22nd. Then a three-day continuous session was performed from February 28th, and a one-week continuous session was performed starting on June 15th. At both 11-m stations, continuous GPS observations were also performed as IGS sites, and these data are used to compare with the results from VLBI observations. The evaluation of the obtained results is still under investigation, but the initial analysis suggested the capability of VLBI methods for precise time transfer of the level of 16 picoseconds.

For technical developments, the baseline between Kashima and Koganei is also used as a test bed for real-time VLBI observations based on the Internet Protocol (IP). The two stations used to be connected by 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 are connected to the JGNII backbone with OC-192 (10 Gbps) connection. JGNII is a follow-on project of the JGN (Japan Gigabit Network) which was operated by the Telecommunications Advancement Organization of Japan (TAO) for 5 years from 1999. When TAO was merged with Communications Research Laboratory to establish NICT as a new institute, JGNII succeeded the JGN project. Whereas the JGN project was operated based on the ATM architecture, the new JGNII network mainly uses IP. One GbE (Gigabit Ethernet) interface is installed at Koganei station and two GbE interfaces are connected at Kashima station. This environment provides us with an ideal opportunity for e-VLBI research and developments.

Efforts to determine precise orbit of spacecrafts by means of differential VLBI observations were also continued from previous years. The S-band telemetry signal from the Geotail and Hayabusa spacecraft were used to demonstrate precise orbit determination by means of differential VLBI observations. These efforts were initiated in 2003 with the requirements for precise orbit determination of spacecraft Nozomi and Hayabusa. Such efforts are still continuing hoping to improve the technique for future space missions.

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 solar terrestrial environment and 3D image of the Sun and solar storms. The Koganei 11-m antenna is therefore operated everyday even if there is 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 operations 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
Yasuhiro KOYAMA	Administration
Eiji KAWAI	Antenna system
Hiromitsu KUBOKI	Antenna System
Mamoru SEKIDO	Field System, Calibration and Frequency Standard Systems
Ryuichi ICHIKAWA	Meteorological Sensors, IGS Receivers
Masanori TSUTSUMI	System Engineer

4. Future Plans

In 2008, we plan to continue the precise time transfer VLBI experiments, e-VLBI developments, and differential VLBI observations to the spacecraft for precise orbit determination. In addition to the VLBI observations and developments, the data downlink from the two STEREO spacecraft will be continued.

References

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