Technology Development Center at CRL

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Abstract

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

1. Introduction

Communications Research Laboratory (CRL) has been leading the development of the VLBI system in Japan since the development of the K3 VLBI system in 1979 which is compatible with the Mark III VLBI system developed by the US group. CRL then developed the K4 VLBI system, which facilitated ease in both operation and transportation. In October 1990, the International Earth Rotation Service (IERS) designated the Communications Research Laboratory (CRL) and Haystack Observatory (in the United States) as Technical Development Centers (TDC). In September 1996, the IERS directing board designated CRL as TDC again. The function of the IERS VLBI Technical Development Center was taken over by the IVS Technology Development Center after its establishment on March 1, 1999. Since then CRL has participated in IVS as one of its Technology Development Centers. The CRL-TDC newsletter is published biannually to inform the VLBI community of its current activities. The newsletter is also available through the Internet at the following URL **http://www.crl.go.jp/ka/radioastro/tdc/index.html**.

2. Recent Activities

2.1. Real-Time VLBI

The Keystone (KSP) real-time VLBI [1] system observed extraordinary crustal deformation of over 2 cm/month on the Kashima-Tateyama baseline during July-August 2000 (Fig.1). It occurred just after the volcanic eruption event at Miyake Island about 150 km south of Tokyo at the end of June. To provide data to the Headquarters for Earthquake Research Promotion more frequently, we changed a 24-hour session frequency from every two days to every day. Every-day observation continued till November when the crustal deformation seemed to be well settled. During this period we had no technical problems in real-time VLBI operation. Although it was planned to terminate the Keystone project at the end of March, 2001, it was decided from the importance of KSP observation to extend the term of the project for one more year with three stations, Kashima, Koganei, and Tateyama.

This real-time VLBI technique is also used to connect a 64-m antenna at USUDA and a 34-m antenna at Kashima so as to realize a large virtual radio telescope. A test observation was successfully carried out in December 1998, then this project was named GALAXY and has carried out radio astronomical observations once every several months. The GALAXY has been carried out in collaboration with the Institute of Space and Astronautical Science (ISAS), National Astronomical Observatory (NAO), and Nippon Telegraph and Telephone Corporation (NTT)[2].

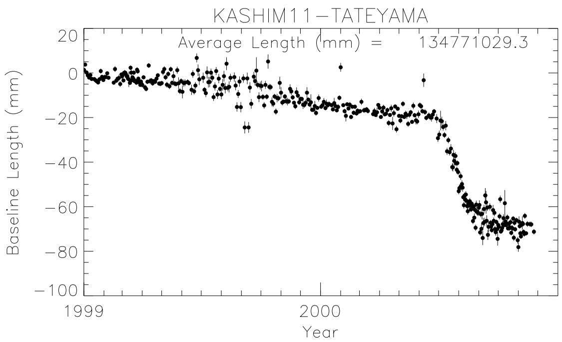

Figure 1. Kashima-Tateyama baseline length change. Extraordinary crustal deformation over 2 cm/month was observed during July-August 2000.

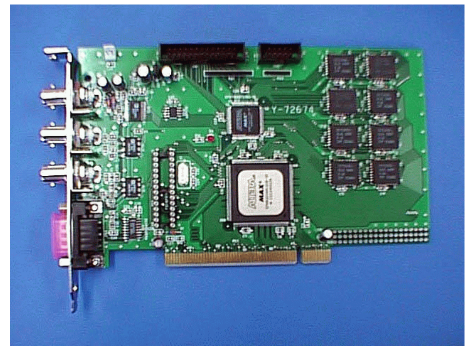

Figure 2. PCI sampler board for the IP-VLBI system.

In the KSP real-time VLBI system, data are transmitted through the high-speed ATM network. However, network cost is still expensive and connection sites are still limited, so that ATM-VLBI is not yet well generalized. We therefore aimed to develop a new real-time VLBI system using IP (Internet protocol) technology that has already spread widely, to reduce network cost and to expand the connection sites of network. We call this system “IP-VLBI” or “VLBI over IP”, and started the development in late 1999. We have been developing the PC-based IP-VLBI system consisting of a PCI-bus sampler board (Fig.2) and PC software to make real-time data transmission and reception. We also intend to carry out real-time correlation by PC software. One sampler board has 4 video signal inputs and is designed to be able to sample each signal with a frequency of up to 16 MHz for 1 bit A/D. The sampler board has been tested by using actual signals from radio sources. Real-time characteristics have been evaluated by using the LAN at the Kashima Space Research Center. So far we can confirm the sufficient performance of “coherent sampling” up to 8 MHz sampling. Although the performance of 16 MHz sampling has not yet been confirmed, it will be checked soon. Regarding the “real-time correlation processing” by using PC software, we can process 2 MHz sampling data in real-time at present time. An improvement in the algorithm to make correlation processing faster is in progress[3].

2.2. Giga-bit VLBI System

The developments of the giga-bit VLBI system at the Communications Research Laboratory started in 1996. The system consists of the A/D sampler unit (TDS580D/TDS784A), the recorder system (GBR1000), the correlator (GICO), sampler interface unit, the timing control unit (DRA1000), and the data buffer unit (DRA2000). In 1998, first fringes were successfully detected on the Kashima-Koganei baseline using this system.

