# Tsukuba VLBI Correlator

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**Abstract**

This is a report of the activities at the Tsukuba VLBI Correlator in 2009. The Tsukuba VLBI Correlator processed 99 IVS-INT2 sessions and seven JADE sessions. It should be mentioned that the INT2 processing and analysis has been automated. We can obtain the dUT1 value within one hour at the latest after the end of INT2 sessions with the automatic processing system.

## 1. Introduction

The Tsukuba VLBI Correlator is a part of VLBI facilities operated by the Geographical Survey Institute (GSI) in Japan, as well as the Tsukuba 32-m VLBI station (TSUKUB32). The system consists of a K5/VSSP correlation software package developed by National Institute of Communications and Technology (NICT), a number of servers, and disk storage [1]. For regular correlation, we process JADE sessions, domestic geodetic 24-h VLBI sessions, and IVS-INT2 sessions that are observed on the TSUKUB32 – WETTZELL baseline the weekend.

## 2. Component Description

The specifications of the K5/VSSP correlation system components in the Tsukuba VLBI correlator are described in Table 1.

Table 1. Specifications of the K5/VSSP correlation system components

| | system 1 | system 2 |
|---|---|---|
| management computer | 1 | 1 |
| (CPU) | Intel Pentium 4, 3.0GHz | Intel Pentium 4, 3.0GHz |
| data servers | 12 | 6 |
| (CPU) | Intel Pentium 4, 3.0GHz | Intel Pentium 4, 3.4GHz<br>Intel Xeon 3.4GHz (dual CPUs) |
| correlation servers | 16 (rackmount type computer) | 6 (rackmount type computer) |
| (CPU) | Intel Xeon 3.06GHz (dual CPUs) | Intel Xeon 3.4GHz (dual CPUs) |
| format | K5/VSSP | |
| media type | SATA disk cartridge | |
| kernel program package | ipvlbi20080930, komb20080219 | |
| aid application | PARNASSUS 1.3, MK3TOOLS | MK3TOOLS, Cor_mgr |
| OS | Linux | |
| purpose | JADE | IVS-INT2 |
| operation | $\sim$ April 2008 | $\sim$ August 2006 |

All of the hardware such as servers and HDDs are commercially-based products.

As for international network connections, the Tsukuba correlator has been connected to SINET3 (Science Information NETwork 3) operated by the National Institute of Informatics (NII)

for high-speed data transfer to overseas. The UDP-based protocol "Tsunami (ver.1.1 build 36)" is used for the data transfer. TCP-based protocols such as FTP are also available. There are three servers (Intel Xeon 3.8 GHz) for the data transfer and large HDD storage (45.8 Tbyte) for storing raw VLBI data.

The K5/VSSP kernel software developed by NICT and the graphical user interface "PARNASSUS" developed by GSI are used in correlation processing [2]. PARNASSUS is also used for distributed processing in correlation. The data in Mark 5 format is processed after being converted to K5 format. A Linux server (Intel Xeon 3.8 GHz) with the CALC 10.01 & SOLVE release of 2008.07.31 and OCCAM version 6.1 installed is used for primary analysis.

## 3. Staff

Table 2 shows a list of the staff at the Tsukuba VLBI Correlator. Almost all operations have been carried out by operators from the private contractor "Advanced Engineering Service Co., Ltd (AES)".

Table 2. Staff of the Tsukuba VLBI correlator

| Name | Position |
|---|---|
| Yuji MIURA | Technical staff (management) |
| Kentaro NOZAWA | Technical operator (AES) |
| Yasuko MUKAI | Technical operator (AES) |
| Toshio NAKAJIMA | System engineer (Network) |

## 4. Current Status and Activities

### 4.1. JADE Session Processing

JADE is a geodetic 24-h VLBI session series observed at GSI stations (TSUKUB32, SINTOTU3, CHICHI10, and AIRA) and two VERA stations (VERAMZSW and VERAISGK) operated by the National Astronomical Observatory of Japan (NAOJ). Out of these stations, only TSUKUB32 and VERAISGK are connected to the broad-band network, so data transfer via Internet is available. For the other stations, the network transfer speed is too slow to transfer raw VLBI data to the correlator, so we need data media shipping.

The JADE sessions processed at the Tsukuba correlator in 2009 are shown in Table 3.

The SINTOTU3 (3.8-m main reflector diameter) – CHICHI10/AIRA (10-m main reflector diameter) baselines had not been correlated because of the low sensitivity of the baselines that use SINTOTU3. We tried to optimize the observation schedule so that we can process these baselines in JADE-0911. As a result, fringes were detected in 79 observations on SINTOTU3 – CHICHI10 and 91 observations on SINTOTU3 – AIRA, and these observation data were used for baseline analysis.

Table 3. JADE sessions processed in 2009

| Session | Stations | Processed baseline # |
|---|---|---|
| JADE-0901 | TsAiCcVmVs | 10 |
| JADE-0903 | TsAiCcVmVs | 10 |
| JADE-0905 | TsAiCcS3VmVs | 13 |
| JADE-0906 | TsAiCcS3Vs | 7 |
| JADE-0907 | TsAiCcS3Vs | 7 |
| JADE-0908 | TsAiCcS3Vm | 7 |
| JADE-0911 | TsAiCcS3 | 6 |

## 4.2. IVS-INT2 Session Processing

IVS-INT2 sessions processed at the Tsukuba correlator in 2009 are shown in Table 4.

