TECHNOLOGY DEVELOPMENT CENTER NEWS

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Technical Reports

Remarks: Logo used in the news title is not an official IVS logo. See page 27 for the official IVS logo.

Overview of the 15th TDC Meeting

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The 15th meeting of the Technology Development Center was held on September 8, 1999 at the Communications Research Laboratory.

Attendance

CRL members

Kenichi Okamoto, Taizoh Yoshino, Michito Imae, Noriyuki Kurihara, Hiroo Kunimori, Futaba Katsuo, Jun Amagai, Hitoshi Kiuchi, Kouichi Sebata, Akihiro Kaneko, Yuko Hanado, Michiyasu Igarashi, Kuniyasu Imamura, Noboru Kotake, Fujinobu Takahashi, Hiroshi Kumagai (KSRC: Kashima Space Research Center), Yasuhiro Koyama (KSRC), Junichi Nakajima (KSRC), Ryuichi Ichikawa (KSRC), Eiji Kawai (KSRC), Mamoru Sekido (KSRC), Tomonari Suzuyama (KSRC), and Tetsuro Kondo (KSRC)

Special members

Noriyuki Kawaguchi (National Astronomical Observatory), Kosuke Heki (National Astronomical Observatory), Misao Ishihara (Geographical Survey Institute), Kazuo Shibuya (National Institute of Polar Research) Takahiro Iwata (NASDA), and Hisao Uose (NTT Information Sharing Platform Laboratories)

The following special members could not attend: Hideyuki Kobayashi (National Astronomical Observatory), and Alata Sengoku (Hydrographic Department, Maritime Safety Agency)

Observer: Hiroshi Okubo, Hiro Osaki, and Tang Lili (Research Cooperators)

Minutes

1. Opening Greeting

Kenichi Okamoto, director of IVS TDC at the Communications Research Laboratory (CRL), greeted meeting holding.

2. Introduction of Special Members

Eight individuals have been appointed as special members of the TDC for this term (July 1, 1999 - June 30, 2001). Six special members who attended the meeting introduced themselves to the attendants of the meeting. Hisao Uose prepared a document entitled “Real-time VLBI and the high-speed network technique” and gave a brief explanation about the material.

3. Report on the 2nd Directing Board Meeting of IVS (*Tetsuro Kondo*)

First, the purpose and outline of the International VLBI Service for Geodesy and Astrometry (IVS) which started on March 1st of this year were explained to the special members of CRL-TDC. Then, the 2nd directing board meeting held during the IUGG General Assembly in Birmingham, England in July, 1999 was outlined as follows. The IVS annual report will be published soon (it was issued in September). The first general meeting of IVS will be held in February, 2000 in Germany. Yasuhiro Koyama was appointed as a member of program committee of this meeting. CRL operates the formal mirror site of the Web page of IVS. In the establishment of VLBI standard interface (VSI), Japanese TDC group has been highly contributing. The working group will be established in order to measure the phase center of GPS transmitting antenna by VLBI as a cooperation theme with IGS.
Q: Is there any information on subsequent about the cooperation relation with IGS?
A: So far no information on subsequent.

4. Technical Development Center Activity Reports

4. 1 VLBI Interface Standardization Work

At first, Tetsuro Kondo outlined an effort to establish VLBI Standard Interface (VSI). The effort started in January of this year by a proposal by IVS technical-development coordinator, Alan Whitney. Since then, we have held meetings to discuss VSI almost once a month in Japan. At the time of IUGG General Assembly, IVS TDC members, Alan Whitney, Cannon Wayne and Tetsuro Kondo, met and discussed the proposed draft of the VSI. They brought back action items raised at the meeting. The action items have been discussed in Japanese TDC group.

Then Yasuhiro Koyama gave a general concept of VSI. He explained the purpose of VSI, its composition, observations using VSI, media conversion, and the example of connection at the time of the correlation processing.

Junichi Nakajima reported on the connector examined as VSI with the actual sample of connector under examination as VSI.

After these explanations, Noriyuki Kawaguchi, one of the special members, proposed a discussion about the use of LVDS (Low Voltage Differential Signaling) in the VSI. He said, "Although the conventional VLBI terminal had adopted ECL as the electricity signal level and VSI proposal in Japan also assumed ECL, adoption of LVDS is beginning to be considered recently. The required area of LVDS circuits on a board is small, and the power consumption is also low. When the VSI adopts LVDS, however, backward compatibility will become a problem. We should discuss this matter as a technology development center in Japan." Although this proposal was received and discussion began, materials of the arguments could not be presented enough to other special members. TDC meeting decided that this matter will be discussed in a VSI working group meeting being held later. Decision will be made after that meeting.

4.2 Key Stone Project (Crustal Deformation Monitoring System in the Tokyo Metropolitan Area)

Current Status of KSP-VLBI System (*Yasuhiro Koyama*)

The following reports were made about the current status of KSP-VLBI system. Miura station was disconnected from the high speed communication network in May, 1999. At that time form of regular observation was changed. Routine real-time VLBI has been carried out on Kashima, Koganei, and Tateyama on every 2 days basis since then. Miura attends observations as a "tape-based VLBI" but every 6 days. The analysis result in SINEX (Solution Independent Exchange) file format became available to the public since June, 1999. Now, there is a problem which many observation data cannot be used on the baseline including Miura station (i.e., tape-based observation). This problem should be settled as soon as possible. Estimation of atmospheric horizontal gradient is scheduled to be taken in to the KSP analysis software, obtaining cooperation of Kosuke Heki who is a special member. (See page 7 for details.)

Q: How much is the error of the current baseline analysis?

A: The formal error in the analysis of each experiment is about 2 mm for horizontal component, and is about 7-8 mm for vertical component. Repeatability is about 2 times worse than the formal error.

Q: How much will the introduction of horizontal-gradient model of atmospheric delay improve the positioning accuracy?

A: Although the formal error of each experiment will not be improved, repeatability is expected to be improved to the value closer to the formal error.

C: In the case of GPS, the repeatability of the position estimation in winter is improved to the almost same grade as the formal error of each observation.

C: When repeatability becomes the almost same level as a formal error, the technical development of the observation system to improve a formal error can have a meaning.

C: According to a preliminary evaluation, position of each antenna has to be known with the accuracy of 1mm to achieve the purpose of VERA (VLBI Exploration of Radio Astrometry) project. What is the accuracy attained in the current geodetic VLBI?

C: It is still impossible to attain 1 mm accuracy in the vertical component.

Q: Judging from the original plan of observing every day, it is decreased even to the frequency of once every 6 day for Miura station. Does this satisfy the original project purpose of detecting the crustal deformation as a precursor of an earthquake?

A: The observation frequency of performing observation of 5 hours every day was changed to that performed for 24 hours by every other day to improve measurement accuracy, and the effect has actually appeared. The current observation frequency for Miura station is as frequent as possible under the current condition where the real-time experiment became impossible.

Current Status of KSP-SLR System (*Hiroo Kunimori*)

The reports about data productivity and quality, system R&D, and future plans were presented. Efforts have been made to increase the data productivity which is currently low compared with other stations in the world. Moreover efforts for the multi-station simultaneous path acquisition for getting a short arc solution, i.e., improvement in a link, maintenance schedule optimization, etc., are continued.

Q: The difference between the vertical components is in the tendency that the difference with GPS is larger than the difference between VLBI and SLR, by coordinates comparison of SLR, VLBI, and GPS. What is the reason?

A: It is recognized to be due to the problem of a model used in the GPS analysis, such as the use of old type mapping function.

Current Status of KSP-GPS System (*Ryuichi Ichikawa*)

Reports were presented as follows about the current status of KSP-GPS which started observations in July, 1997 for the purpose of the mutual comparison with VLBI and GPS. The concrete contents of mutual comparison are evaluation of station position, evaluation of the collocation between different space geodetic techniques, evaluation of atmospheric model and increasing its accuracy, evaluation of the influence of ionospheric change, etc. Displacements of the KSP stations based on GPS analysis are mostly in good agreements with those obtained from VLBI in the size and the direction. However, for a vertical component, about 3 cm of bias is expected in GPS measurements due to the influence of radio wave absorber attached directly under an antenna to avoid multipaths, use of the low-accuracy-mapping function, and so on. From May, 1998, water-vapor-radiometer (WVR) observation started at Kashima station for the purpose of understanding time change of atmospheric horizontal gradient, and evaluation of atmosphere model used in GPS and VLBI. Calibration observations were carried out at Tsukuba from May to June in 1998. Raw data were calibrated based on the results, and the atmospheric gradients were compared between Kashima and Tsukuba. Consequently, different gradient patterns on both sites were observed in spite the distance between 2 points is as short as 54 km. This result suggests the influence of meso scale (a several 10 km - 100 km) phenomenon and the necessity of performing atmospheric delay correction specialized for each observing station. In order to advance the data analysis further, improvement of GPS analysis software and evaluation by using numerical-weather-prediction data with a high spatial resolution of about 1 km are planned to be performed.

Q: Generally speaking, the east-west component is said to be higher than that of north-south for the atmospheric-horizontal gradient. However, a plot of the gradient change obtained by WVR shows that the north-south component at Kashima changed violently. May I actually understand that a north-south gradient is large at Kashima?

A: I think that the north-south gradient at Kashima is actually large. The rice field zone, the rivers, and the lakes which spread in the south of Kashima are considered to serve as a main water vapor source, and enlarging the horizontal gradient of refractive index in the direction of north and south is suggested from the simulation.

Q: Is the variation seen in the plot of calibration observation due to the characteristics of the WVRs or due to the actual atmospheric fluctuation?.

A: Considering from the result of sonde observation it is considered that an actual atmospheric change is reflected probably. A little more detailed check is however required.

C: If correlation is taken between observation data of WVR of a different body number, the problem of apparatus or change of the actual atmosphere will be separated and will be possible.

A: Since it is easy, I will make the plot on the basis of the comment.

(Supplement) : The amount of zenith delay in the case of radiosonde is computed from the altitude profile obtained by a radiosonde rising from the ground to the altitude of about 30 km for about 1 hour, while WVR outputs the amount of zenith delay in every minute. Therefore, strictly speaking, a time gap of about a maximum of 1 hour arises between these values. This may cause a variation in the figure.

4.3 R&D Experiment Reports

Local Signal Transmission of a Sub-millimeter Wave Interferometer (*Jun Amagai*)

Regarding the transmission of local signals in a sub-millimeter radio wave interferometer, two methods have been introduced. One is a conventional method that transmits the standard reference frequency signal at low frequency. The other is a method that generates sub-millimeter radio wave directly. As for the former method, a fundamental experimental result was reported. Regarding the second method, the research concerning the detector is currently performed at the Kansai Advanced Research Center of CRL.

Q: Isn't the stability of laser a problem rather than a detector in the second method?

A: I don't know any example which checked stability. I want to measure the stability.

Simultaneous Reception of Laser Pulse Reflected From a Satellite at two Close SLR Stations (*Jun Amagai*)

Jun Amagai reported on the experiment of receiving satellite reflected laser pulse simultaneously at Kashima KSP-SLR station and a mobile SLR station. The distance between two SLR stations is very short (about 20 m) compared with the distance to the satellite. So that it can be considered that an arrival reflective wave is a plane wave. Under this assumption, the baseline vector was estimated using the same simple observation equation as VLBI. (See page 9 for details.)

Q: You mentioned, "It contributes to a comparison between ground survey and space geodesy." I don't understand the meaning.
A: When we try to connect the ground survey and space geodetic measurement, a geoid inclination and the determination of north direction become a problem in the ground survey. The relation will be given by measuring a short distance by using both techniques, because a highly precise ground survey is available on a short distance. Although it is not so realistic to make observation using two sets of SLRs separated by a very short distance, if it is GPS, it may alive as an idea.
Q: If it can be regarded as a plane wave, it will be good also to the moon. How much is the beam irradiation range in the case of the moon?
A: Probably it is several km (10 microrad corresponds about 4 km at a distance of 400,000 km).
Q: Although it is called simultaneous reception, can it be said that the reflection from the same mirror was caught at both SLRs?
A: It is thought that it is observing the same reflective wave since the reflective wave of a satellite is not looking at the reflection from one mirror separately and is observing the broad waveform which is composition of the reflection from two or more mirrors.
Q: We hear that range bias is a problem in an SLR analysis. Does it affect this analysis method?
A: The range bias is estimated as a clock offset.