During 1999 - 2000, four geodetic VLBI experiments were performed using the giga-bit VLBI system. Two of them are on the Kashima-Koganei baseline and others are on the Kashima-Gifu baseline (about 360 km). In each experiment, observations were performed with K4 VLBI system in parallel to compare the results. As the sampling frequency of giga-bit system (1024MHz) is much higher than that of K4 system (16 MHz), performance of the giga-bit system is influenced by the stability of the sampling frequency. By developing a method to compensate for the sampling jitter using a superimposed tone signal, data quality and estimation errors have been improved to a level comparable to the K4 VLBI system [4].

A new compact VSI Gbps sampler, ADS-1000, has been developed. A design of ADS-1000 started to provide a simple portable Gbps sampler. Antenna front-end mounted with AD samplers will eliminate long analog transmission in near future. Although, the current AD packages weigh 50 kg and occupy 6U in the system, the ADS-1000 weigh less than 10 kg and occupies 1/2U (Fig.3). Sampling jitter is expected to be reduced by using a high purity-sampling signal which is directly supplied from a PLO. As a remarkable feature, the sampler output is VSI-H (VLBI Standard Hardware Interface) compatible. According to the endorsed document VSI-H proposal, LVDS devices have been examined and this is CRL's first VSI-H instrument. The ADS-1000 is manufactured by DigitalLink Co.Ltd. and Venetex corporation. They are venture companies which are distinguished by advanced digital technology [5].

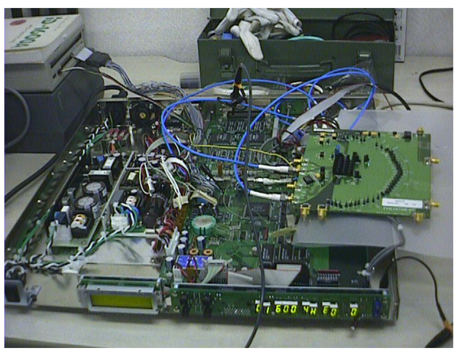

Figure 3. ADS-1000, the new compact VSI Gbps sampler under test.

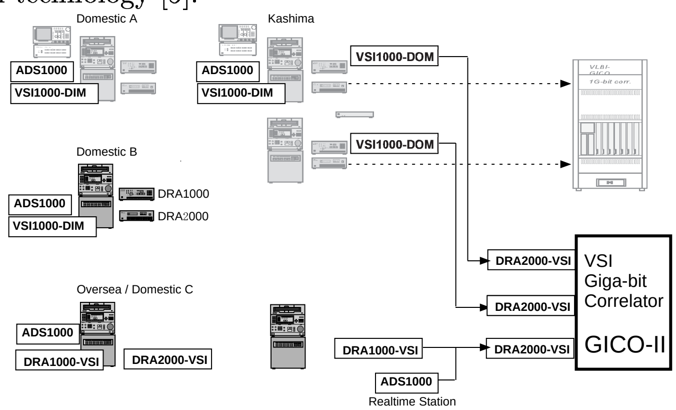

Figure 4. Proposed Gbit VLBI system enhancement for the global baseline.

2.3. VLBI Standard Interface

CRL TDC has been contributing to the establishment of the VLBI standard interface (VSI) with Dr. Alan R. Whitney, Technology Coordinator of IVS. We had international telephone conferences several times to discuss VSI and reached the agreed specification of VSI hardware (VSI-H). VSI-H Ver1.0 was opened to public in August, 2000. It can be accessed through the VSI homepage (**http://dopey.haystack.edu/vsi/**) or Japanese VSI homepage (**http://www2.crl.go.jp/ka/radioastro/tdc/ivs/vsi/**).

We are adapting VSI-H to S2-K4 copying system and VSI-based K4 data acquisition system. One of the motivations was the request for a S2-K4 data copying system. Antarctica VLBI data observed in 1997-1999 and Pulsar VLBI observation data are recorded on an S2 system. These data are desired to be correlated with K4-type (K4, KSP) correlators because of easiness to handle it in Japan. Also S2-K4 copier will expand the ability of organizing VLBI network observation [6].

Late 2000 supplementary budget to make upgrade of the giga-bit VLBI system was approved. The importance of the parallel data transmission is recognized again in the VSI-H, while IT technology promoted high-speed serial transmission by IP. All the VLBI instruments in the Gbps system developed by CRL will adopt VSI-H. We also intend to encourage the application of the VSI interface to a wide scientific use through the demonstration that will be made using the upgraded giga-bit VLBI system. Preliminary plan of the enhanced Gbit VLBI system is shown in Fig.4. Upgraded Gbit data recorders are introduced and new Gbit samplers, ADS-1000 are disposed to each station. The number of the Gbit recorders is doubled and this will increase Gbps observation sites. As well as K4 and/or KSP system, a robot tape exchanger is being designed for automatic observation. While the experimental correlator UWBC-GICO will continue its operation, a new multi-baseline Gbit correlator equipped with VSI-H ports will start operation. The correlator system of the CRL-TDC is promised to open in the other VLBI groups and new countries. Technical supports and VSI related supplies are also planned [7].

3. Future Perspectives

CRL TDC will continue to make efforts to develop new technologies introduced in this report and to apply them to actual observations. In particular, we will demonstrate VSI-H instruments as soon as possible. We also continue the development of the "Internet VLBI" system which is the succession of the current real-time VLBI technique but aims at realizing more economical (lower running cost) and flexible connections between VLBI stations by using the Next Generation Internet (NGI).

References

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