Kashima 34m Radio Telescope

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Abstract

In April 2004, Communications Research Laboratory (CRL) will re-organized to National Institute of Information and Communications Technology (NICT, Figure 1). From a policy to promote communication technology and related science, NICT will be doubled its scale in number of staff and research budget. In NICT, VLBI is getting more important application to handle huge amount data transfer as well as its scientific results. There is no change in Kashima Space Research Center under the NICT. This is network station report mainly focused to telescope related projects in 2003.

1. Introduction

Communications Research Laboratory (CRL) constructed the Kashima 34-m telescope in 1988 (Figure 2). The telescope is located 100km east of Tokyo. During 15 years operation, the telescope is kept in good condition and joined VLBI and single-dish observations. The 34-m telescope is operated by Radio Astronomy Applications Group.

NICT National Institute of Information and Communications Technology

Figure 1. NICT, new institute logo reorganized from CRL.

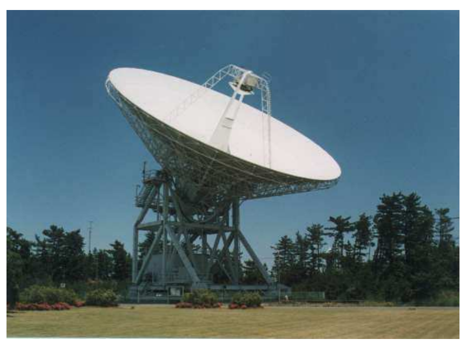

Figure 2. The Kashima 34m radio telescope.

2. Telescope Status

2.1. Conventional Back-end system and Field System

As a role of VLBI technology development center,TDC, Kashima 34-m is particular site with functions where all kind of back-ends are gathered. Currently, G-bit(1024Mbps), K-4(256Mbps), K3-A (Mark-IIIA compatible), VSOP, and S-2 VLBI magnetic tape systems are available. K4, VLBA and S2 are controlled from the Field System (FS-9) together as well as 34m telescope. The

FS-9 functional enhancement are done by Kashima-group. Weather monitoring logging system are renewed. As for single dish observation, there are two AOS systems in operation. One is the Pulsar AOS timing measurement system. The another is multi purpose AOS spectrometer. Please see the AOS details in previous Annual reports. Latter AOS system will be moved to digital spectrometer using K5/PC-VSI. New weather monitoring and logging system are installed.

2.2. New VLBI Back-end, unified K5-series

New PC-based VLBI system become popular to support VLBI observations. Two PC-based VLBI system had been developed at CRL. These are system up to 256Mbps and 2048Mbps. In 2003, both system are unified under name of K5 (Figure 3).

We have developed K5/PC-VSSP narrow band multi-channel system to substitute system up to 256Mbps. The K5/PC-VSSP is unique since each unit is integrated with on board 4-channel AD converters. Four 4-channel K5/PC-VSSP units are equivalent to conventional 16-channel 256Mbps VLBI system. With the matured 256-Mbps data rate, the K5/PC-VSSP system was used in Nozomi-space craft positioning, geodetic and ERP observations. Different from magnetic tape recorders, the PC-based K5/PC-VSSP can also perform data correlation. K5 correlation software packages are completed and distributed to sites. In this view, K5/PC-VSSP is a hardware and software in a body. K5 correlation software is used at JIVE correlator. Speed of these software is increasing and GRID cluster PC system under development enables real-time VLBI experiment. Results from K5 correlation software is directly connected to analysis software and provide reliable results.

Another new VLBI back-end is K5/PC-VSI system for high speed VLBI acquisition. Two high-speed AD samplers ADS-1000 (1ch,1024M-Sps,2048Mbps) and ADS-2000 (16ch,64M-Sps,2048Mbps) are prepared for K5/PC-VSI. Essential of K5/PC-VSI is that the components are using VSI interface which internationally specified. Successive K5/PC-VSI recording system can capture the high-speed interface data up to Gbps to normal Linux file system. With this K5/PC-VSI system acquired G-bps data can be transmitted network or processed simultaneously. These multi task features during recording are achieve by well designed PCI-X interface board (PC-VSI2000DIM, digitallink co. ltd.) and newly invented linux device driver ability. To handle huge amount of Gbps data stored to T-Byte disk-array, high speed software correlation core is developed separately. By recent CPUs Intel Xeon series, the core reached performance of 100Mbps processing. This means multiple CPU and small number of cluster PCs will reach real-time processing of G-bps data.

name	hardware	software
K5/ PC-VSSP geodesy	IP-VLBI board 4ch on board AD 64-256Mbps	proofed K5 package vlbi@home
K5/ PC-VSI astronomy	PC-VSI board 1ch-wide /16ch AD 512-2048Mbps	high-speed *gico3* soft GRID corr.

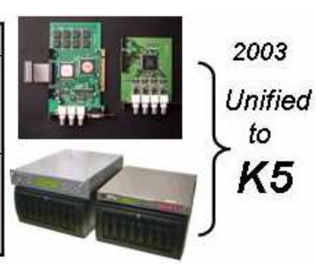

Figure 3. K5 unified character descended from two PC based eVLBI system.

