NICT Technology Development Center 2014 Annual Report

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Abstract The National Institute of Information and Communications Technology (NICT) is developing and testing VLBI technologies and conducting observations with this new equipment. This report gives an overview of the Technology Development Center (TDC) at NICT and summarizes recent activities.

1 NICT as IVS-TDC and Staff Members

The National Institute of Information and Communications Technology (NICT) publishes the newsletter "IVS NICT-TDC News (former IVS CRL-TDC News)" at least once a year in order to inform people about the development of VLBI-related technology as an IVS Technology Development Center. The newsletter is available at the following URL: **http://www2.nict.go.jp/aeri/sts/stmg/ivstdc/news-index.html**. Table 1 lists the staff members at NICT who are contributing to the Technology Development Center.

Table 1 Staff Members of NICT TDC as of January, 2015 (in alphabetical order).

Shingo Hasegawa	Eiji Kawai
Tetsuro Kondo	Yasuhiro Koyama
Yuka Miyauchi	Mamoru Sekido
Kazuhiro Takefuji	Hiroshi Takiguchi
Masanori Tsutsumi	Hideki Ujihara

2 General Information

We have been developing a new broadband VLBI system called Gala-V, which not only meets the VGOS (VLBI2010 Global Observing System) requirements, but also includes upgrading the Cassegrain 34-m antenna by replacing the feed horn. Distinguishing the features of Gala-V, we applied a direct sampler called the K6/OCTAD-G (code name Galas) and a broadband feed horn called Iguana. Here we report the current progress and activities.

First, the compact antenna (MARBLE1) was moved from GSI in Tsukuba to the National Metrology Institute of Japan (NMIJ) also in Tsukuba for the purpose of time and frequency (T&F) comparison between NICT and NMIJ. Both NICT and NMIJ keep the national time standard UTC(NICT) and UTC(NMIJ). Before the time and frequency comparison, the position of MARBLE1 was determined by geodetic VLBI sessions in X-band. Moreover we made a fringe test by broadband frequencies. Next, we made a VLBI experiment for broadband with the recently inaugurated GSI Ishioka 13-meter antenna in December 2014. We could successfully detect fringes in a 10 GHz and 13 GHz frequency range with 1024 MHz of bandwidth. It was also the memorial first fringe for the Ishioka station.

Kashima Space Technology Center, National Institute of Information and Communications Technology

3 Time Comparison between NICT and NMIJ by Compact Antennas

For the sake of the time and frequency transfer (T&F), we moved the MARBLE1 compact antenna to NMIJ in Tsukuba (Figure 1 shows MARBLE1 on the roof of NMIJ). Before the T&F, we carried out several VLBI sessions for determining the position of MARBLE1. Each backend of the compact antenna is a direct sampling system with no analog down-converters. Normally, 1024 MHz bandwidth of X-band single channel is recorded. Because we cannot obtain any fringes between MARBLE1 in Tsukuba and MARBLE2 at the NICT headquarters in Tokyo, a time difference between UTC(NICT) and UTC(NMIJ) is measured by calculating an epoch difference (baseline AB) between MARBLE1-Kashima34m (baseline AO) and MARBLE2-Kashima34m (baseline OB) via the large 34-m antenna. We take the Earth's rotation into account with epoch conversion, and the epoch difference is obtained by the following equation,

$$\tau_{AB} = \tau_{OB} - \tau_{OA} - \dot{\tau}_{AB} \times \tau_{OA} \qquad (1)$$

where τ shows a delay and its subscript variable shows a station. Figure 2 shows a recent time comparison result including VLBI and GPS and UTC(NICT)—UTC(NMIJ) provided by BIPM on 1 and 3 August 2014. GPS has a day boundary caused by an uncertain satellite orbit, but VLBI had no day boundary and was also consistent with GPS and BIPM results.

Fig. 1 The MARBLE1 compact station on the roof of the NMIJ building in Tsukuba.