Results of Source Survey Observations Using KSP System (*Akihiro Kaneko*)

Akihiro Kaneko reported on source survey observations using KSP VLBI network. Total of 1981 sources were surveyed. Among of these, fringe was detected for 1129 sources, and the number of those for which correlation was further detected on all baselines in both S and X bands was 189. He also showed an interesting result that there are some sources in HII domain for which correlation was detected. He said that he wants to perform a verification observation of these sources.
C: It is better to also see the catalog in infrared rays, although you pointed out that there is no radio source near sources in HII domain.
C: If secular change is seen, it is an interesting one.
Q: How often do you observe?
A: Since KSP carried out 24 hour-observation every other day, a part of the vacant time was assigned to this R&D observation.

Large Virtual Radio Telescope (GALAXY) Report (*Hitoshi Kiuchi*)

The report was made about GALAXY experiment which combined the large-sized antennas by high-speed communications link. After a brief introduction of real-time VLBI system including network, acquisition system, correlator, and transmission system, experiment results were reported. (See page 12 for details.)
Q: What is the sensitivity of detection?
A: If SNR=20 is made into a detection limit and integration period is 600 seconds, sensitivity is about 5 mJ.

VLBI Experiment by Using a Higher-order-mode Sampling Method (*Tomonari Suzuyama*)

Tomonari Suzuyama reported on VLBI experiment by using a higher-order-mode sampling method as follows. VLBI observations using the higher-order-mode sampling with 4ch × 32MHz were performed on the baseline between Kashima 34m antenna and Mizusawa 10m antenna. Data were processed by an FX correlator at National Astronomical Observatory at Mitaka, and fringes were successfully detected for all four channels. Moreover, the channel separation of the signals compoounded by the higher-order-mode sampling could be carried out by applying the different fringe rotation by each channel.
Q: When it processes with the FX correlator, coherence loss occurs at the band edge of a filter which is apart from the fringe rotation frequency center, doesn't it? Especially an influence becomes large in the 4-th channel of which frequency is 1488 MHz.
A: Although it is thought to be influential, as long as data is seen, remarkable influence has not come out.
C: Although it is related with the loss of correlation amplitude, it is thought that a fringe stopping is not influenced.

Current Status of Gigabit VLBI System (*Mamoru Sekido*)

Mamoru Sekido reported on the current status of gigabit VLBI system. At first he introduced development status of hardware and software. Then an experimental observation result was reported. Moreover, he showed the development schedule towards the first geodetic VLBI experiment (GIFT experiment) using the gigabit system. (See page 16 for details.)

4.4 Cooperation With Other Institutions

Cooperation for VERA Project

Basic Experiment Plan on Dual-beam Receiver's Phase-difference Calibration Technique (*Kouichi Sebata*)

The report was made on the planned experiment to evaluate a technique to calibrate the phase difference between dual-beam receivers used in a VERA antenna system. The experiment will be carried out step by step as follows. At first dual-beam receiver equipment is examined individually at a factory, then the first time radio-darkroom experiment is carried out. Followed by the second radio-darkroom experiment is performed, then a field experiment is carried out at Mizusawa. Especially, the second darkroom experiment and the Mizusawa field experiment are important to evaluate a horn-on-dish method which calibrates the phase difference by using a cross correlation of wide-band noise signals and is the core of VERA system. (See page 18 for details.)
Q: The reading of AZ and EL encoder of rotation stand used for the field test at Mizusawa is important, I think. What is the resolution?
A: An encorder is not attached on the rotation stand. It performs the observation of changes in the vertical direction at the time of rotation of the rotation stand. The main purpose of the field test is to check the feasibility of phase calibration from such data.

Digital Data Transmission and Data Recorder (*Hitoshi Kiuchi*)

The report was made as follows about the digital data transmission system and data recorder system which are being developed in the VERA project. A digital data transmission system transmits the signal input from high-speed sampler (1 Gsps) by the optical parallel transmission system. Transmission of 14 Gbps per one connector is possible in capability. Furthermore, the report was made also about the present condition of 1G/2G recorder, and the time code inserting method. Moreover, the report was made also about the real-time transmission system including the CRL system. VERA project is important as a place of the first actual proof of VSI (VLBI Standard Interface). (See page 20 for details.)
Q: When transmission is at a low rate, how observation is made?. Moreover, isn't there any method combined with the recorder?
A: The real-time transmission system has the interface of both STM-1 and ISDN (INS1500). In either case transmission rate is below the observation rate, and burst-observation is performed by FIFO using the built-in memory in this case. With the equipment already developed by CRL, the observation time for 24.4 seconds is possible for the case of 256 Mbps observation and 80 Mbps transmission rate. This is sufficient time for detecting fringe of a strong radio source, and might be useful at the time of VERA operation. If system performance can be checked by the real-time transmission system, an experiment in a tape base can be conducted in comfort. As mentioned above, unlike the real-time system of the STM-16 present system, fringe detection serves as the main purpose. Moreover, if a recorder and this equipment are combined, it is also possible to send continuous data.

GIFT (Gifu Telescope) Experiment Plan (3m VLBI antenna will be transported to the Gifu University) (*Tetsuro Kondo*)

It is planning that CRL moves a transportable VLBI station with a 3-m antenna to Gifu in cooperation with the Gifu University, and conduct VLBI experiment. The project was named GIFT (Gifu Telescope). An antenna transportation work started in September. It would be installed in Gifu in November. We will perform the first geodetic VLBI experiment in January, 2000 using a gigabit recorder system.
Q: What is the prospect accuracy of earth rotation measurement?
A: Since antenna diameter is small, a good accuracy is not expected in GIFT experiment. However, we set UT1 measurement of a 10 micro second accuracy in 1 hour as a target of a technical development.

After all activity reports, Fujinobu Takahashi introduced a database software PostgreSQL which is currently developed by CRL for multi-dimension data for GIS application.

5. Greeting of Closing

Hiroshi Kumagai, the vice-director of the IVS TDC at the Communications Research Laboratory, greeted the closing.

The social gathering was performed after the meeting end and opinion exchange was performed further.

Current Status of the Keystone VLBI System

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1. Regular Observations

Number of successful geodetic VLBI sessions with the Keystone VLBI Network had reached 1143 as of September 7, 1999. The time duration of each session was about 6 hours until September 29, 1997 and was expanded to about 23.5 hours after the date. Instead of increasing the duration of the continuous session, frequency of the observation session was decreased from daily basis to once every two days, but the occupation of the VLBI antennas by the observation was still increased from 25% to 50% as a result. Improvements of the estimation errors and the repeatabilities of the estimations by the expansion of the duration of each session are clearly visible in the results as seen in the Figure 1 for example. The same improvements can be seen in both baseline lengths and three dimensional site position estimations. Such a frequent observations became possible with the availability of the real-time VLBI data processing system.

The real-time VLBI data processing system was realized under a collaborations with the Telecommunication Network Laboratory Group of Nippon Telegraph and Telephone Corporation. But the high speed ATM (Asynchronous Transfer Mode) communication network connection to the Miura station was terminated on May 3, 1999. Currently, only three other stations (Kashima, Koganei, and Tateyama) are connected with the high speed ATM network. The frequency of the geodetic VLBI sessions with the four stations had to be decreased because the tape-based VLBI data processing requires more time than the real-time VLBI data processing. As the results, Miura station is now participating geodetic VLBI sessions once every six days and the real-time VLBI sessions are performed twice between the tape-based four station VLBI sessions.

2. Data Analysis

The data analysis system for the Keystone VLBI system was improved and the SINEX (Solution INdependent EXchange) file outputs are now available for all the sessions performed with the Keystone VLBI system. The URL (Unified Resource Locator) of the SINEX files is `<http://ksp.crl.go.jp/sinex/>`.

From the beginning of the Keystone VLBI system operations, correlated amplitude of the observed radio sources have been evaluated and the plots of the time variations for each source are released to the public through a World Wide Web server. The algorithm of evaluating the source flux variations was improved. Figure 2 shows the variations of the radio emission strengths at S-band and X-band for three radio sources. While the radio emissions from 3C84 seem to be very stable at both bands, 3C273B and 3C279 show interesting radio emission variations.

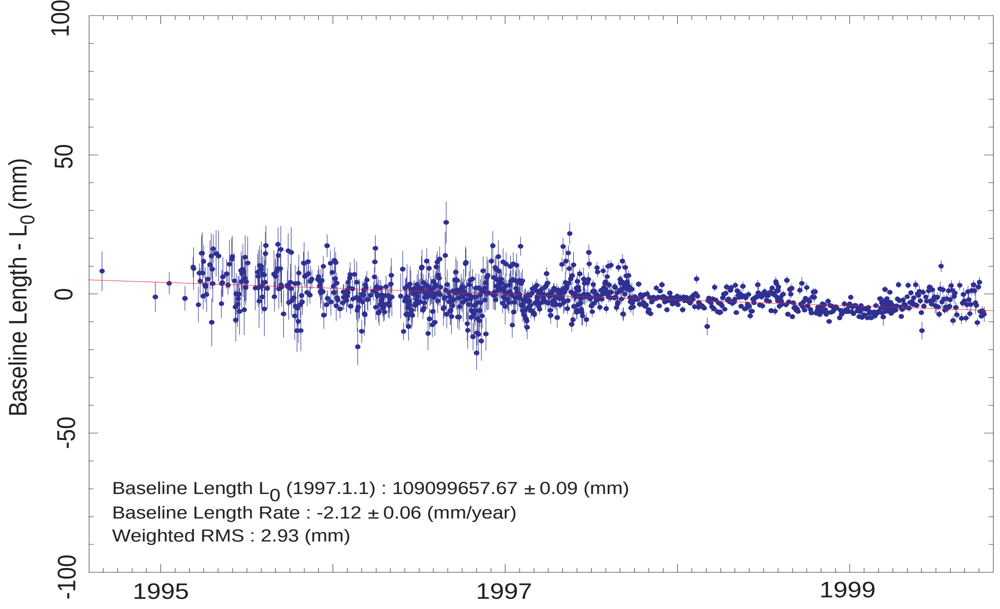

Figure 1. Baseline length between Kashima and Koganei stations estimated from the regular geodetic VLBI sessions with the Keystone VLBI network.

