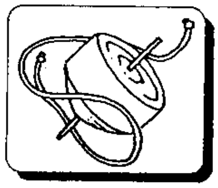
Technical Development Center News No.3

(International Earth Rotation Service VLBI Technical Development Center News)

published
by
the Communications Research Laboratory
in Tokyo, Japan

August, 1992
(Reproduced in June, 1998)



Introduction

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).

The Technical Development Centers are concerned with

I. the development of new observation techniques and new systems for advanced Earth's rotation observations by VLBI and other space techniques,

II. the promotion of research in Earth rotation by advanced methods in VLBI,

and

III. the distribution of new VLBI technology.

The TDC meeting is held twice a year, including the special members from outside the CRL. The committee is advised, concerning the plan of Technical Development by the special members. The Technical Development Center News is published biannually by the Communications Research Laboratory to inform on current activities to the IERS community. From the second TDC news, we publish the TDC News only in English taking the international distribution into account.

The third TDC Meeting was held

on July 22, 1992 at the Conference Room of CRL.

Agenda

1. Opening Mr.A.Sugiura, Director of Standards and Measurements Division, CRL
2. Technical Development Plan in 1992
   (1) Outline of the short term technical development
   (2) Technical Development Plan in 1992
   (3) Report from each institution
   (4) IRIS-P Promotion Plan
   (5) Announcement of the iRiS Workshop '93 in Tokyo
3. Discussion on the reports

Attendees:

Akira Sugiura	CRL/Tokyo
Taizoh Yoshino	CRL/Tokyo
Hiroo Kunimori	CRL/Tokyo
Kuniaki Uchida	CRL/Kashima
Michito Imae	CRL/Kashima
Shin'ichi Hama	CRL/Kashima
Yukio Takahashi	CRL/Kashima
Kosuke Heki	CRL/Kashima
Hiroshi Takaba	CRL/Kashima
Koichi Yokoyama	NAO/Mizusawa
Noriyuki Kawaguchi	NAO/Nobeyama
Makoto Murakami	GSI
Masaki Ejiri	NIPR
Makoto Nakayama	NEC

Abbreviation:

CRL: Communications Research Laboratory
NAO: National Astronomical Observatory
GSI: Geographical Survey Institute
NIPR: National Institute of Polar Research

MINUTES OF THE MEETING

2-(1) Outline of the short term technical development

After showing the brief description of the each item, discussion was made freely. (See the description in this issue.)

Murakami: Excess path delay correction by water vapor is discussed in 1cm, while 3cm error is discussed in ionospheric correction by single band VLBI. How can I understand these differences?

Takahashi: Delay induced by water vapor is important to establish the precise global coordinate. Single band VLBI is being made in the domestic experiment using the mobile station. In this case, measurements of the vector between stations are more important than to define the frame. So 3cm is acceptable.

2-(2) Technical Development Plan in 1992

The plan for this year is reported. Most of them are introduced in the "Technical topics" in this issue.

2-(3) Report from each institution

Yokoyama (NAO/Mizusawa): (The GPS activity shown at the last IERS Workshop in Paris is described.) Sharing the work between VLBI and GPS should be considered again. Upgrading plan of IRIS-P network will be explained later.

Kawaguchi (NAO/Nobeyama): Less expensive VLBI Data Acquisition Terminal is developed for wider use. A ground terminal for VSOP is now under development. In the design, A/D converter to be developed by SONY is supposed to be used. 4Gbps burst sampler is being made.

Murakami (GSI): Authority of 26m antenna in Kashima will be soon transferred to GSI. GSI will participate in DOSE project using 26m antenna. 2.4m antenna was completed for mobile station, which will be tested next at Kanozan station. At Minamitori Island (Marcus), VLBI reference point by CRL and SLR reference point by JHD are connected by GPS measurement. MDX (Metropolitan Diamond Cross) experiments were made with CRL. 5m antenna in Tsukuba will be transported to Omaezaki (Shizuoka) station in October. VLBI data analysis software in Engineering Workstation was introduced from GSFC.