Table 4. IVS-INT2 sessions processed in 2009

| Session | Stations | Processed baseline # |
|---|---|---|
| IVS-INT2 | TSUKUB32–WETTZELL | 97 |
| IVS-INT2 | KASHIM34–WETTZELL | 2 |

In IVS-INT2 processing, almost all processes are automated, including the data transfer from the stations, the data conversion from Mark 5 to K5 format, correlation, and analysis (Figure 1) [3].

By automated processing and analysis, the dUT1 result is calculated within one hour at the latest after the last scan. CALC/SOLVE had been used for a long time for our primary analysis. However, as it is not adequate to automate VLBI analysis, we utilized OCCAM for this. The Mark III database is submitted to an IVS Data Center after being checked by the operator.

Figure 2 shows the IVS-INT2 dUT1 time series with respect to IERS EOPC04 during 2009. The standard deviation of estimated dUT1 is around 5 – 15 $\mu$sec.

## 4.3. Ultra Rapid DUT1 Experiments

Following last year's results we have continued the Ultra-rapid dUT1 experiments based on a joint project of Japan (GSI & NICT) and Fennoscandia (Onsala & Metsähovi). The description of the experiments is reported in "Tsukuba 32-m VLBI Stations" in the Network Stations section of this volume.

## 5. Plans in 2010

In 2010, the Tsukuba correlator will continue to process JADE & IVS-INT2 sessions. Nine JADE sessions and 102 IVS-INT2 sessions are scheduled.

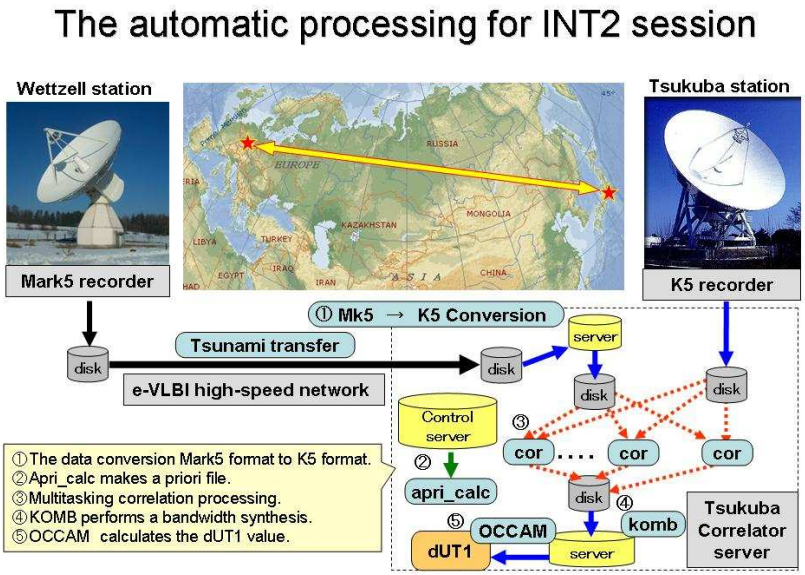


Figure 1. The automatic processing for INT2 sessions

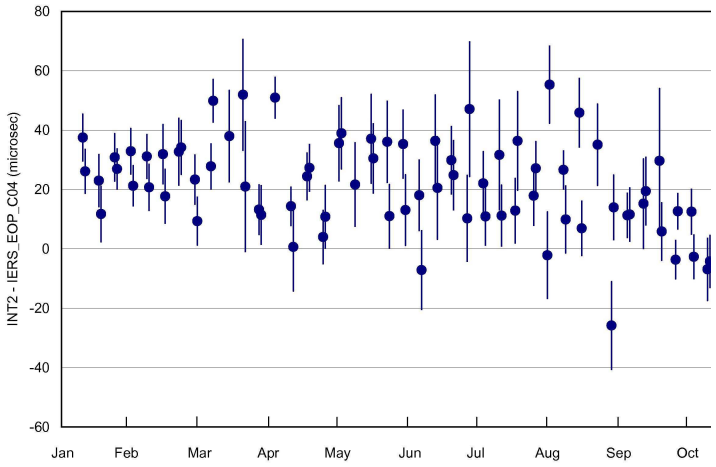


Figure 2. UT1–UTC time series w.r.t. IERS EOPC04

## References

[1] T. Kondo: K5/VSSP VLBI SYSTEM, http://www2.nict.go.jp/w/w114/stsi/K5/VSSP/index-e.html.

[2] M. Machida, M. Ishimoto, K. Takashima, T. Kondo, Y. Koyama: K5/VSSP Data Processing System of Small Cluster Computing at Tsukuba VLBI Correlator, IVS 2006 General Meeting Proceedings, edited by D. Behrend and K. Baver, NASA/CP-2006-214140, 117-126, 2006.

[3] K. Nozawa, H. Shigematsu, K. Kokado and S. Kurihara: Data processing and analysis tools for ultra-rapid UT1 measurement, IVS NICT Technology Development Center News, No. 30, 33-35, 2009.