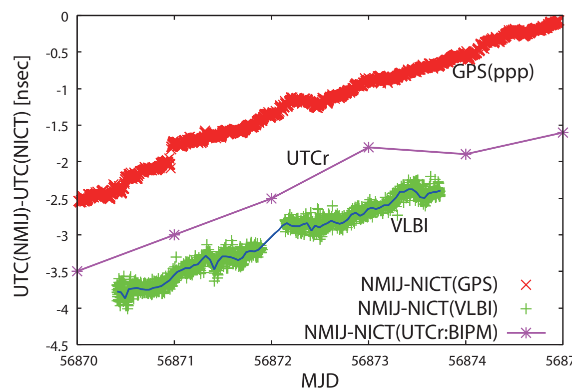

Fig. 2 A time comparison result between NICT and NMIJ. Plots include VLBI, GPS, and time difference provided by BIPM.

4 Broadband Fringe Test between Gala-V of Kashima 34 m and MARBLE1

In the latest NICT TDC IVS annual report, we reported the simultaneously received 6.7 GHz and 12.2 GHz methanol maser lines with the Gala-V system [1]. We carried out a VLBI experiment of double maser lines. Each frequency down-converter was made for Gala-V for the purpose of the methanol maser lines. On the other hand, we set a DBBC frequency of the direct sampler (nickname Galas) for MARBLE1. Figure 3 shows the fringes in the frequency domain of the 6.7 GHz and 12.2 GHz methanol maser lines from the star-forming region of W3OH. The 12.2 GHz fringe of methanol maser was lighter than the 6.7 GHz one. But we could identify the methanol line by checking the frequency. Kashima 34 m joined in cooperative observations of the Japanese VLBI network (JVN) for the methanol C-band session in October 2014. Because other JVN stations receive circular polarization, our linear polarization will make low SNR fringes. To make better fringes, we will install a linear-to-circular polarization converter.

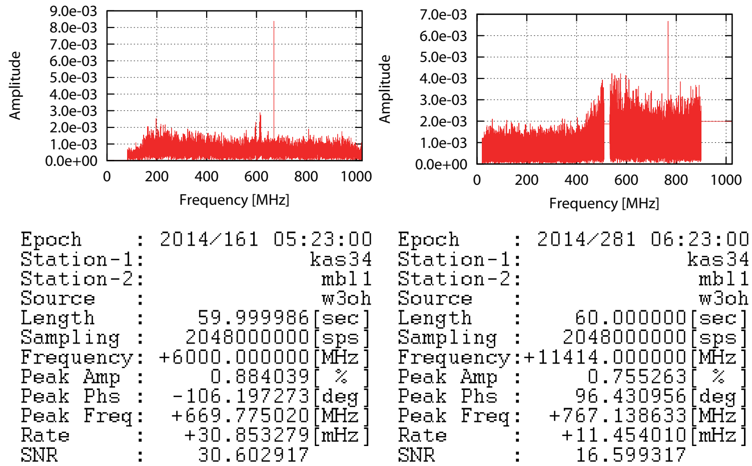

Fig. 3 Fringes of the 6.7 GHz and 12.2 GHz methanol maser lines from W3OH between the Gala-V system of Kashima 34 m and MARBLE1.