Ejiri (NIPR): Budget of the Antarctic experiment is applied for. Resolution made at the last TDC meeting should be a great help. Feasibility for 22GHz VLBI in Syowa is also studied.

Okihara (SONY): 32Mbps A/D converter is being developed. As an interface to the K-4 Data Recorder. RS-232C and RS-485 are available as well as RS-422.

Nakayama (NEC): For the 22GHz VLBI at Syowa, performance of the antenna and radome were studied. It must be possible to adopt 22GHz facility.

DISCUSSION

Yoshino:	If the 22GHz VLBI become possible at Syowa, which station will be a partner?
Kawaguchi:	The VLBI station in South America is a candidate.
Heki:	According to Dr.Yokoyama, VLBI observation should be made to monitor a long term variation of the Earth rotation, while GPS observation is enough for a short term variation. If the GPS result is assured in observing Earth rotation, how often should the VLBI observation be made?
Yokoyama:	It is important to continue VLBI observation for a long term. But it does not mean that much less frequent observation is enough.

2-(4) IRIS-P Promotion Plan

Yokoyama: (He explained the meaning of the following proposal.)

- -

The Upgrading Plan of the VLBI IRIS-P Network
for Monitoring the Earth's Rotation

July 22. 1992
The National Astronomical Observatory
The Communications Research Laboratory

Space techniques like very long baseline interferometry [VLBI] has brought about a drastic breakthrough in the study of the earth's variable rotation, and the observable results have contributed not only to the scientific development of astronomy, geodesy and geophysics, but also to space development. However, the VLBI data which have so far benefited users have been those produced mainly by the VLBI IRIS-A [International Radio Interferometric Surveying, Atlantic] network composed of the stations in USA and Europe. The data from the IRIS-P [Pacific] network, whose observational frequency is low and *whose correlation completely relies upon US facilities, have not made enough contributions. Thus it is now internationally required that Japan play a leading role in operating the IRIS-P network and produce significant data. To accomplish this, the Japanese VLBI group has come to an agreement to endeavor to equip all IRIS-P stations with the next-generation K-4 recording systems developed in Japan, and to establish a data acquisition system covering all necessary procedures, such as, scheduling, correlation and analysis. Operational targets will be focused on the detection of rapid changes in the earth's rotation with high accuracy. This will help improve our knowledge of the physi cs of the earth's deep interior and the mechanism of global changes.*

Any assistance and advice will benefit NAO and CRL to proceed in their plan composed of the following items:

- *To take responsibility in monitoring the earth's rotation by the IRIS-P network equipped with the K-4 systems.*
- *To establish a technological development plan to start an experimental system in the third year, and complete the whole system in the fifth year.*
- *To develop research on global changes and the physics of the earth's deep interior by integrating various types of data, i.e., the earth's rotation data which they aim to acquire, the oceanographic data acquired by TOPEX/POSEIDON, and the atmospheric angular, momentum data.*

NAO and CRL are pleased to make the announcement of the above plan here to the international communities. Progress reports will be made at relevant international meetings. NAO and CRL believe that this project will result in producing significant scientific outcome, and will provide an opportunity to prove that the K-4 system is an efficient tool for future international VLBI observation.

2-(5) Announcement of the iRiS Workshop '93 in Tokyo

At the IRIS Steering Committee held during the XX th IUGG General Assembly in Vienna in 1991, the workshop on VLBI in 1993 was suggested by Dr.W.Carter as a Coordinator of VLBI in IERS. Since the Science and Technology Agency in Japan approved the budget for the workshop, the workshop is hosted by the Communications Research Laboratory which is acting as a VLBI Technical Development Center of IERS.

The title of the workshop is "International workshop for Reference frame establishment and technical development In Space geodesy". So it is named "iRiS Tokyo '93". It will be held on

Jan.18 (Mon) to Jan.21 (Thu), 1993
at the CRL Conference room
(Tokyo, Japan).