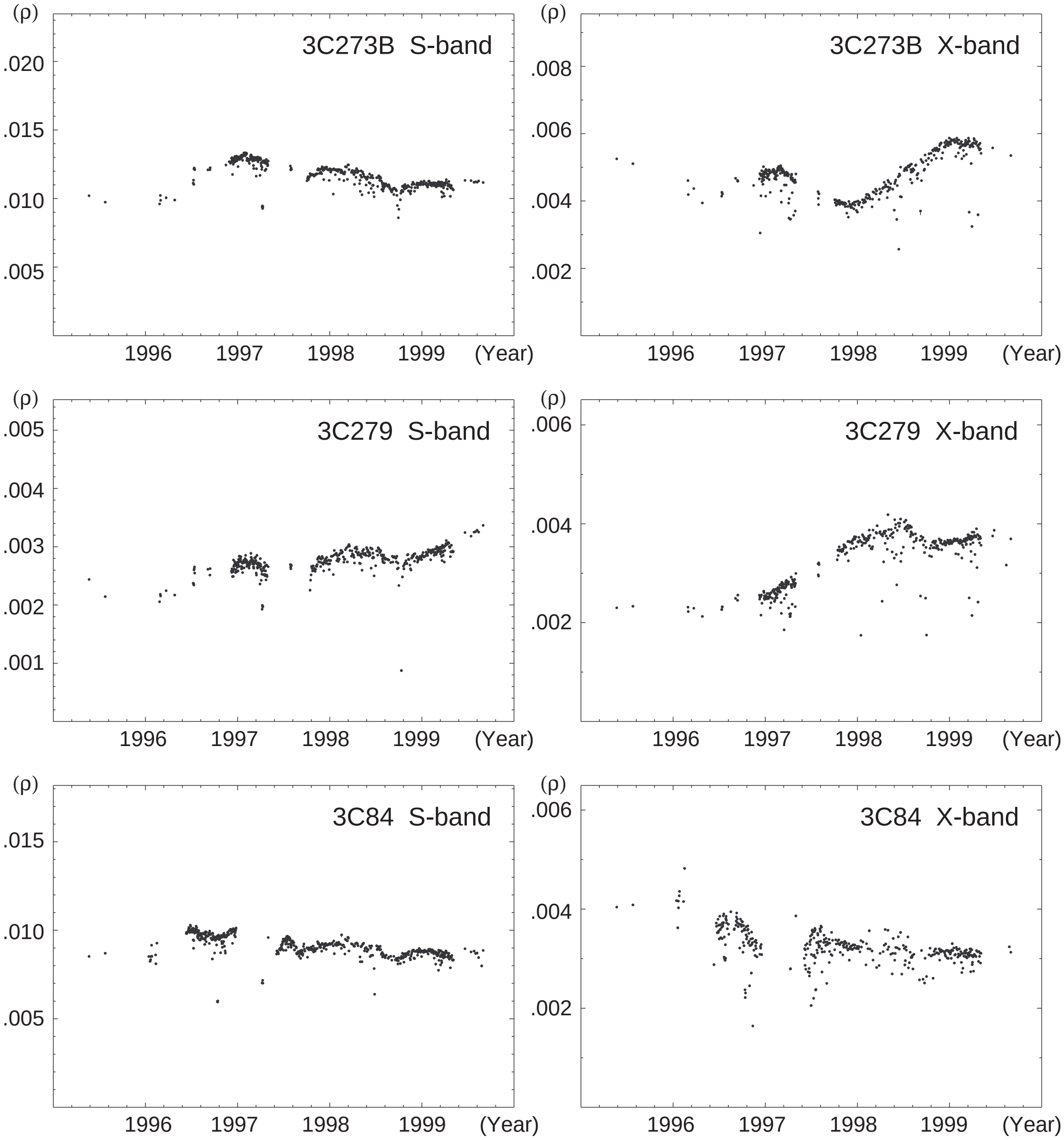

Figure 2. Variations of the radio emissions from three radio sources at S-band and X-band. The vertical axes are the ratio (ρ) of the flux density of the source (S_{source}) to the equivalent flux density of the receiver system (S_{rec}).

Detection of Reflected Pulses From a Single Source by Using Adjacent SLR Stations

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Laser pulses from a single source were reflected by a satellite and detected by both the KSP/SLR Kashima station [*Kunimori et al.,* 1999] and a mobile SLR station. The two stations were separated by 20 m. Both stations are situated within the beam area of the signals reflected by the satellite,so both stations can detect reflected laser pulses fired from either station (see Figs.1 and 2). The baseline between these two stations is short enough (20 m) so that the wave-front of a signal reflected from a satellite more than several hundred kilometers distant can be regarded as a plane rather than a section of a spherical surface. We can therefore use the following simple observation equation,as used in very long baseline interferometry,to estimate the baseline vector.

$$T_m - T_k = -\vec{S} \cdot \vec{B}/C + \tau_c + \dot{\tau}_c t$$

where T_k and T_m are the times at which the reflected signal reaches the Kashima and mobile stations,respectively, $\vec{S}$ is a unit vector in the direction of the satellite, $\vec{B}$ is the baseline vector, C is the speed of light, τ_c and $\dot{\tau}_c$ are the clock time and clock rate differences between the two paths, respectively,and t is the time of the observation.

The observations for the baseline determination were made on June 10th and 11th 1999 (Fig.3). Experimental conditions and estimated clocks are summarized in Table 1 and the estimated positions of the mobile station are shown in Fig.4.

References

Kunimori,H.,T.Otsubo,B.Engelkemier,T.Yoshino, and B.Greene, Timing precision of active Q-switched mode-locked laser and fire control system for synchro- nous satellite laser ranging, *IEEE Trans.IM, Vol.44, No.3,* 1995.

Kunimori,H., KSP SLR system:Design concept of the KSP SLR system, *J.Commun.Res.Lab., Vol.46,No.1,* pp97-102, 1999.

Figure 1. The Kashima station and the mobile station used to detect the reflected pulses. The baseline vector in the direction of the mobile station from the Kashima station lies in the west-east direction and is about 20 m in length.

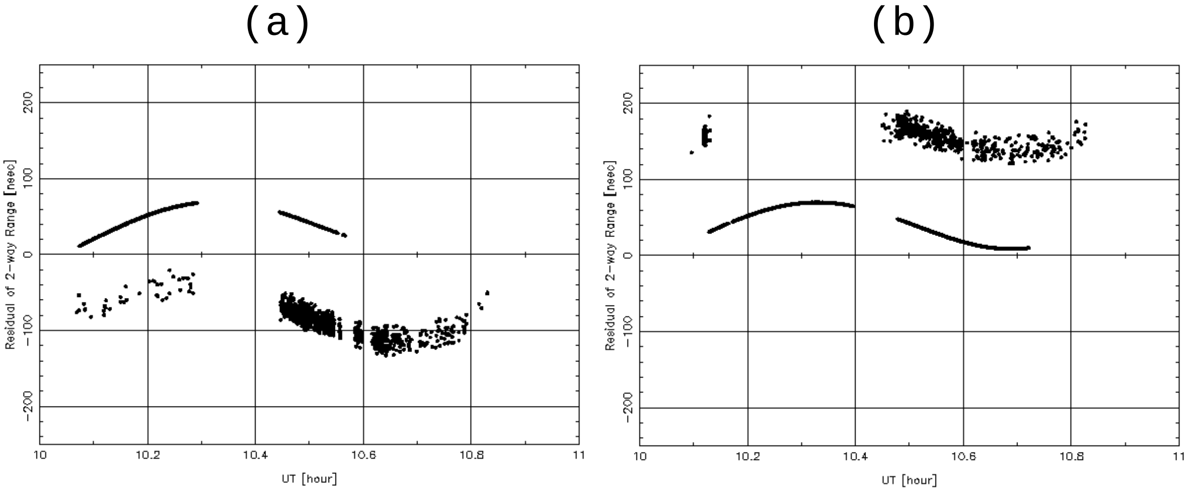

Figure 2. The first observation of the reflected pulses. The observations were made from 1 UT May 7th 1999 and lasted for 5 minutes. The Lageos-2 satellite was used as it passed through the northern sky from north-east to east. The maximum observed elevation of the satellite was about 60 degrees. SLR in synchronous ranging mode [Kunimori et al., 1995] was done at both stations. Figs.2(a) and 2(b) show the signals detected by the Kashima station and the mobile station, respectively. The data in the figures represents the residual error (difference between calculation and measurement) of the two-way range (return time minus laser-fire time). Signal trains with a smaller fluctuation represent reflected pulses originating from the given station and those with a larger fluctuation represent reflected pulses originating from the other station. The RMS residual errors after trends are removed are 150 psec and 8 nsec, respectively. For ideal synchronous ranging, the two trains in Fig.2 might be identical. However, in practice, the trains disagree as can be seen because of the clock and internal delay time differences between the two stations. The larger fluctuation of signals originating from the other station resulted from the difference in laser-fire timing between the two stations.

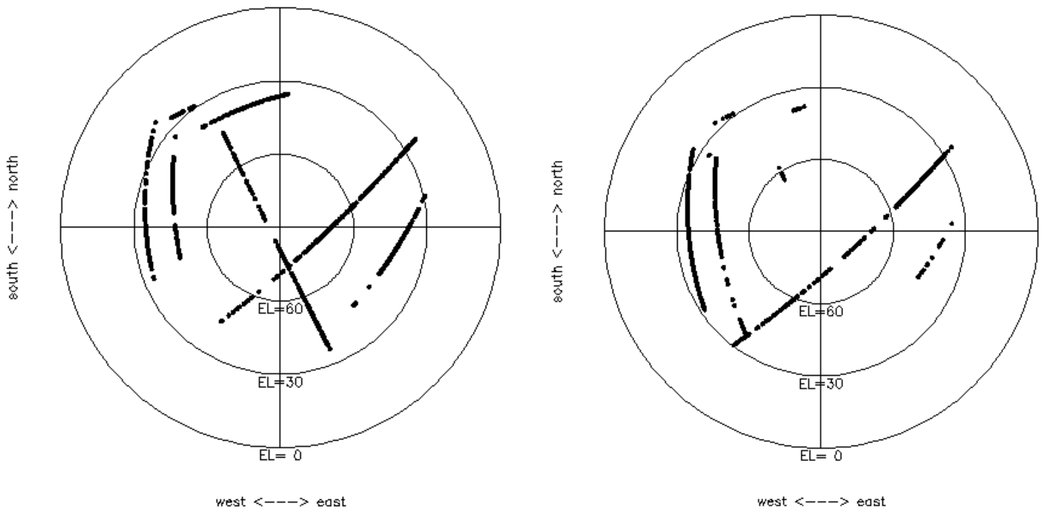

Figure 3. Satellite positions used during the baseline determination experiment. Left : fired from the Kashima station. Right : fired from the mobile station.

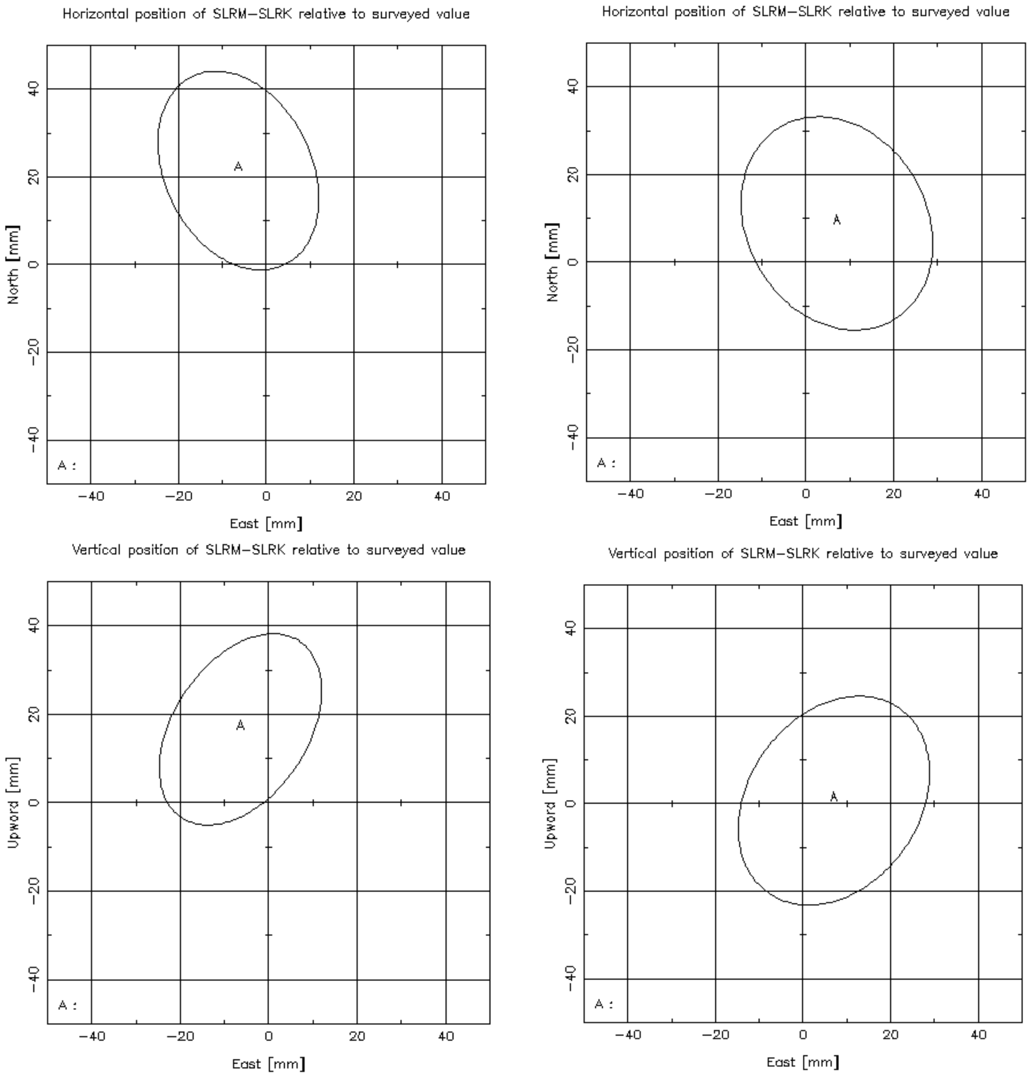

Figure 4. Position of the reference point of the mobile station obtained by baseline analysis. The center of each figure denotes the position obtained by a ground survey. Left: The estimated position using reflected pulses fired from Kashima station. Right: The estimated position using reflected pulses fired from mobile station.

