Technology Development Center at NICT

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Abstract

National Institute of Information and Communications Technology (NICT) has led the development of VLBI technique and has been keeping high activities in both observations and technical developments. This report gives a review of the Technology Development Center (TDC) at NICT and summarizes recent activities.

1. TDC at NICT

National Institute of Information and Communications Technology (NICT) has published the newsletter "IVS NICT-TDC News (former IVS CRL-TDC News)" at least once a year in order to inform about the development of VLBI related technology as an IVS technology development center. The newsletter is available through the Internet at following URL **http://www2.nict.go.jp/w/w114/stsi/ivstdc/news-index.html**.

2. Staff Members of NICT TDC

Table 1 lists the staff members at NICT who are involved in the VLBI technology development center at NICT.

Table 1. Staff Members of NICT TDC as of December, 2007 (alphabetical).

Name	Works
HOBIGER, Thomas	VLBI analysis
ICHIKAWA, Ryuichi	CARAVAN* system, Delta-VLBI, VLBI analysis
ISHII, Atsutoshi	CARAVAN system
KAWAI, Eiji	34m and 11m antenna system
KIMURA, Moritaka	e-VLBI, Giga-bit system, K5/VSI, Software correlator
KONDO, Tetsuro	e-VLBI, K5/VSSP32, Software correlator
KOYAMA, Yasuhiro	e-VLBI, VLBI analysis
KUBOKI, Hiromitsu	Antenna system, CARAVAN system (left our group in December 2007)
SEKIDO, Mamoru	e-VLBI, Delta-VLBI, VLBI analysis
SHIRATO, Kazuyuki	Antenna system, e-VLBI
TAKEFUJI, Kazuhiro	e-VLBI (joined our group in December 2007)
TAKIGUCHI, Hiroshi	e-VLBI, VLBI analysis
TSUTSUMI, Masanori	e-VLBI, K5 system

* CARAVAN: Compact Antenna of Radio Astronomy for VLBI Adapted Network system

3. Current Status and Activities

3.1. e-VLBI

We have been developing an "ultra-rapid UT1 measurement" system by using an e-VLBI technique in collaboration with Geographical Survey Institute (GSI Tsukuba, Japan), Onsala Space Observatory (Sweden), and Metsähovi Radio Observatory (Finland). The locations of these stations and a block diagram of the data flow and data processing are indicated in Figure 1. NICT and Metsähovi have developed the PC-based VLBI data acquisition systems K5/VSSP and VSI-B, respectively. Additionally Metsähovi developed "real-time Tsunami", which is a UDP-based network data transport software for VLBI. These technologies enabled real-time data transfer in 256 Mbps observation mode. We started the near-real-time UT1-observation project in April 2007. Observation data were transferred from Nordic stations to Kashima with the 'Tsunami' software in real time. Then correlation processing and data analysis was performed with software correlator developed at NICT and CALC/SOLVE software package developed at GSFC. We made an automated pipeline data processing system. Consequently, UT1 determinations with a minimum latency of 30 minutes became available by the end of May 2007. The UT1 data measured by this project is plotted in Figure 2, where the UT1 data by e-VLBI observation is compared with prediction and rapid combined solution of Bulletin-A. The plot indicates that the UT1 values observed on these baselines have the same accuracy level as the rapid combined solution. This e-VLBI project will be continued with the aim of (a) confirming stable operability of ultra-rapid UT1 observation with e-VLBI technology, (b) improving the observation precision using higher data rates, and (c) showing consistency of ultra-rapid UT1 results with standard IVS results.

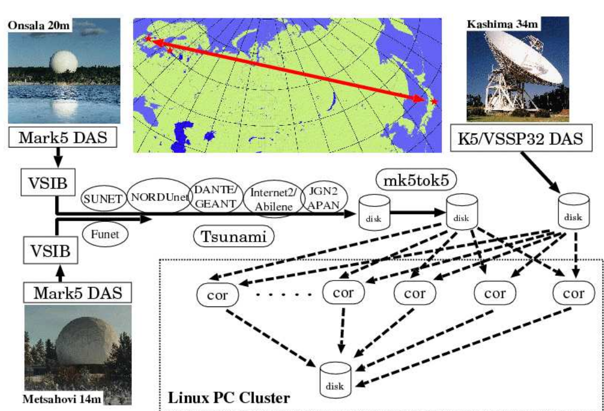

Figure 1. VLBI stations participating in the Ultra-rapid UT1 measurements and a block diagram of the data flow and data processing.

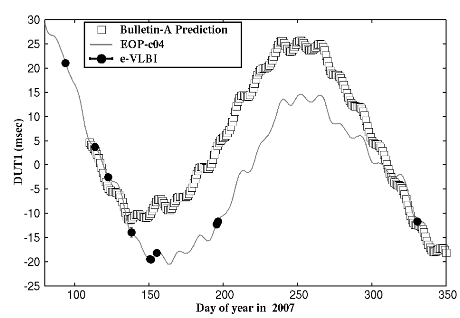

Figure 2. Comparison of UT1-UTC from EOPc04, prediction of Bulletin-A, and e-VLBI observation. A linear trend of UT1-UTC has been removed in advance. It is obvious that UT1 measured by e-VLBI observation has higher precision than prediction values.

3.2. CARAVAN2400 – Contribution to VLBI2010

We have been developing a 2.4 m antenna VLBI system named CARAVAN2400 for various R&D purposes, such as to evaluate the performance of a small antenna system as geodetic VLBI system and to test the design of antenna system in VLBI2010, among other things.