We will focus the subject on the future plan of VLBI and other techniques in IERS to establish the reference frame.

iRiS '93 TOKYO

Outline of the short term technical development plan

Technical Development at the TDC in Japan
by T. Yoshino

IERS activities have two aspects. One for the regular service. And the other for introducing advanced technology for more precise observation. TDC understands the both needs for technological improvement of observation and practical use. We discussed the items of technical development in short term range taking these needs into account.

K-4 SYSTEM
by H. Kiuchi

In developing VLBI data acquisition system, it is impossible to ignore the requirement of the multi-bit sampling and the wide-band data sampling. Nowadays, each VLBI network becomes isolated due to the data acquisition and the data compatibility. We are developing the next generation VLBI system, and whose data acquisition mode include the VLBA (2-bit 16 MHz) and the VSOP (2-bit, 32 MHz) data mode. The new acquisition system has one bit sampling and two bit sampling modes for VLBI, furthermore 4 and 8 bit sampling for general purpose data acquisition. The total data rate is reached to 256 Mbps (DIR-1000 data recorder).

It is supposed that the input video bandwidth is 32 MHz. The anti-aliasing filtering is made in analog, and after sampling the 16 MHz, 8MHz, etc. filtering are made by digital filter. It is possible to get the good filtering and good phase characteristics by using digital filter. Number of video channels can be selected (from 2 to 16 ch) for each station and each observation purpose, geodesy or astronomy. An effort has been made to achieve an IRM (Image Rejection Mixer) for 32MHz bandwidth .

K-4 Correlator
by S. Hama

We decided to use the K-4 correlator not only for R&D experiments but for a routine processing in some degree. It makes use of a custom LSI for the center part. Its main features are; 2 bit sampled data processing, milli-second pulsar gate, 16Mbps $\times$ 15ch, good for Earth-Moon VLBI. Software for this correlator is also to be developed.

K-4 Supporting Software
by Y. Koyama

K-4 back end terminals and K-4 data recorders have a GP-IB control capability. To perform VLBI observations, it is needed to send command and request protocols from a host computer. NKAOS, which has been developed on HP1000/A400 computer, can interface with the 34m antenna system at Kashima Space Research Center and organizes data acquisition with either K-3 and K-4 systems. MAOS software, which has been developed on HP BASIC running on HP9000 series computers, is convenient to control K-4 system in a various configurations.

Development of New Delay and Phase Calibrators by M. Imae

A new Delay and Phase Calibrators of the VLBI system are now under development at CRL. This calibrators use a 100MHz reference signal obtained by making frequency multiplication of the 10MHz reference signal of the Hydrogen Maser frequency standard.

Namely the comb generator of the Phase Calibrator is driven by 100MHz signal and it generates phase calibration signals of 100MHz frequency spacing. This 100MHz phase calibration signals are fed to a micro-wave attenuator which has a gate signal of 1MPPS obtained from the same 100MHz reference signal. The output signal from this micro-wave attenuator has a impulse train of 1 micro-second spacing in time domain and 1MHz frequency spacing in frequency domain. This impulse train is used as the phase calibration signal.

The Delay Calibrator also uses the 100MHz band reference signal by measuring the round trip time between the main unit placed at back-end site of VLBI equipments and the antenna unit placed at the front-end site.

The new system also has a temperature compensation function to reduce the effect of the environmental temperature perturbation.

Millimeter Wave VLBI for geodesy by H. Takaba

Merits

1. Precise delay time determination by the wide band receiving.
2. One frequency band geodesy VLBI (useless of the ionospheric delay time correction).

Demerits

1. Poor system performance compared to the S/X bands (Low aperture efficiency, tracking problem, and high receiver noise temperature).
2. Large atmospheric absorption (optical depth exceeds O.1 at the zenith in case of rain).
3. Low correlation amplitude because of the intrinsic characteristics and the resolving out of the radio sources.
4. Large coherence loss because of the atmospheric fluctuation and the local's fluctuation.

System consideration

10-20m antennas' pair, 20 - 40 GHz band low noise receiver (super HEMT or SIS ?), IF band width of 2 GHz, 8 MHz $\times$ 16 ch or 16 MHz $\times$ 8 ch video conversion system, and a 256 Mbps recorder.

