VLBI Correlators in Kashima

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Abstract

K5 VLBI data acquisition and processing systems developed at the Kashima Space Technology Center have been used for R&D VLBI experiments. Correlation tasks processed in 2011 were mainly for crustal deformation monitoring between the Kashima 11-m and Koganei 11-m stations after the big earthquake that occurred on 11 March 2011.

1. General Information

The VLBI group of the Kashima Space Technology Center (KSTC) of the National Institute of Information and Communications Technology (NICT: Figure 1) has been contributing to the VLBI community by developing the K5 VLBI data acquisition system (DAS) and correlation systems.

The multi-channel DAS named K5/VSSP32 [1] has been used for geodetic and radio science observations. A corresponding software correlation package for the K5/VSSP32 DAS has been developed and maintained by Dr. T. Kondo. Another high speed software correlator called "GICO3" [2], has been developed by M. Kimura.

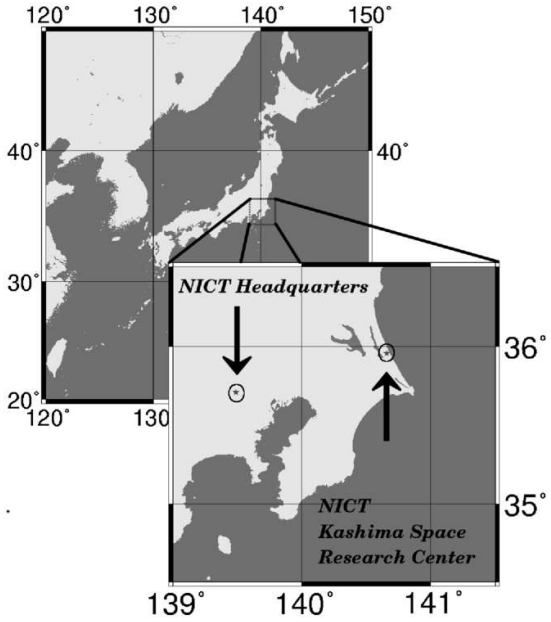

Figure 1. Locations of NICT Headquarters and KSTC.

The K5/VSSP32 system is a multi-channel data acquisition system with four channels input per unit. One unit has the sampling capability in the range of 40 kHz to 64 MHz at 1, 2, 4, and 8 bits quantization within the limit of output data rate up to 256 Mbps. A geodetic K5 DAS system is composed of four K5/VSSP32 units. The K5/VSSP software package contains a variety of VLBI data manipulation utilities from data acquisition with the K5/VSSP32 in accordance with the observation schedule file and data checking of K5 and Mark 5 data, to conversion between K5/VSSP32 format and the Mark IV, Mark 5, and VLBA data formats. This DAS and the software correlator package have been widely used for geodesy operationally. e-VLBI experiments for rapid UT1 measurements have been performed by using the K5 software correlator for the Onsala, Metsähovi, Tsukuba, and Kashima stations [3, 4].

Another K5 system (K5/VSI) is the name of the recording system with a VSI-H interface. NICT has developed three kinds of samplers with a VSI-H interface [5] (see Table 1). Thus a variety of combinations of sampling rate and number of output channels is possible. And the K5/VSI can be connected with not only NICT's ADS samplers, but also any sampler with a VSI-H compliant data interface. A good example is the combination use of the K5/VSI and Mark 5B

Table 1. Three VLBI samplers with VSI-H interface developed by NICT

	ADS1000	**ADS2000**	**ADS3000Plus**
Pictures			
Sampling rate	1024Msps	64Msps	$\sim$ 4Gsps
No. of inputs	1	16	4
No. of channels	1	16	Programmable
Max. Data Rate	2048Mbps	2048Mbps	8192Mbps

sampler at Wettzell, which has routinely been used for real-time data transfer in the INT2 sessions. The VSI-H output data stream from the Mark 5B sampler is captured by the K5/VSI. Then it is transfered to the Tsukuba station and recorded in K5/VSSP32 format in real-time for ultra-rapid UT1 measurements on the Wettzell—Tsukuba baseline.

2. Staff

The mega-earthquake that occurred on 11 March 2011 caused destruction of roads and some parts of KSTC's buildings. Fortunately there were no personal injuries in our laboratory.

The names of the staff members who contribute to the Correlation Center at NICT/Kashima and their tasks are listed below in alphabetical order.