Table 1. Conditions and estimated clocks for the baseline determination experiment. 1141 pulses originating from the Kashima station and 986 pulses originating from the mobile station were detected.

				Laser fired from Kashima			Laser fired from Mobile		
Satellite	Date	Start	Stop	# of returns	Residual [ps]	Estimated Clk difference [ns]	# of returns	Residual [ps]	Estimated Clk difference [ns]
Starlt	6/10	11:11	11:19	386	114	38.3±0.09	304	137	38.3±0.09
Stella	6/10	12:37	12:41	116	147	25.9±0.07	448	156	25.7±0.07
Starlt	6/10	13:02	13:06	145	114	38.4±0.08	33	145	38.2±0.10
ERS1	6/10	13:11	13:13	10	101	38.4±0.10	9	141	38.2±0.08
ERS2	6/11	13:10	13:12	135	128	38.4±0.07	1	130	38.4±0.09
Starlt	6/11	13:21	13:23	37	140	38.4±0.09	7	133	38.3±0.13
Ajisai	6/11	15:08	15:13	136	327	25.7±0.10	16	754	25.3±0.39
Topex	6/11	15:25	15:31	176	271	38.2±0.08	5	442	37.8±0.41

Real-time VLBI via the STM-16 ATM Network

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Abstract

The Communications Research Laboratory (CRL), the National Astronomical Observatory (NAO), the Institute of Space and Astronoutical Science (ISAS), and the Telecommunication Network Laboratory Group of Nippon Telegraph and Telephone Corporation (NTT) have developed a very-long-baseline-connected-interferometry array [*Kiuchi et al.,* 1999a], maximum baseline-length was 208 km, using a high-speed asynchronous transfer mode (ATM) network with an AAL1 that corresponds to the constant bit-rate protocol. The very long baseline interferometry (VLBI) observed data (256 Mbps/station) is transmitted through a 2.488-Gbps [STM-16/OC-48] ATM network instead of being recorded onto magnetic tape. The system was composed of two real-time VLBI [*Kiuchi et al.,* 1999b] networks: the Key-Stone-Project (KSP) network of CRL (which is used for measuring crustal deformation in the Tokyo metropolitan area), and the OLIVE (optically linked VLBI experiment) network of NAO and ISAS which is used for astronomy (space-VLBI). These networks operated in cooperation with NTT. The cross-correlation processing and data observation were done simultaneously in this system and radio flares on the weak radio source (HR1099) were detected.

1. Real-time VLBI system

CRL developed an automated real-time VLBI system using an ATM network called the KSP

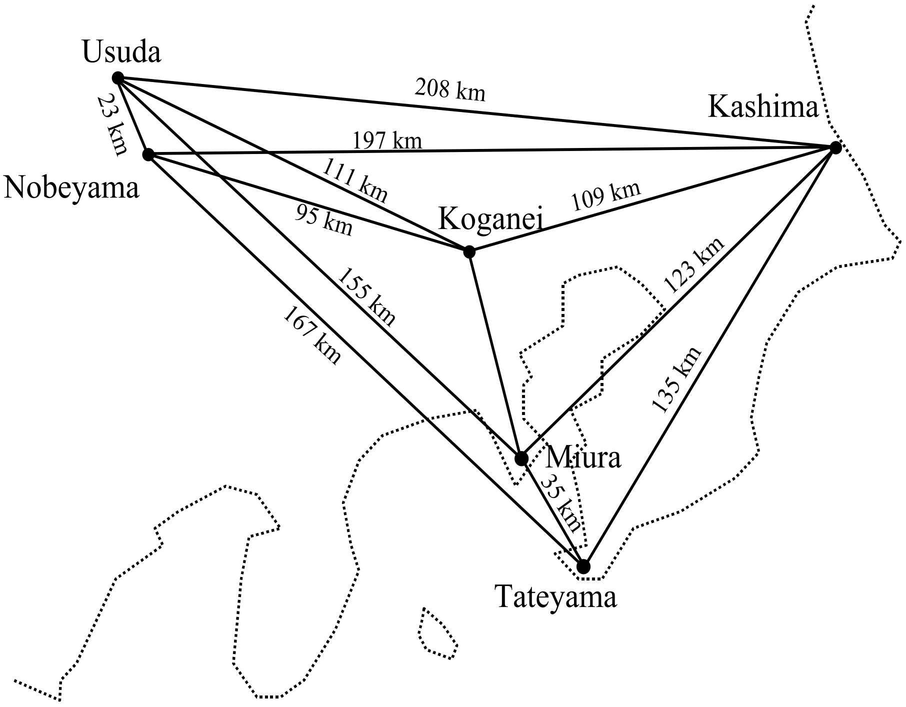

Figure 1. Very-long-baseline-connected-interferometry array.

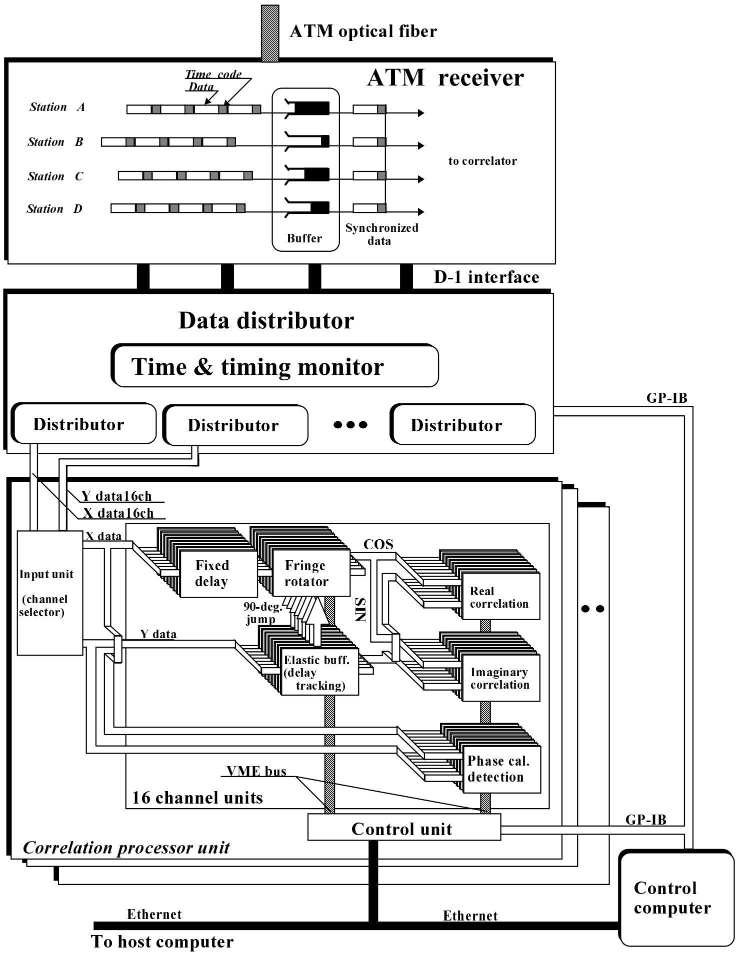

Figure 2. Block diagram of correlation-processing system.

network on 1996. The KSP project, which began in 1994, was developed in order to measure crustal deformation in the Tokyo metropolitan area [*Kondo et al.,* 1998; *Koyama et al.,* 1998]. In regular geodetic KSP, VLBI experiments run every other day for 24 hours. It was found that a horizontal position uncertainty of about 2 mm and a vertical position uncertainty of about 10 mm were achieved [*Koyama et al.,* 1998]. The system was designed to operate automatically throughout the entire process; the results obtained are available to the public via the Internet (http://ksp.crl.go.jp).

NAO and ISAS also developed the OLIVE real-time VLBI network on 1997 for astronomy. The network was used for monitoring the space-VLBI (VSOP: VLBI space observatory program) signal.

These networks were operated in cooperation with NTT. In both systems, STM-16/OC-48 (SDH: synchronous digital hierarchy/SONET: synchronous optical network) ATM networks [*Sato et al.,* 1998] are used.

The large-size (208 km) highly-sensitive array (very-long-baseline-connected-interferometry array, Fig.1) was established by high-speed digital optical data links composed of both the KSP and the OLIVE networks. Four of the seven antennas; Usuda (64 m) / Nobeyama (45 m), Koganei (KSP-11m), Kashima34 (34m) / Kashima11 (KSP-11m), Miura (KSP-11m), and Tateyama (KSP-11m) were selected by the ATM cross- connect switch. The virtual telescope (the connected real-time VLBI array) was realized to observe weak radio sources.

2. VLBI data acquisition and correlation system

Received radio-signals from astronomical radio sources at the VLBI site were converted to digital signal by the VLBI data-acquisition system (a high-end version of the K-4 system [*Kiuchi et al.,*

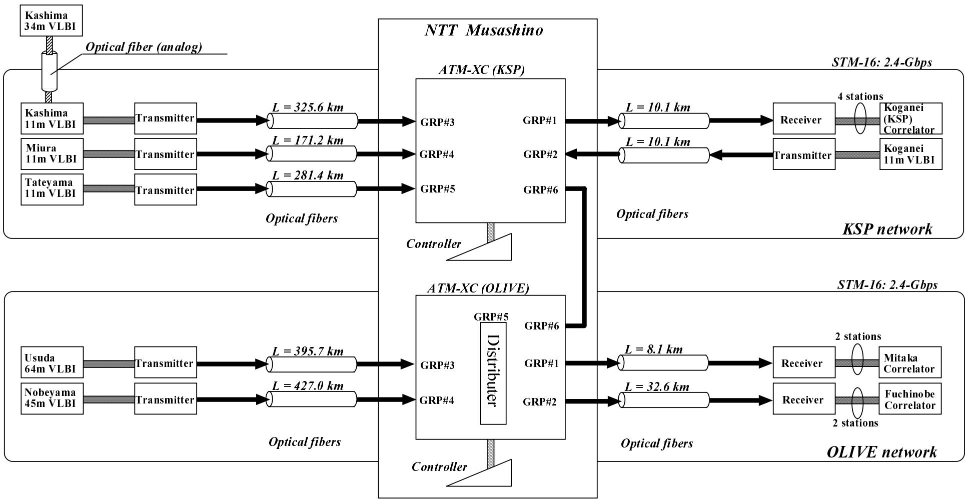

Figure 3. ATM networks.

1997]). The data rate of the ATM transmission was selected from five rates (ranging from 16 to 256 Mbps).

The six-baseline real-time KSP correlation system (Fig.2) is usually operated as the very-long-baseline-connected-interferometry array. The KSP correlation-processor is an XF type using field-programmable gate arrays (FPGAs) on a VME board. The correlation processor has a 512-Mbps data processing speed capability and 512 complex lags in total.