Report of Water Vapor Radiometry
by M. Sekido

One of the most important source of error in very-long-baseline interferometry (VLBI) is propagation delay caused by water vapor. Water vapor radiometry (WVR) is an instrument to estimate this wet delay by measuring the sky brightness temperature with Water Vapor Radiometer. The typical uncertainty of VLBI group delay data is within an order of 10mm. So, if we can estimate the wet delay with an uncertainty much less than 10mm, it is a great improvement on VLBI technology. G. Elgered et. al [1] have reported the comparison between the propagation delay estimated by WVR and that obtained by Kalman filtering of the VLBI data themselves. According to them, the repeatability obtained for baseline length estimates shows comparable accuracies with both methods. On the other hand, T.Tanaka et. al [2]. have observed wet component of the delay by using water vapor radiometer at Uji in Kyoto. But the estimated delays are different by several centimeters from one equipment to another. So the data are not sufficient to imp rove the accuracy of base-line length estimates yet.

Present important problems in WVR are as follows;

1: biases in the measurements depending on the instruments
2: improperly modeled height profiles of pressure, temperature and humidity
3: uncertainty of attenuation coefficients of liquid water drops.

[1] G.Elgered, J.L.Davis, T.A.Herring, and I.I. Shapiro "Geodesy by Radio Interferometry : Water Vapor Radiometry for Estimation of the Wet Delay", J.Geophys. Res., 96, 6541-6555, 1991.

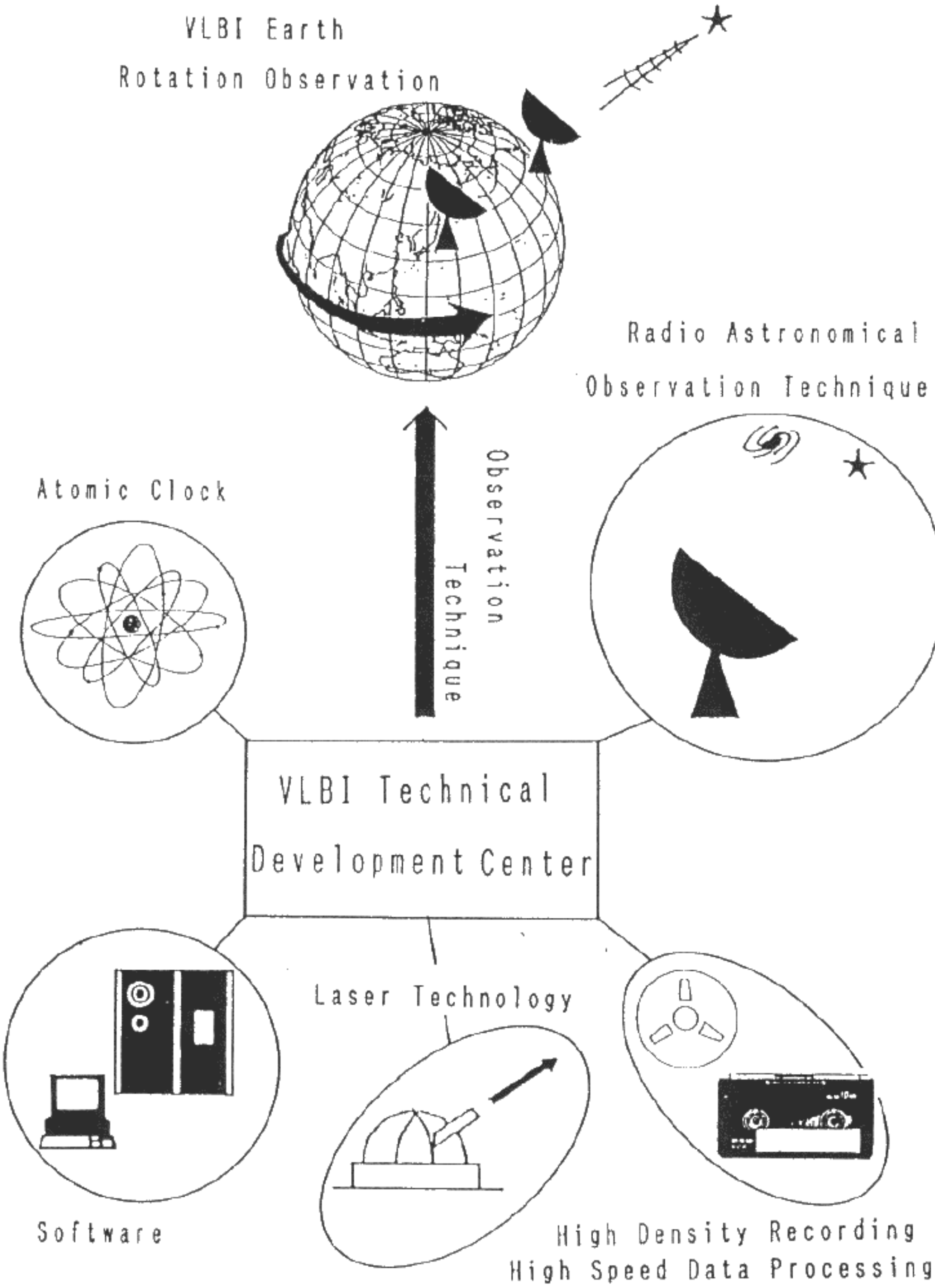
[2] T.Tanaka, K.Nakamura, and K.Hirahara, "PRELIMINARY RESULTS FROM AN OBSERVATION OF WATER VAPOR IN THE TROPOSPHERE WITH TWO MICROWAVE RADIOMETER AT UJI", Proceedings of the Japanese Symposium on Earth Rotation, Astronomy, and Geodesy, 153-156, 1991.