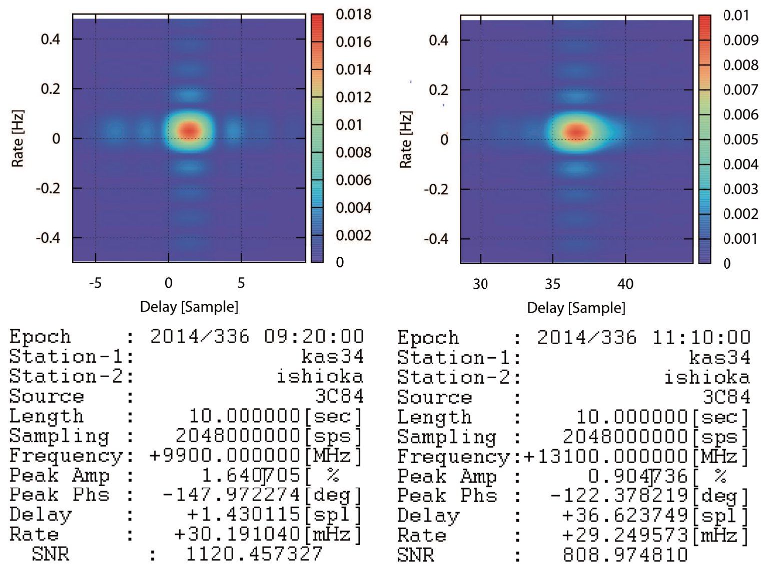

Fig. 4 First fringes between the Kashima 34-m and Ishioka 13-m antennas.

5 Broadband Fringe Test with a VGOS-type Ishioka 13 Meter

We made a VLBI observation for broadband with the recently inaugurated GSI Ishioka 13-meter antenna in December 2014. Ishioka is northwest of Kashima (about 60 km). A Field System and backends, including down-converters, digital samplers, and VSI-recorders were moved from Kashima and installed in Ishioka. We then carried out the broadband session in the 10 GHz and 13 GHz frequency ranges. A frontend cartridge of Ishioka consisted of an Eleven-feed system assembled by Omnisys. The cartridge can be replaced by other feed systems such as the Tri-band feed and the Quad-ridge flared feed horn (QRFH). Each frequency had a 1024 MHz bandwidth by 2048 MHz sampling speed and 1-bit quantization. Unfortunately, there was no Internet connection in Ishioka, and we had to send VLBI data classically, by car. Figure 4 shows the fringe map. They were memorial fringes for Ishioka. We will expand the bandwidth of the Gala-V system at Kashima 34 m from 3.2 GHz to 18 GHz, so that much wider VLBI observations are planned for next summer or autumn.

6 New Wideband Feed (NINJA)

Two types of the wideband feed NINJA have been undergoing development for the 34 m and MARBLE in the 3.2-14.4 GHz frequency range for Gala-V. First, the parabolic focus feed was initially designed for MARBLE which has a -10dB beam width of 50-60 degrees opposite of the parabolic mirror. But for getting a better SNR, we decided to replace the main mirror of the MARBLE from 1.6 m to 2.4 m, from prime focus to Cassegrain focus. The NINJA feed was also redesigned for a sharper 20-30 degree beam width. Figure 5 shows the initial version of the NINJA feed under the far field measurement of the Kyoto University METLAB. Next, the Iguana daughter feed #2 that was deployed in 2014 will be left at the 34 m. The NINJA feed, which is newly developed for the 34 m, will be installed beside the Iguana in this spring. Figure 6 shows the NINJA feed and Iguana prototype #1. The near side feed shows prototype, which is currently used for initial checking such as aperture efficiency in early 2014. The far side feed will be for the 34 m without a beam-shaping lens.

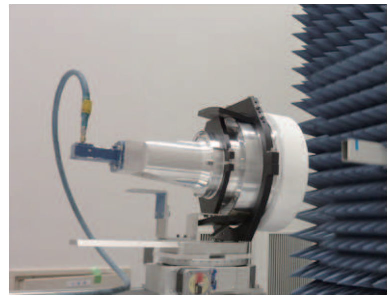

Fig. 5 Initially designed wideband NINJA feed equipped beam-shaping lens.

Fig. 6 The NINJA feeds displayed at the Micro Wave Exhibition 2014 in Yokohama, Japan.

7 Future Plans

The Kashima 34-m antenna is being upgraded for wider bandwidth such as 3.2-18 GHz. The NINJA feed will be installed in Spring 2015. We also have a plan to install cryogenic receivers hopefully during the next fiscal year.

References

1. Kazuhiro Takefuji, Hideki Ujihara, NICT Technology Development Center 2013 Annual Report, in International VLBI Service for Geodesy and Astrometry 2013 Annual Report, edited by K. D. Baver, D. Behrend, and K. L. Armstrong, NASA/TP-2014-217522, 2014.