3. System evaluation

The real-time VLBI system (very-long-baseline-connected-interferometry) was operated from September, 1998. The very-long-baseline-connected-interferometry experiments were carried out in 256-Mbps data rate at each station. Four stations were selected from seven stations; Usuda64 (64 m) / Nobeyama45 (45 m), Koganei (KSP-11m), Kashima34 (34m) / Kashima11 (KSP-11m), Miura (KSP-11m), and Tateyama (KSP-11m). The selection of Usuda64 (64 m) and Nobeyama45 (45 m) was alternated, as well as the selection of Kashima34 (34m) and Kashima11 (KSP-11m). All of the radio telescopes were Az-El type antennas. The KSP system is a dual-frequency system (8GHz-band and 2GHz-band) for compensating ionospheric delay. Usuda64 has band receivers ranging from 1.5 to 22 GHz. Nobeyama45 has band receivers ranging from 22 to 110 GHz, and Kashima34 has band receivers from 1.5 to 43 GHz. The VLBI observation equipment at each site includes an ATM transmitter. The Kashima34 station was the only station that transmit IF (intermediate frequency) analog signal to the Kashima11 VLBI site about 600 m. The IF analog signal is sent using commercially available fiber-optic links modulated in the radio-frequency range. The fiber-optic links were the Ortel 10341A laser diode and the Ortel 10455A photo detector. The IF signal is converted to digital signal by the KSP VLBI data-acquisition system (high-end version of the K-4).

The 16-ch digital filtering was done after sampling in the VLBI data-acquisition system, the bandwidth of each channel was 8-MHz. The cross-correlation processing using the KSP six-baseline real-time correlation processor and observation were done simultaneously.

The weak star observations were carried out. One of the sources was HR1099. The binary system HR1099, which is considered the non-thermal nature of its radio emission, is a non-eclipsing system. It is probably related to and consistent with the magnetic activity scenario emerging. In this scenario, the radio flux arises from the interaction of mildly relativistic particles and magnetic fields (gyro-synchrotron emission) on one or both components. The radio behavior of HR1099 is quite characteristic: two rather different phases, quiescent and active, appear to alternate.

The observation was carried out in a dual-frequency (X-band and S-band) using Usuda, Kashima34, Koganei, and Miura. The detected active phase of HR1099 (flare-up of X-band signal) is shown in Fig.4. The correlated amplitude of the quiescent phase was 3.14×10^{-5} in X-band (4.16×10^{-5} in S-band) and that of active phase was 2.61×10^{-4} in X-band (1.77×10^{-5} in S-band). The period of the quiescent phase is far longer than that of the active phase and the active phase detection was done between Usuda64 and KSP antennas. Unfortunately, the Kashima34 was not possible to operate because of a moderate gale when the flare-up detection.

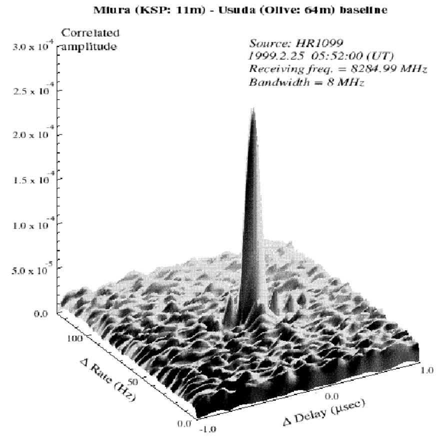

Figure 4. Result of weak star (HR1099) observations.

4. Conclusion

A real-time VLBI system that corresponds to the constant bit-rate protocol using the STM-16/OC-48 ATM networks with AAL1 was developed. The system was demonstrated its function successfully. This system is a significant advance in VLBI and should provide more precise information about radio astronomy.

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Status Report of Giga-bit VLBI System

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1. Hardware component of Giga-bit VLBI system

Communications Research Laboratory and National Astronomical Observatory are developing prototype-type of next generation Giga-bit VLBI system. The high speed data rate of 1024Mbps has achieved by using commercial High Definition TV recorder GBR-1000. Interfaces of GBR-1000 for VLBI application were developed by CRL [*Nakajima et al.,* 1997] and recently Giga-bit correlation processor is developed with based on Nobeyama mm-array interferometer correlator. The Ultra-Wide-Band-Correlator (UWBC) chip was developed by Kawaguchi of NAO. To adopt high speed sampling ability of digital oscilloscope (TDS784A/TDS580:SONY Tektronix) for VLBI data observation, sampler interface box with de-multiplexing function has also developed. Picture of hardware components of the Giga-bit VLBI system is shown in Figure 1 and function is listed in Table 1. Logical wire number of this data acquisition system is prepared in accordance with the VLBI Standard Interface (VSI) specification.

The first fringe has been already detected with a pair of KSP 11 m antennas [*Sekido et al.,* 1998]. Now each equipment of the system is stage of adjusting and removing minor bugs for routine VLBI observation and is very close to the completed system.

2. Software implementation

Software is also important component for regular VLBI observation and data processing. Three component of software is under the preparation for the Giga-bit VLBI system.

Observation Software Observation software controls Giga-bit VLBI data acquisition terminal from PC following a VLBI observation schedule. All the Giga-bit VLBI backend equipments are controlled from GP-IB interface. Currently two kind of software is present as candidates. One is HP-Basic software running on HP-basic for windows. The other is observation software coded in C on Linux. The two software are compared from view point of convenience and stability.

Correlation Software Correlation software consists of correlation management software (CMS) and set of task programs (TP). The former interact with operator for correlation setup and invokes correlation task. The latter includes correlator model calculation program and correlation task communicating with correlator and other equipment. These software run on HP-UX 10.20 workstation. The CMS is coded in Perl/Tk to provide GUI for easy operation. The TPs are made by OKI Electric Co Ltd., which constructed the GICO. These software are already working and will be improved through some bug fix and functional extension.

Post correlation software Giga-bit correlation system is currently 512MHz bandwidth single channel VLBI system. Then bandwidth synthesis over several frequency channels can be skipped in post correlation data processing. Already some programs are working such as quick look fringe detection program. We are going to use the Giga-bit VLBI system for geodetic measurement in GIFT (Gifu telescope) experiment, which is introduced in the other article of this issue. For geodetic use, post correlation data processing program, which output the same format with KOMB (bandwidth synthesis program), is under the development. Then group delays and phase delay rates data are stored in Mark-III data base and geodetic baseline analysis will be done with CALC/SOLVE package.

3. Working plan

We have been doing test experiment named GEX-n for preliminary observations. In the middle of October 1999 GEX-6 was performed, which will continue 6 hours simultaneous observation with KSP system on Kashima- Koganei baseline. The purpose of the experiment is comparison of group delay, phase delay rate, correlation amplitude, and SNR between Giga-bit system and 256 Mbps conventional VLBI system.

As a milestone of development of the Giga-bit VLBI system, a GIFT experiment is planned in the first quarter of 2000. A 3 m diameter antenna,

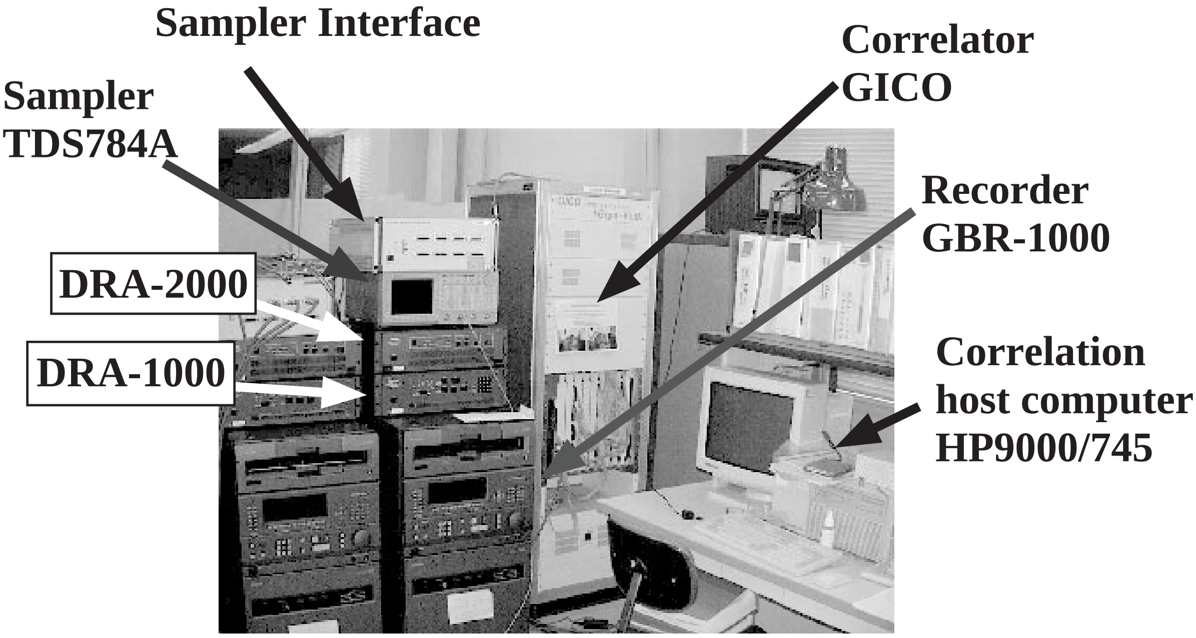

Figure 1. Hardware components of Giga-bit VLBI system.

Table 1. Equipment for Giga-bit VLBI system

Device name	Used in Observation	Used in Correlation	Function
GBR-1000	YES	YES	Data reordering and playing back unit
DRA-1000	YES	YES	Data recorder and time data control
TDS784A/580	YES	NO	Sampling unit (max 1Gsps x 2bit x 4ch)
Sampler Interface	YES	NO	Sampler output demultiplexing
DRA-2000	NO	YES	Buffering data stream for correlation
GICO	NO	YES	Experimental correlation processor.

which had been used as mobile VLBI station in CRL, is moved to Gifu university as a kind of ‘gift’. In January 2000, the first geodetic purpose experiment will be performed named as GIFT experiment. At the same time GPS observation will be carried out and the geodetic solution will be compared with the Giga-bit VLBI experiment.

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Phase Calibration Test for Dual Beam Receiving System of VERA

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1. Introduction

Project VERA's goal is the development of a receiving system for radio astronomy with the ability of extremely accurate measurement of the relative phase between two radio sources. In this system,a dual beam antenna is used to observe two independent radio sources simultaneously.The antenna is composed of a parabolic surface dish with a 20-m diameter and two receivers installed at Casegrain focus of the antenna.Accurate measurement of the relative phase (between two radio stars) requires phase calibration of the dual beam antenna system.This paper reviews the phase calibration tests for the system.

2. Causes of delay

Delays in the system result from the following causes.

(1) The angular distance between two radio stars (an observable of the radio astronomy).

(2) Electric path length difference between the two receiving systems (the accuracy after calibration should be better than 0.05 mm).

(3) Path length difference of the antenna structure (the accuracy after calibration should be better than 0.05 mm).

(4) Path length difference caused by the rotatable dual beam driving mechanism.

(5) Changes in the atmospheric path delay.

3. Phase calibration tests for the dual receivers

The calibration system of the dual beam antenna system is to be tested as follows.

(1) performance test for individual receiver, which is a fundamental performance test conducted before shipment from the factory.

(2) a first step test in a radio anechoic chamber (phase delay stability check).