Development Schedule

	1992	1993	1994	1995
Multi-bit, Wideband	–wideband VC –2bit test →	Manufac- turing →		
K-4 Correlator	Specification LSI design	Manufac- turing Test	IRIS-P Cor Assistance	
K-4 Supporting Software	←	Documentation →		
	←	System Upgrade support →		
	←	Assistance for station →		
Phase, Delay Calibrator	Development (2.4m) Test Development (34m)			
Single band VLBI	— Horizontal distribution of ionosphere estimation from TECMETER data →			
	— Conversion from horizontal distribution og ionosphere to the excess path delay →			
Millimeter wave VLBI	40GHzRx(SIS)	40GHz VLBI 100GHzRx Design	100GHzRx 40GHz VLBI →	100GHz Wband VLBI
WVR	Review of WVR			

Technical Topics

In every issue of the TDC News, topics of technical development is introduced by researcher in TDC.



Status Report of System Development

by S. HAMA

1. K-4 Correlator

We decided to use the K-4 correlator not only for R&D experiments but for a routine processing in some degree. It makes use of a custom LSI for the center part. It can be a base of a correlator for IRIS-P. So its specifications are as follows;

ch & Speed	16Mbps $\times$ 16ch
Lag (/16ch)	256 (not considered maser observations)
Type	XF
2bit-sampled data	OK
Milli second pulsar	OK
d τg/dt	96 μs/s (good for Earth-Moon)
Fringe Rate	2.5MHz (ditto)

2. New K-4 Input Interface

The prototype model, which is to be added on a present input interface, is about to be completed. The whole set of a new K-4 input interface is completed at the end of 1993 FY. The particular version for VSOP (space VLBI), which doesn't make use of MkIII type time label, will be rather different from the original new K-4 version.

An effort is being made to achieve an IRM for 32MHz band-width.

3. New Phase/Delay Calibrator

A new type phase/delay calibrator of better stability is under trying.