- HASEGAWA Shingo: in charge of maintenance and troubleshooting of K5 system computers, operation of the 34-m antenna for IVS sessions.
- HOBIGER Thomas: working at Koganei Headquarters in Tokyo for development of a new VLBI database system that uses NetCDF, research on atmospheric delay calibration with the ray tracing technique, and development of a software receiver for GNSS.
- ICHIKAWA Ryuichi: VLBI Project Manager at Kashima, in charge of research on the small size antenna with wide band receiver system named MARBLE project [6] and on atmospheric delay with ray tracing.
- KAWAI Eiji: in charge of maintenance of the 34-m and 11-m telescopes, operation of the telescopes for IVS sessions.
- KIMURA Moritaka: developer of the high speed Gigabit software correlator "GICO3" and the K5/VSI DAS. He left from KSTC at the end of March 2011.
- KONDO Tetsuro: continuing development and maintenance of the software correlator package of the K5/VSSP32.
- SEKIDO Mamoru: e-VLBI development, Time and Frequency transfer experiments, and maintenance of the 34-m and 11-m antennas.
- TAKEFUJI Kazuhiro: correlation processing operation with GICO software correlator, development of MARBLE antenna, and its application for Time and Frequency transfer.
- TSUTSUMI Masanori: maintenance of K5 system computers and network environment.

3. Component Description

After the big earthquake occurred on 11 March 2011 in the north east region of Japan, post-seismic crustal deformation monitoring with the Kashima-Koganei VLBI baseline was regularly conducted from 7 May 2011 until October with a 20 day interval (Figure 2). Correlation processing of these data were performed by using Multi-core PC (e.g., CPU Intel Core i7 920 2.67 GHz cache 8192KB, Processor 4 (Hyper Threading Total Core8), Memory 12 GB) and cluster of PCs, which are used for data recording of K5/VSSP32. Table 2 shows a list of experiments processed at Kashima.

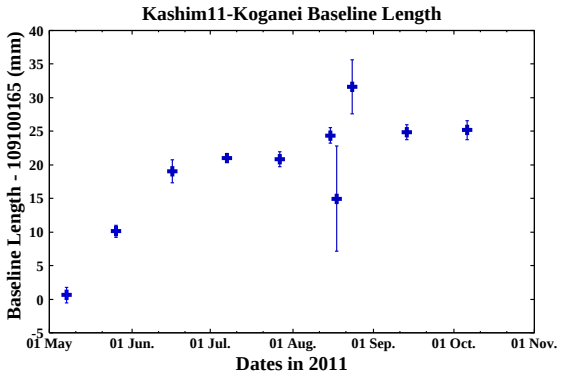

Figure 2. Post-seismic baseline length changes of Kashima11 – Koganei11 from sessions that were correlated at NICT and are listed in Table 2, as well as APSG29 and T2077 (which were correlated at GSI/Tsukuba and are omitted from Table 2). The APSG29 and T2077 points have the largest error bars.

Table 2. Major correlation tasks processed at Kashima in 2011. The first eight sessions (K11127 through K111279) are also shown in Figure 2. R&D experiment D11292 is not shown in that figure.

Project	Exp code	Date	Stations	baseline x scans	Data rate (Mbps)
Geodesy	K11127	7 May	K1, Kg	1 x 1085	256
Geodesy	K11146	26 May	K1, Kg	1 x 1379	256
Geodesy	K11167	16 Jun.	K1, Kg	1 x 1338	512
Geodesy	K11188	07 Jul.	K1, Kg	1 x 1192	512
Geodesy	K11208	27 Jul.	K1, Kg	1 x 1256	512
Geodesy	K11227	15 Aug.	K1, Kg	1 x 1264	512
Geodesy	K11256	13 Sep.	K1, Kg	1 x 1278	512
Geodesy	K11279	6 Oct.	K1, Kg	1 x 1278	512
Direct Sampling	D11292	19 Oct.	K1, Ts	1 x 928	1024

Ts:Tsukuba-32m, K1:Kashima-11m, Kg:Koganei-11m

4. Development and Future Plans

4.1. Direct Sampling Experiment

A geodetic VLBI experiment with the Radio Frequency Direct Sampling system was conducted on 19 October, and its data were processed with the GICO3 software correlator. That system samples joined S-band and X-band radio frequency signals simultaneously with 1024 MHz-2bit quantization. It uses an aliasing effect to record the signal outside of the Nyquist frequency range of the sampling rate. A total of 1.5 GHz of frequency range of X-band was recorded with 1024 MHz sampling. Reversely folded frequency signals of X-band and S-band were processed separately

with different RF correlation parameters in accordance with the observation. Since only a single sampler is used for dual band observation, a sampling clock offset between S and X-band could be avoided. Thus it has the potential to be a key technology for utilizing phase delay observables across the wide frequency band. More details are described in "Technology Development Center at NICT" in this volume [7].

References

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[1] http://www.vlbi.org/vsi/

[2] http://www2.nict.go.jp/aeri/sts/stmg/ivstdc/news-index.html