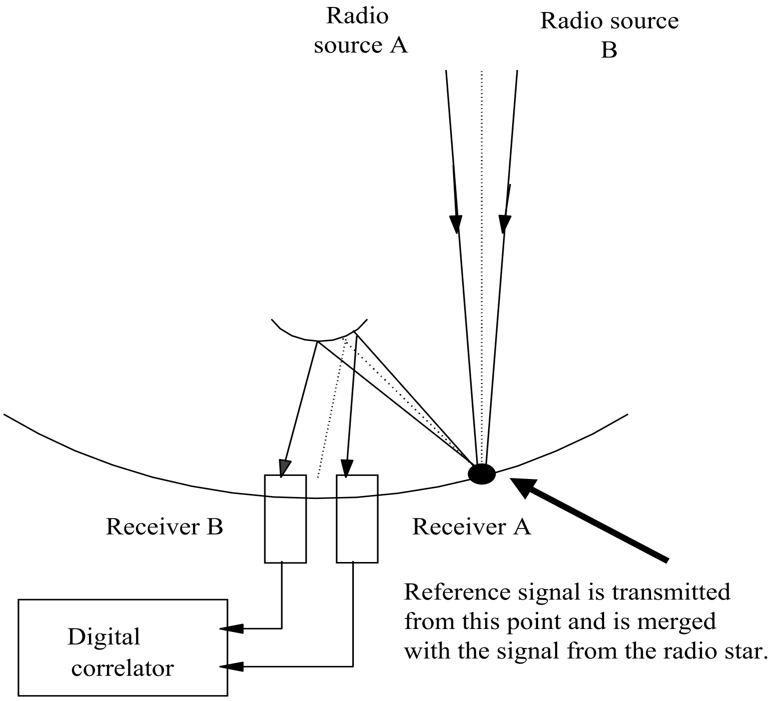

Figure 1. Antenna relative delay calibration by using reference signal transmitted from antenna surface.

(3) a second step test in a radio anechoic chamber (Figs.1,2) to check the accuracy of the horn-on dish method by correlated phase calibration using wide band noise.

(4) field test at the Mizusawa observatory (Fig.3 Integration test for the phase calibration system using a mock-up antenna).

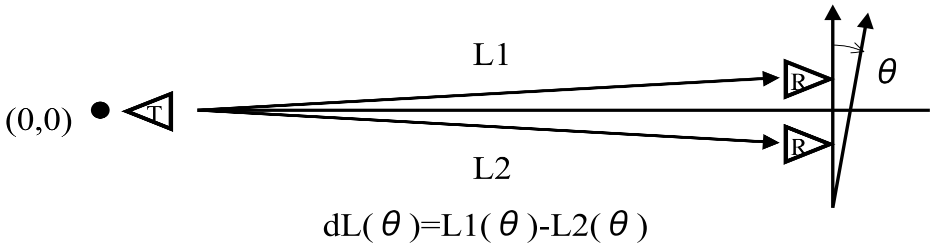

Figure 2. Calibration method.

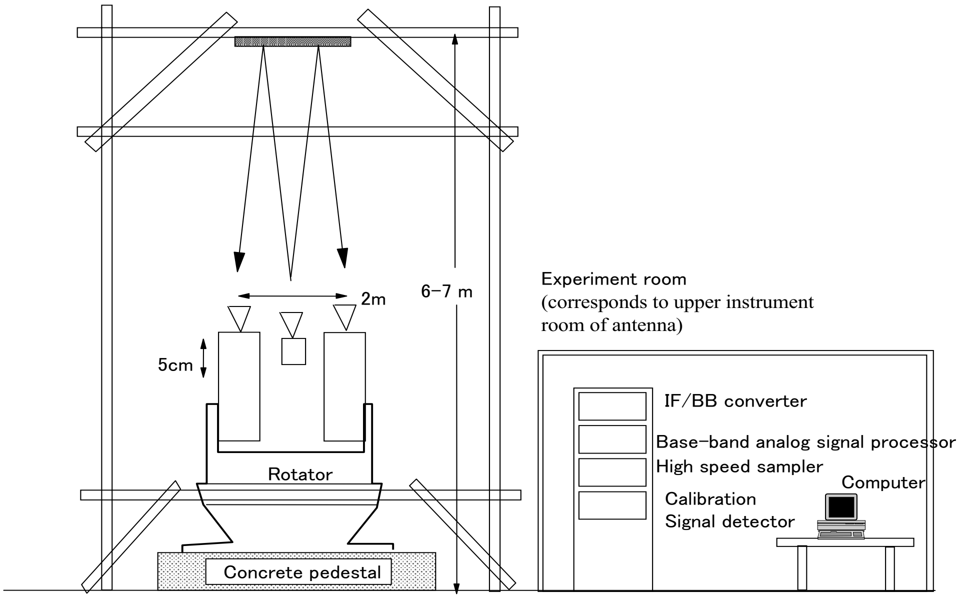

Figure 3. Test measurement at the Mizusawa site.

Contribution to the VERA Project – Digital Section

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The Communications Research Laboratory (CRL) is participating in the VLBI Exploration of Radio Astrometry (VERA) project of the National Astronomical Observatory (NAO). The CRL is working primarily on the digital section, including a sampler, a parallel data transmit system, a data recorder, and a real-time VLBI system. The development is done under the leadership of Dr. N.Kawaguchi. The CRL recommends some parts of the system. This is a preliminary version, an alteration will be done depend on the budget of the NAO. Furthermore, the project is aiming at realization of the VLBI standard interface (VSI).

1. Sampler

A modified Tektronix TDS-580 oscilloscope was incorporated into a high-speed A/D sampler. We can make use of our past experience, the CRL modified a TDS-784 oscilloscope to work as a VLBI sampler. The sampler has four channels and a sampling speed of 1024 Msps/ch (max). The high-lank two-bit of sampled data by A/D is used for the VLBI data.

2. Optical data-transfer system

The sampled data is transmitted from the antenna site to the main building (300m apart) via optical fibers. Because the transmission speed must be higher than 2048 Mbps, we use a parallel optical system (Optobahn Co., URL http://www.optobahn.com) with skew-matched fibers and MTP (or MPO) connectors. The connectors receptacle are embedded in the module to make connecting the fiber ribbons extremely easy. The source is 1.3- micron meter edge-emitting laser arrays, and the detector is PIN photo diodes.

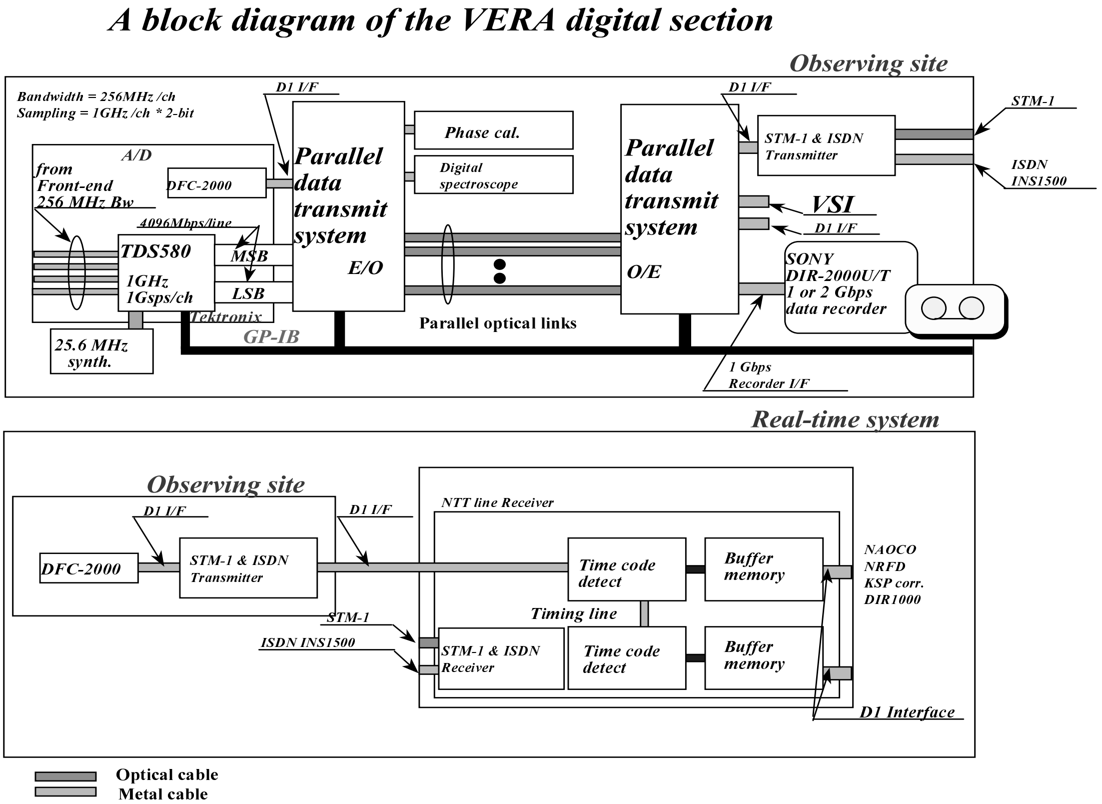

Figure 1. A block diagram of the VERA digital section.

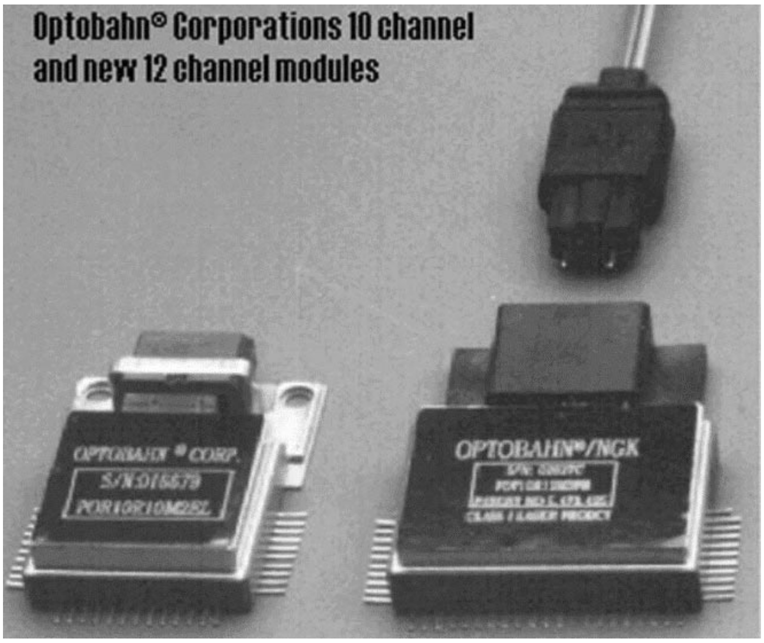

Figure 2. A parallel optical system.

The data rate of the module is 1 Gbps/ch, and there are 12 channels.

3. Data recorder

We incorporated a rotary-head type recorder (SONY DIR-2000U/T) that uses a cassette tape the same size as that of the K-4 system. It has a 1024-Mbps data-recording speed which will be boosted to 2048-Mbps in the next model. A time code is inserted into the data, and the data rate is slightly faster (332 PPM) for time-code insertion. The recorder has backward compatibility; it can read DIR-1000 series (American National Standard 19-mm Type ID-1 Instrumentation Digital Cassette Format) tapes.

With a large cassette, the recorder provides up to 640 Gbyte of data-storage capacity. The recording time is about 80 min (large cassette, 11-μm-thick tape) at the recording speed is a 1024-Mbps. Recording and playback are possible at different data rates: 1024, 512, and 256 Mbps, making the recorder suitable for many applications. The playback head is side by side with the recording head, so recorded data is immediately played back during recording. This "read-after-write" facility makes it possible to monitor the error conditions of recording in real time. The bit error rate after correction is better than 1×10^{-10}. The recorder employs a built-in diagnostic system designed to detect operation errors and hardware faults. Error messages and warning information is fed to the host computer via a remote control interface and to the front panel display.

4. Real-time VLBI system

The real-time VLBI system was designed based on CRL's STM-1 real-time VLBI system. The ATM network it uses transmits information in fixed-length packets called cells. Each cell (AAL type 1) holds 53 bytes of data, consisting of a 5-byte header, a 47-byte data payload, and 1 byte used as a sequence number to check for cell loss and mis-delivery. The signals input to the ATM transmitter are written into the payload of the ATM cell in arrival order. A cell header showing the destination is attached when the payload is filled; the cell is then output to a 155.52-Mbps [STM-1/OC-3] or ISDN (INS net 1500) transmission path. The ISDN communication is an appended function. The virtual-path identifier (VPI) in the header shows the destination virtual path. It is possible to transmit data at various rates over the same transmission path.