Transportable VLBI antenna development and Cluster antenna

by Y. Takahashi

1. Transportable 2.4m VLBI system

CRL and GSI has developed a small transportable VLBI system for the sea level monitoring system. The change in the long term is suitable to use the tide gauge data of tidal station. The position of the tidal station may be moving in long term by local crustal deformation. Therefore we should measure the movements of tidal station, and its data should be corrected to the change in tide gauge data. We developed the VLBI system in order to measure the movements of tidal stations. As there are many tidal stations in Japan, the system should be transportable and small for Japan narrow roads. 2.4m antenna and receiving system were developed. We confirmed that it has the performance to be used for the VLBI with Kashima 34m antenna to observe the Moon by single dish. We conducted the test VLBI observation with the strong radio source 3C84 with Kashima 34m antenna, and we detected good fringe as shown in Figure-1. This system will be transported to the tidal station near Tokyo in this year, and we will measure the som e tidal stations in Japan for several years.

2. VLBI using four cluster antennas

We conducted the VLBI experiments by new VLBI technique between two antennas in each site on 29th May and 27th June. The 34m and 26m antennas in Kashima of CRL, and 6m and 45m antenna in Nobeyama of Nobeyama Radio Observatory were used for this experiment (Figure-2). The main purposes are (1)relative VLBI, (2)the investigation of integration time longer than 1000 sec, (3)weak source observation such as Cygnus3 and SS433, (4)the characteristic of atmosphere scintillation for the different angle distance less than 10 degree, (5)deformation of large antenna, (6)application of the relative VLBI for the geodesy. At first, we make an analysis of the integration longer than 1,000sec. The coherence loss of correlated amplitudes are caused by the long variation of atmosphere scintillation and hardware stability. The correlated amplitudes become smaller in according to the integration time when it is longer than 600. Signal to Noise Ratio (SNR) becomes maximum when the integration time is about 1,200 sec as shown Figure-3. We continue to make the detail analysis of the reason. The data will be also analysed from the other aspects.

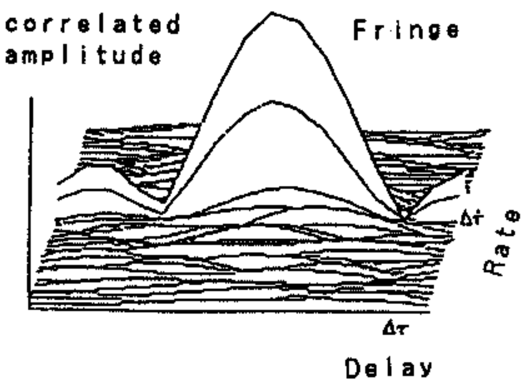


Figure 1. Fringe detection (Source 3C84).

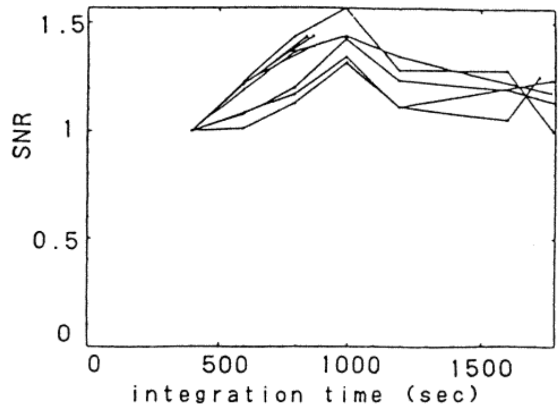


Figure 2. SNR as integration time normalized at 400sec.