Geodetic VLBI with a Gigabit system. In 2006, first geodetic VLBI observations using the CARAVAN2400 were successfully conducted with Tsukuba 32 m antenna (baseline length is about 54 km) at X-band using a conventional multi-channel back end system. Eight video channel signals, each with an 8 MHz bandwidth in X-band, were sampled using K5/VSSP samplers at both stations. We carried out an experiment again on February 1, 2007, this time to evaluate the performance of a gigabit system (K5/VSI with 1ch×512MHz) by comparing a geodetic result with that observed by multi-channel system (K5/VSSP with 8ch×8MHz) simultaneously. The purpose is to utilize evaluation results to a planned small antenna system dedicated to the precise measurement of a reference baseline maintained by GSI for the calibration of surveying equipment. Both results coincide well with each other as shown in Table 2.

Table 2. Baseline length between CARAVAN2400 and Tsukuba 32m observed by K5/VSSP and K5/VSI

	K5/VSSP (8ch×8MHz)	K5/VSI (1ch×512MHz)
Length (mm)	53814844.5±1.9	53814844.9±4.5

Implementation of a wide-band feed—realizing the smallest S/X band receiving antenna. A quad-ridge horn antenna (QRHA) (Figure 3) that covers 2-18 GHz has been installed at a main focus point of CARAVAN2400 as a wide-band feed in November 2007. Wide-band RF signals received by the QRHA are filtered to S and X bands by a diplexer and fed to a VLBI backend. A fringe test was carried out on December 5, 2007, and fringes were successfully found for both S and X bands (Figure 4).

Figure 3. A quad-ridge horn antenna (QRHA). It covers 2-18 GHz.

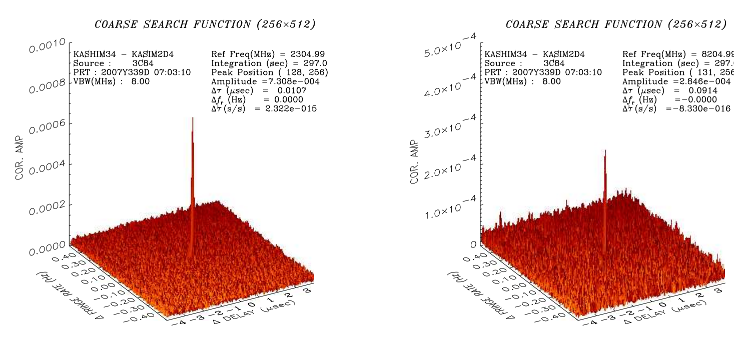

Figure 4. Fringes on S-band (left) and X-band (right) detected by CARAVAN2400 equipped with a QRHA.

3.3. VLBI Using Cs Gas-cell Frequency Standard

A laser-pumped Cs gas-cell atomic frequency standard (Cs gas-cell standard) developed by Anritsu Co. Ltd. [1] is more stable than the conventional Cs frequency standard and cheaper than the hydrogen maser frequency standard. A VLBI experiment was performed between Kashima 34 m and Koganei 11 m on July 19, 2007 in order to evaluate its capability in the geodetic VLBI experiments. At Kashima, the LD-pumped Cesium gas-cell atomic frequency standard (Cs gas-cell standard) was used in place of the hydrogen maser standard. Although the Allan variance of the Cs gas-cell standard is worse by a factor of about ten than that of the hydrogen standard, the analyzed baseline result was almost identical to previous results.

3.4. K5 Samplers

NICT has developed two types of samplers: 1) ADS series sampler equipped with a VSI-H interface; 2) VSSP series sampler not equipped with a VSI-H but directly connectable to a host PC. Samplers developed by NICT are summarized in Table 3. Besides NICT, K5/VSSP32 is now also used routinely for observing at GSI.

Table 3. Specifications of the K5 samplers.

	ADS1000	ADS2000	ADS3000	K5/VSSP	K5/VSSP32
Ref. Sig.	10 MHz 1 PPS	10 MHz 1 PPS	10 MHz 1 PPS	10 MHz 1 PPS	10/5 MHz 1 PPS
# of Input Ch.	1	16	1	4	4
A/D bits	1, 2	2	8	1, 2, 4, 8	1, 2, 4, 8
Sampling Freq. (MHz)	512, 1024	2, 4, 8, 16, 32, 64	2048	0.04, 0.1, 0.2, 0.5, 1, 2, 4, 8, 16	0.04, 0.1, 0.2, 0.5, 1, 2, 4, 8, 16, 32, 64
Output Interface	VSI-H	VSI-H	VSI-H ×2	PCI-bus	USB2.0
Function	—	PCAL detection	DBBC etc.	—	digital LPF

4. Future Plans

We have started, in collaboration with GSI, the development of a 1.6m antenna system equipped with a wide-band feed for the MARBLE (Multiple Antenna Radio-interferometry for Baseline Length Evaluation) project that is a project to measure a reference baseline maintained by GSI by using the VLBI technique for the calibration of surveying equipment. Fringe tests will be carried out in 2008. Regarding a sampler's development, we will make improvements of ADS3000 so as to realize multi-channel DBBC.

References

[1] Ouchi, Y., H. Suga, M. Fujita, T. Suzuki, M. Uchino, K. Takahei, M. Tsuda, and Y. Saburi, A high-stability laser-pumped Cs gas-cell frequency standard, *Proc. 2000 IEEE/EIA International Frequency Control Symposium and Exhibition,* pp.651–655, 2000.