In the receiver, the multiplexed signal (cells) is disassembled, then reassembled into signals corresponding to the stations according to the destination in the cell-header data. The system has functions to compensate for transmission-line delay, absorb cell-delay fluctuations, and compensate for cell mis-delivery and cell loss in the receiver. The delay suffered by each cell depends on the cross-connect switching timing. Therefore, the cell interval is not

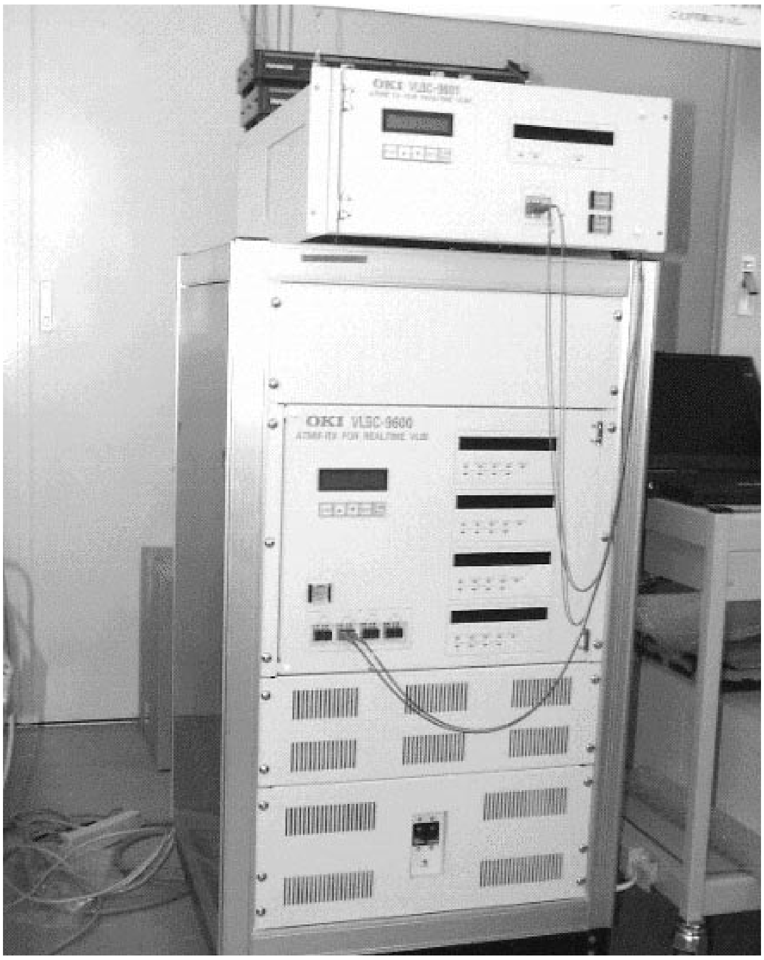

Figure 3. Current STM-1 real-time VLBI system (by CRL). Upper: transmitter. Lower: receiver

preserved in the network, and the arrival interval differs from that on the transmitter side. This cell-delay fluctuation depends on the number of devices the cells must pass through, the data rate, the transmission-line accommodation rate, and the traffic characteristics in the virtual path.

The cell-delay fluctuations are absorbed in the receiver by using a buffer memory (more than 32 cells for STM-1); the cells are reassembled so that the data is regularly spaced with the same spacing as on the transmitter side.

Cell loss or mis-delivery may occur in the transmission of signals through the ATM network. For VLBI, mis-delivery or cell loss that leads to bit-make and bit-slip actions are regarded as fatal errors. If cell loss occurs, the lost bits are replaced by a duplicate of the immediately previous cell, and if a cell is mis-delivered, it is removed. The maximum delay fluctuation, recommended to be 3 ms by a telecom company, is adjusted by the FIFO memory.

The STM-1/OC-3 (155 Mbps) ATM VLBI system can be applied to both optical-fiber and satellite links. We use AAL1 corresponding to the constant bit-rate protocol and 512-Mb memory, which can support plus or minus 1 s of data. For lower-speed virtual channels, the memory can support multiple data speeds down to 8 Mbps. Although the selectable data rate of the K-4 system is 256/n Mbps (n=1, 2, 4, 8, ...), the 156-Mbps ATM transmits up to only 119 Mbps because of its overheads. We solved this problem by using a 4-Gb buffer memory in both the transmitting and receiving units. This enables 256-Mbps observation for a limited duration (about 16 s). If the observation data rate is greater than the data transfer rate, the data is accumulated in the memory. Observations can be made from 8 to 256 Mbps, and the data transfer rate can be set from 8 to 119 Mbps.

An Experimental Campaign for Evaluation of Wet Delay Variations Using Water Vapor Radiometers in the Kanto District, Central Japan

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Radio signal delay associated with the neutral atmosphere is one of the major error sources for space-based geodetic techniques such as the Global Positioning System (GPS) and Very Long Baseline Interferometry (VLBI). Recently, several anisotropic mapping functions have been developed for the purpose of better modelling these propagation delays, thereby improving the repeatability of horizontal site coordinates [*MacMillan,* 1995; *Chen and Herring,* 1997]. The anisotropic mapping function is considered a powerful tool for removing or calibrating the effects of horizontal variability of atmosphere from GPS and VLBI analyses. Atmospheric gradients are assumed to have a simple linear form in the anisotropic mapping function. However, it suggested that this assumption is not always appropriate in the context of intense mesoscale phenomena such as the passing of cold front, heavy rainfall events, and severe storms. Thus, in June 1998 we initiated a field experiment for detecting and characterizing water vapor variati ons using water vapor radiometers(WVRs) in the Kanto district of central Japan. In this short report we present a preliminary analysis of our findings.

Three WVRs were installed on the east-west line from Kashima to Tsukuba as shown in Figure 1. Dual-frequency geodetic GPS receivers were installed nearby these WVR sites, allowing intercomparison of the atmospheric delay parameters derived using each technique. The delay estimates derived from WVR observations are calibrated in standard fashion by comparing WVR results with those obtained by numerical integration of operational radiosonde profiles observed by the Japan Meteorological Agency (JMA) at Tsukuba (Tateno). Figure 2 shows that calibrated WVR

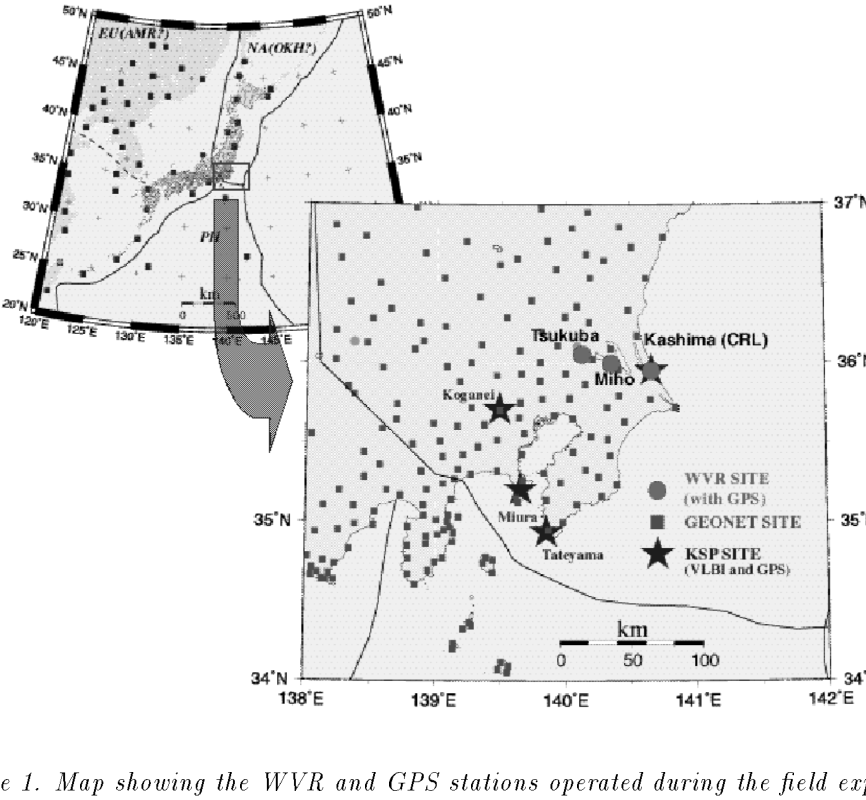

Figure 1. Map showing the WVR and GPS stations operated during the field experiment.

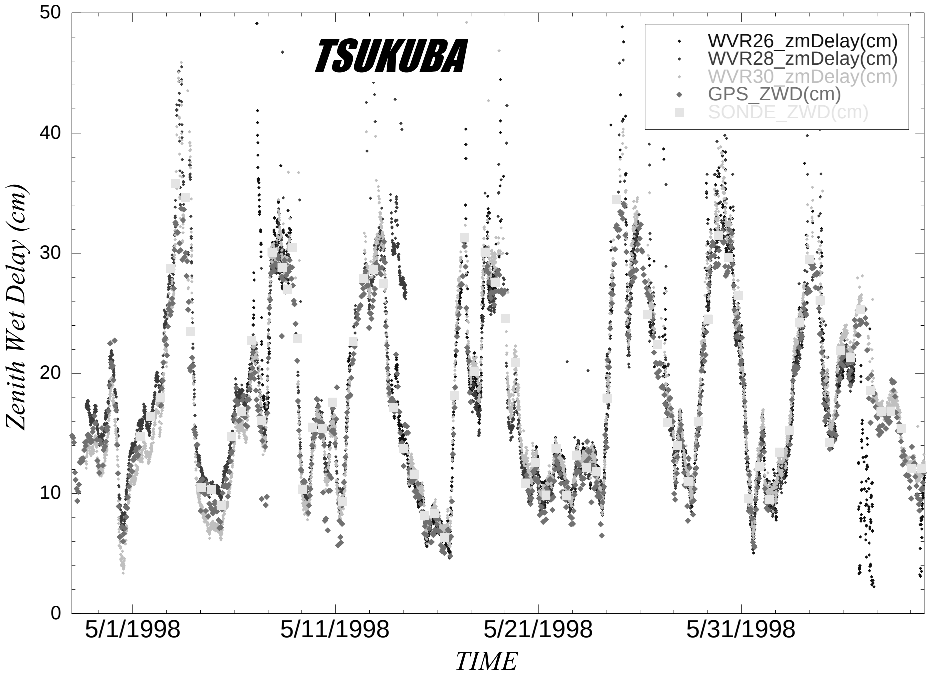

Figure 2. Zenith wet delay at Tsukuba as measured by WVR, GPS, and radiosondes from 28 April to 10 June 1998. The WVR wet delay is calibrated by comparing with the delay based on the radiosonde data.

delays are very consistent with the delay derived from radiosonde profiles during the period 28 April - 10 June 1998. GPS-derived delays are also consistent with the other measurements as shown in the same figure.

Time series of atmospheric gradients estimated by WVR slant delays at Tsukuba and Kashima are compared each other as shown in Figure 3. In this figure we show the estimates of the EW (upper) and NS (lower) gradient delay during July 1998. Here, the gradient vector was estimated as a piecewise linear function with two-hour intervals. Both series of the EW and NS gradient components are smoothed with 24 hour window. In spite of relatively short distance between Tsukuba and Kashima (about 54 km) the atmospheric gradients solutions are significantly different. The magnitude of the NS gradient component at Kashima is approximately several times larger than that at Tsukuba during 3-4, 9-10, and 30-31 July 1998. We investigated the zenith wet delay (ZWD) field retrieved by the permanent GPS array of the Geographical Survey Institute (GSI), by constructing maps in which ZWD is represented as a continuous spatial function (by interpolating between the GPS stations). In the vicinity of Kashima, for the period 3-4 July 1998, the ZWD field had a strong NS gradient of up to 1cm/10km. But the gradient in Tsukuba during this time period was very much smaller. This result suggests that the mesoscale weather pattern caused large differences to develop in the NS gradient (between Kashima and Tsukuba). We are now analyzing the output of high resolution numerical weather prediction models in order to investigate these results more deeply.