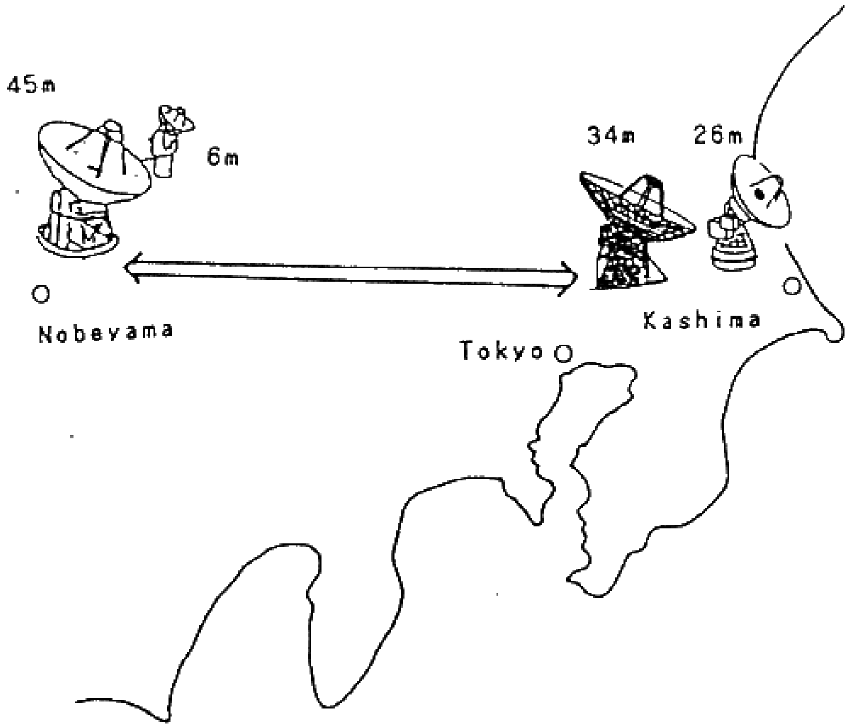


Figure 3. VLBI using four antennas cluster.

IONOSPHERIC CORRECTION IN A SINGLE BAND VLBI

– APPLICATION TO MINAMIDAITOJIMA EXPERIMENTS –

by T. Kondo, Y. Koyama and J. Amagai
(Geodesy Group)

GPS signal measurements provide observations of the total electron content (TEC) which are applicable for the correction of the ionospheric excess delays in case of VLBI measurements made at a single frequency band. The directions of GPS satellites from a station are, however, usually different from those of radio stars observed by VLBI. Hence the TEC obtained by GPS measurements must be mapped to other directions. A practical model has been developed to perform this mapping with sufficient accuracy. In the model, trajectories of GPS measurements are represented by UT and latitude coordinate of intersection points of sight with the ionospheric shell. A TEC distribution on the UT-latitude plane is first estimated from GPS measurements, then TEC is mapped to radio star direction. Instrumental offsets of each GPS satellites must be taken into account in the estimation. However, on a short baseline (<2000 km) these offsets tend to be cancel out because of a similarity in trajectories on the UT-latitude planes at both ends of baseline. Evaluation of model by means of comparison with the dual-band VLBI shows that the model can apply to the ionospheric correction of a single band VLBI with an accuracy of about 0.2 ns (0.1 ns in case elevation angle larger than 30 deg) in terms of X band excess delay. The model has been applied to an actual VLBI conducted on the Kashima-Minamidaitojima baseline. Consequently we have been able to detect the motion of Minamidaitojima reflecting the Philippine sea plate motion (Fig.1).

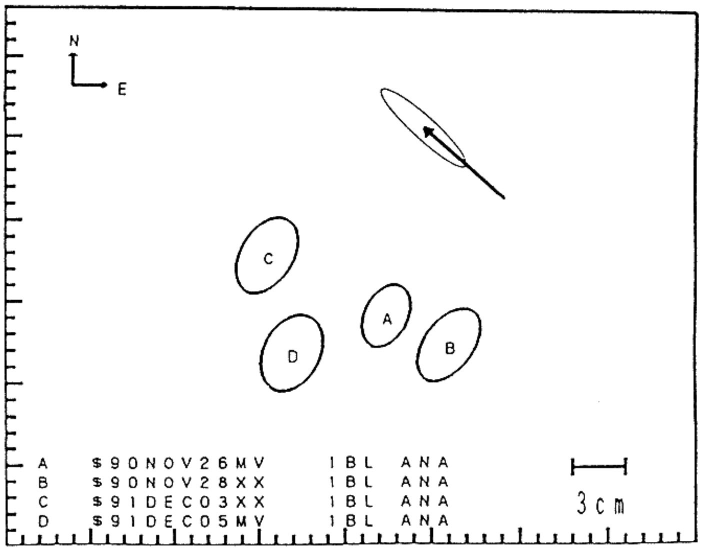


Figure 1. Positions of Minamidaitojima in the horizontal plane obtained by single frequency VLBI conducted on the Kashima-Minamidaitojima. "A" and "B" are positions in November, 1990, and "C" and "D" are in December, 1991. Ellipsoids denote one sigma errors in the estimation. Motion of Minamidaitojima in a year expected from the Seno model is depicted by an arrow with one sigma error ellipsoid.