3. Telescope Status

3.1. Receiver Systems

Receivers in Kashima 34-m telescope are L,C,K,Ka,Q and S/X band. The Ka and K receivers are integrated to a dual-band dewar. These receiver performances are summarized in Table 1. Efficiency of Ka receiver is provisional. Please see receivers details in previous Annual report.

Table 1. Receiver Specification of the 34m Radio Telescope.

Band	frequency(Hz)	Trx(K)	Tsys(K)	Efficiency	Polarization
L	1350-1750	18	43	0.68	R/L
S	2210-2350	19	83	0.65	R/L
C	4600-5100	25	108	0.70	L(R)
X	7860-8680	41	52	0.68	R/L
K	21800-23800	75	160	0.5	L(R)
Ka	31700-33700	85	150	0.4	R(L)
Q	42300-44900	180	300	0.3	L

3.2. RFI Mitigation (Interference)

IMT-2000, mobile phone base stations in S-band once saturated receiver system in Kashima 34-m telescope. To avoid interference from transmitters, we have developed cooled HTS (High Temperature Super-conductor) filters. The sharp cutoff filter skirt of -30dB/MHz enabled to receive lower S-band adjacent to IMT-2000 allocation. The filter is integrated into maintenance free refrigerator cryogenics. See details in TDC News letters from CRL.

3.3. Mechanical System

Continuous effort was put into telescope up-grading. Dehyderator unit of feed system is modified. Part of feed control is replaced to Ether basis. Extra EL and AZ motors are purchased. Encoder electrical units under heating environment was newly produced. MTBF of telescope components are carefully checked, inspected and they are replaced before failure. Key components are ready to change immediately in trouble. Accurate sub-reflector re-alignment tools are developed for annual maintenance. Usually determined position sub-reflector parameters are affected after mechanical overhaul. This year, positioning accuracy less than 0.1mm is realized by invention of caliper like alignment tool. As a result parameter adjustment observation to start up mm-wave observation was reduced to a few days after maintenance.

Table 2. Mechanical Specification of the 34m Radio Telescope.

Maximum Speed Azimuth(deg/sec)	0.8
Maximum Speed Elevation(deg/sec)	0.64
Drive Range Azimuth(deg)	+-270
Drive Range Elevation(deg)	7-90
Operation Wind Speed (m/s)	13
Panel Surface Accuracy r.m.s.(mm)	0.17

4. On-going Projects and Major Results of 2003

eVLBI(Domestic K5 experiment series) Sessions to verify K5 VLBI system were completed. In 2003, comparison between K4 and K5 proved K5 data quality and output validity. The K5 results well agreed the K4 and they increased sensitivity. Koganei 11m and Kashima 11m telescope remotely operated sites are served the experiment too. K5 1024Mbps observation are carried out same time. Universities telescopes related observations are increased too. New telescope Yamaguchi 32m and Tomakomai 11m are operated by small university groups. CRL had been technically support these groups and carried out eVLBI experiment series with these stations.

eVLBI(International K5 experiment series) Monthly IVS-T and IVS-CRF sessions are scheduled at Kashima 34m. Though these observation are recored to tapes, K5 system captured the observations too. Part of the observation data was transferred to Haystack and Washington correlator via the Internet. The VLBI data is processed as well as the tape data. This is a step to regular eVLBI without tape shipping. Another successful international observation has been carried out between Finland. K5 2-Gbps observations were carried out between Metsahovi observatory. Software correlations are running at both site. Distributed correlation architecture utilize network bandwidth between the stations.

NOZOMI observation Satellite positioning by relative VLBI technique has become strong demand to VLBI group in this decade. Positioning software and hardware package development is one of main mission in Kashima Radio Astronomy Applications group. In year 2003, series of experimental observations are carried out targeting NOZOMI spacecraft to the Mars and initial VLBI positioning results were produced. Usuda 64m, Kashima 34m, Tsukuba 32m, universities telescopes and Algonquin joined these sessions. CRL group processed the data rapidly and ISAS NOZOMI operation group referred the results. The spacecraft finally overcome its swing-by maneuver. After the NOZOMI, HAYABUSA spacecraft toward a minor planet needs same VLBI positioning technique. Accuracy and performance of this satellite positioning VLBI system is improving. Here the PC-based eVLBI realized flexible numerical processing and data correlation too.

Pulsar, J-Net, VERA and other projects Long-term periodical observation of pulsars revealed the stability nature in Allan variance. Japanese domestic astronomical VLBI observation, J-Net increased ability with National Astronomical Observatory's VERA stations. Kashima 34m and Nobeyama 45m are requested to join their observations to boost sensitivity. Kagoshima university group had been carried out spectral observation at 22-GHz and 43-GHz.

5. Technical Staff of the Kashima 34m Radio Telescope

Engineering and Technical staff of the Kashima 34m telescope are Eiji Kawai (leader of all operations and maintenance), Hiroshi Takeuchi (scientific engineer), Hiroo Osaki (software engineer), Hiromitsu Kuboki (technician of mechanical and RF), and Yuki Watanabe, Yuujiro Hirose (engineers of Rikei Corp., Vertex TIW). Tetsuro Kondo is a supervisor of the all Kashima 34m project.

6. Outlook

As a VLBI station in network era, Internet bandwidth is will become infrastructure in advanced experiment. 10-Gbps access network to back-borne node is planned to be equipped at Kashima Space Research Center.