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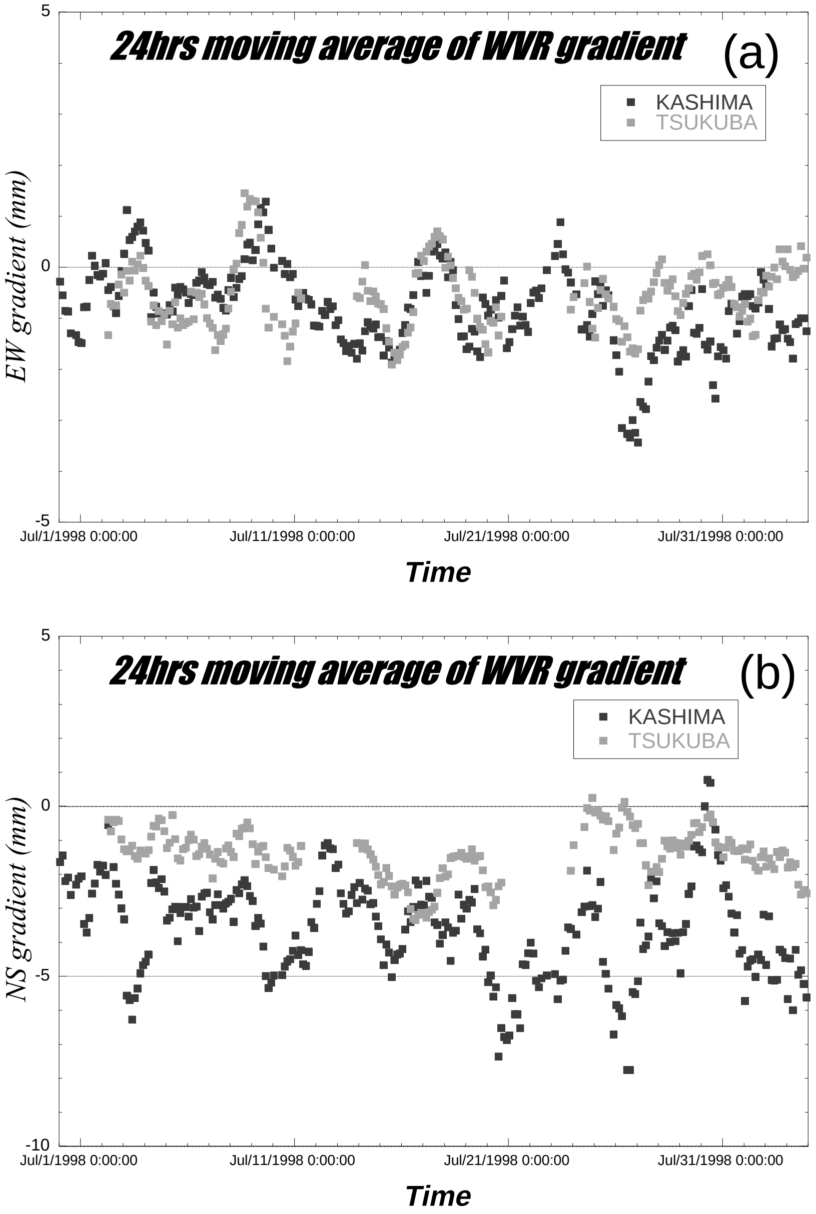

Figure 3. Estimates of the gradients at Tsukuba and Kashima obtained by WVR slant delays in (a) the east-west direction and(b) the north-south direction. The gradient components estimated with two-hour intervals are smoothed with 24 hour window.

Optical and Coaxial Serial Data Transmitter/Receiver for Giga-bit VLBI and VSI

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Abstract

A pair of serial data transmitter and receiver units to be used for VLBI observations at 1024 Mbps has been developed. The transmitter unit converts 1024 Mbps digital data from a parallel interface into a serial format so that the data can be carried over a very long distance. The receiver unit converts the serial data into parallel digital data stream again. The pair of units work transparently with a certain delay. Both optical and coaxial serial transfer cables can be used. The maximum distances of transmission are 20 km and 100 m for the optical and coaxial cables, respectively. It is expected the units will work with an AD sampler located in telescope or at a correlator station where the data transfer over a metal wired digital cable for a long distance is difficult. At present, the specification of the units are based on Japanese VLBI system. But a slight modification of the interface design will fit these units to VSI (VLBI Standard Interface) which is currently discussed in the IVS (International VLBI Service for Geodesy and Geometry).

Specification

The units are named as SPO1152TX and SPO1152RX. They have been manufactured by YEM (Yamashita Engineering Manufacture Inc.). Both units uses HD-SDI module inside. The core module was originally designed for HDTV serial data transfer. The SONY (HK101/102) module is based on BTA-S004 bit serial interface definition and has become popular among broadcasting products. Capacity of the parallel-serial module is 1500 Mbps. 1024 Mbps data/clock and other VLBI attribution signal (ex. 1PPS, time-code, and validity signals) lines required by VSI specifications are packed into the total data rate at 1.5 Gbps and transmitted. We can use both optical fibers and

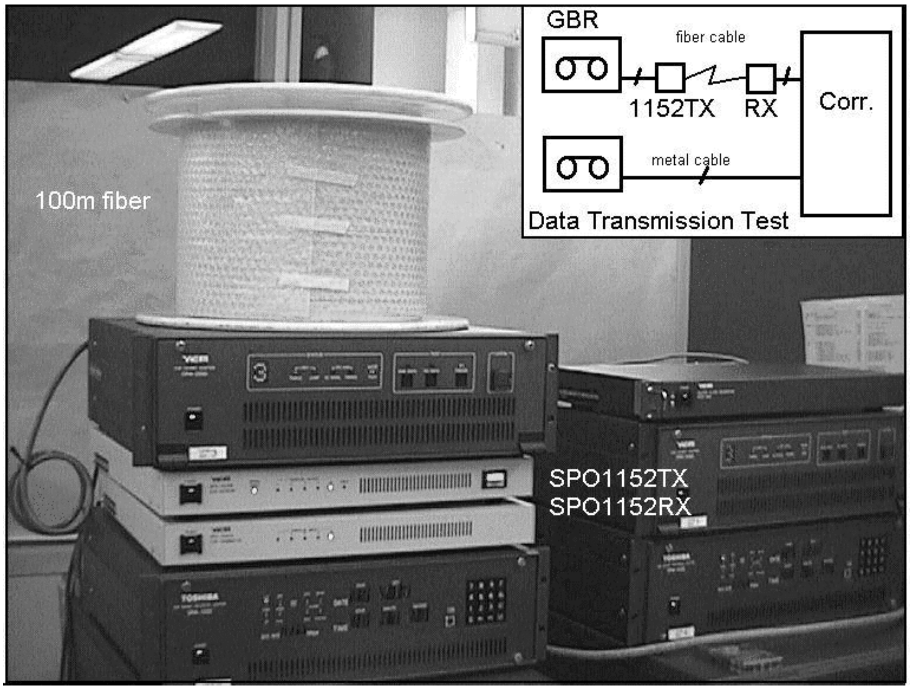
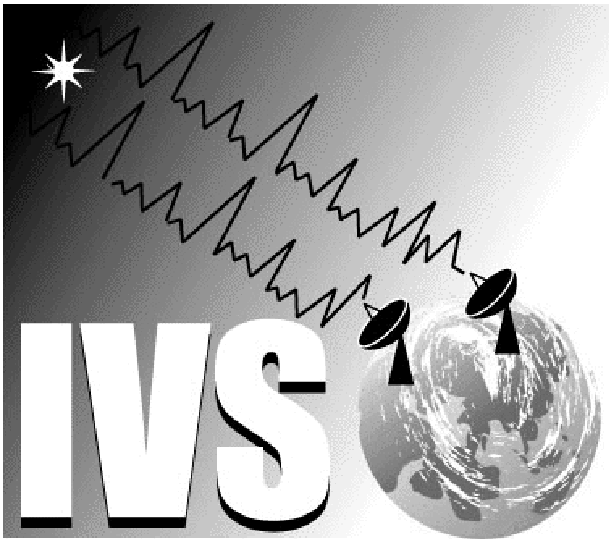


Figure 1. Data transfer test was performed by integrating the optical serial transmitter and receiver units in the Giga-bit VLBI correlation processing configuration. The serial transmitter and receiver units were placed between a recorder interface (DRA1000) and a correlator interface (DRA2000). An 100 m optical fiber was placed above the unit. The test was successful and normal fringes were obtained from the correlated results.

50-ohm coaxial cables for the serial data line. The optical transmitter uses 1.3-micron of wavelength. It is possible to use optical lines already installed at telescope sites for analog E/O-O/E system. This capability will be able to eliminate several number of IF amplifiers and it will reduce system gain variations. Since the maximum distance between serial transmitter and receiver is as long as 20 km if an optical fiber is used, the system can be used for connected element interferometry. When the distance between the transmitter and the receiver units is less than 100 m, a coaxial connection is recommended, since the on-board laser optical module (removable from the board) is relatively expensive. The coaxial transmission will be valuable for example at correlator stations where data have to be transfered over more than 20 m, but not as far as 20 km. At the transmitter side, an alarm LED indicates incoming digital status. When the bits are logically unchanged for certain period, the LED will disappear. This feature is especially useful to check the function of an AD-sampler unit. At the receiver side, an alarm LED indicates the status of the recovered parallel data and the error rate. Thus, it is possible to know whether the connection if fine or not from a distant point from the transmitting site. Fixed clock rate at 256Mbps data transfer is also possible as a part of 1024 Mbps.

Experiment using the units

An experiment using the serial transmitter and receiver units was carried out on 29th October, 1999 (Figure 1). Inspections using HDTV instruments showed its BER (Bit Error Rate) was below its detection limit. Before using the system in actual observations, we also tested its function in the correlation processing. We confirmed a 200-microsecond digital delay was introduced by the serial transmission from the correlated results. Comparisons of the correlated amplitudes did not show any changes. This result can be interpreted to mean that the serial transfer of data was perfect. Other attribution lines and timing of the data transmission were confirmed, too. When we used coaxial cables, 30 dB of attenuation had to be applied to 50-ohm cable by pad attenuators to increase BER and an error is indicated by the LED. This means data can be transmitted for more than 100 m over a coaxial cable. We are planning to use the units in the next Giga-bit VLBI experiment.



IVS Logo

"IVS CRL Technology Development Center News" (IVS CRL-TDC News) published by the Communications Research Laboratory (CRL) is the continuation of "International Earth Rotation Service - VLBI Technical Development Center News" (IERS TDC News) published by CRL. In accordance with the establishment of the International VLBI Service (IVS) for Geodesy and Astrometry on March 1, 1999, the function of the IERS VLBI technical development center was taken over by that of the IVS technology development center, and the name of center was changed from "Technical Development Center" to "Technology Development Center".

VLBI Technology Development Center (TDC) at CRL is supposed

1) to develop new observation techniques and new systems for advanced Earth's rotation observations by VLBI and other space techniques,
2) to promote research in Earth rotation using VLBI,
3) to distribute new VLBI technology,
4) to contribute the standardization of VLBI interface, and
5) to deploy the real-time VLBI technique.

The CRL TDC meeting, attended by the ordinary members from inside the CRL and the special members from the outside, is held twice a year. The special members advise the committee, concerning the plan of technical developments. The CRL TDC newsletter (IVS CRL-TDC News) is published biannually by CRL.

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Summaries of VLBI and related activities at the Communications Research Laboratory are on the World Wide Web (WWW). The URL to view the home page of the Radio Astronomy Applications Section of the Kashima Space Research Center is : **"http://www.crl.go.jp/ka/radioastro/"**. The URL to view the Keystone project's activity is **"http://ksp.crl.go.jp/"**.

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