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 2010 were for crustal deformation monitoring between Kashima 11m and Koganei 11m stations after the big earthquake 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: Fig.1) has been contributing to the VLBI community by developing the K5 VLBI data acquisition system (DAS) and correlation systems.

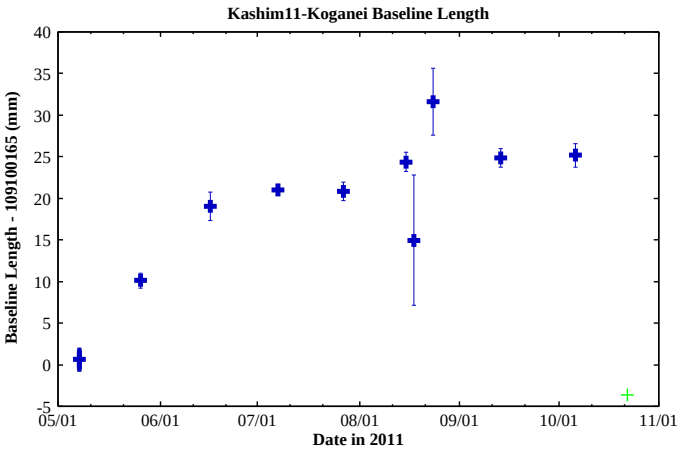

Figure 1. Post-seismic Baseline length changes between Kashima11 – Koganei11.

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.

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, with quantization bits 1, 2, 4, and 8 and the limit for the output data rate of up to 256 Mbps. A geodetic K5 DAS system is composed of four K5/VSSP32 units. K5/VSSP software utility package supports not only data acquisition with K5/VSSP32 in accordance with observation schedule file, but also data checking of K5 and Mark5 data, and data conversion from K5/VSSP32 to the Mark4/5/VLBA data and vice versa.

This DAS and software package have been widely used for geodesy operationally. e-VLBI experiments for rapid UT1 measurements have been performed by using this system among the Onsala, Metsähovi, Tsukuba, and Kashima stations.

Another K5 system (K5/VSI) was originally developed for the purpose of a high sampler for astronomy. Because the K5/VSI DAS is a recording system, which can be used in combination with any sampler systems with the VSI-H interface. An good example is the system routinely been used in a combination with Mark 5B sampler (VSI-H output) at Wettzell for real-time data transfer in the INT2 sessions. VSI-H output data stream from Mark 5B sampler is captured by PC-VSI card interface then it is transfered to Tsukuba station in real-time for ultra-rapid UT1 measurement on the Wettzell—Tsukuba baseline.

2. Staff

The mega-earthquake occurred on 11 March 2010 affected to the building and load destruction at KSTC. Fortunately there were no personal injury 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: in development of a new VLBI database system that uses NetCDF, research on atmospheric delay calibration with the ray tracing technique, and development of 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[3], 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 2010.
- KONDO Tetsuro: continuing development and maintenance of the software correlator package of the K5/VSSP32.
- SEKIDO Mamoru: e-VLBI development, Time & Frequency transfer experiments, and maintenance of the 34-m and 11-m stations.
- TAKEFUJI Kazuhiro: correlation processing operation with GICO software correlator, development of MARBLE antenna and its application for Time & Frequency transfer.
- TSUTSUMI Masanori: maintenance of K5 system computers and network environment.

3. Component Description

After the big earthquake occurred on 11 March 2011 at north east region of Japan, post-seismic crustal deformation monitoring with Kashima – Koganei VLBI baseline were regularly conducted since 7 May 2011 till to October with 20 days interval. 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 12GB) and cluster of PCs, which are used for data recording of K5/VSSP32.

Table 1 shows a list of the main experiments processed at Kashima.

4. Development and Future Plans

4.1. Direct Sampling Experiment

A geodetic VLBI experiment with Radio Frequency Direct Sampling system was conducted in 29 Oct. and its data was processed with GICO3 software correlator. That system samples joined

Table 1. Major correlation tasks processed at Kashima in 2011.

Project	Exp code	Date	Stations	baseline x scans	Data rate (Mbps)
Geodesy	K11127	7 May	Kas11, Kog11	1 x 1085	256
Geodesy	K11146	26 May	Kas11, Kog11	1 x 1379	256
Geodesy	K11167	16 Jun.	Kas11, Kog11	1 x 1338	512
Geodesy	K11188	07 Jul.	Kas11, Kog11	1 x 1192	512
Geodesy	K11208	27 Jul.	Kas11, Kog11	1 x 1256	512
Geodesy	K11227	15 Aug.	Kas11, Kog11	1 x 1264	512
Geodesy	K11256	13 Sep.	Kas11, Kog11	1 x 1278	512
Geodesy	K11279	6 Oct.	Kas11, Kog11	1 x 1278	512
Direct Sampling	D11292	19 Oct.	Kas11, Ts32	1 x 928	1024

Ts32:Tsukuba-32m, Ks34:Kashima-34m, Ks11:Kashima-11m, Kg11:Koganei-11m

S-band and X-band radio frequency signal simultaneously with 1024 MHz-2bit quantization. It uses aliasing effect to record the signal outside of Nyquist frequency range of the sampling rate. Totally 1.5 GHz of frequency range of X-band was recorded with 1024MHz sampling. Reversely folded frequency signal of X-band and S-band were processed with separately with different RF correlation parameters in accordance with the observation.

Since only single sampler is used for dual band observation, sampling clock offset between S and X-band could be avoided. Thus it has a potential as a key technology for utilizing phase delay observable across the wide frequency band. More detail will be described in "Technology Development Center at NICT" in this issued[4].

References

[1] T. Kondo, et al.: Development of a New VLBI Sampler Unit (K5/VSSP32) Equipped with a USB 2.0 Interface, IVS 2006 General Meeting Proceedings, edited by Dirk Behrend and Karen Baver, NASA/CP-2006-214140, p.195-199, 2006.

[2] M. Kimura, et al.: High Speed VLBI Software Correlator, Submitted to Pub. Astr. Soc. Pacific, 2010.

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[1] http://www2.nict.go.jp/w/w114/stsi/ivstdc/news-index.html