The Japanese Radio Astronomy VLBI Network

by H. Takaba
(Radio Astronomy Group)

KNIFE (Kashima Nobeyama Interferometer)

The VLBI experiments between the Kashima 34 m telescope and the Nobeyama 45 m telescope was named KNIFE and had been started at 1989. The baseline length of about 200 km provides the fringe rates of 7 milli-arcsec. at 43 GHz and 13 milli-arcsec. at 22 GHz bands. In the latest session of 5-9 June 1992, mappings of 43 GHz SiO (J=1-0: v=1,2) masers' sources in late type stars and 22 GHz H_20 maser sources in late type stars, star forming regions, and an extra-galactic nucleus were done.

UKAI (Usuda Kashima Interferometer)

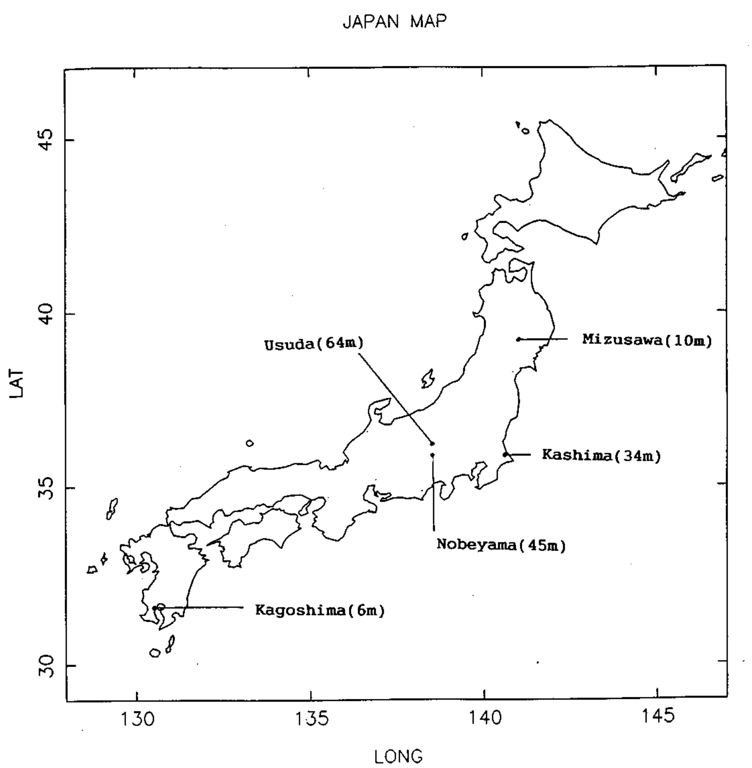
"UKAI" means the cormorant fishing in Japanese; connects ropes to the neck of cormorants and the cormorant fisherman on a boat operates the birds to catch the Japanese trout "AYU" (astronomers think the most delicious river fish in the world). The Usuda 64 m antenna and the Kashima 34 m telescope interferometer is able to catch very little fishes (very faint objects) because of their large mouths (large apertures). The baseline length is about 200 km as well, working frequency bands are 1.6 GHz, 2 GHz, 8 GHz, and 22 GHz.

A monthly VLBI monitoring program of a gravitational lens candidate PKS1830-211 at the S band has been running since November 1991.

Recent results of these experiments will be presented at the IAU Colloquium No. 140 in October 1992.

New Stations

The National Astronomical Observatory is constructing a new 10 m antenna at the Mizusawa Observatory and the old 6 m millimeter wave telescope (now in Nobeyama Observatory) will be moved to Kagoshima, a southern part of Japan. These two antennas will be functional as the VLBI stations in the early 1993.



The TDC News are published biannually. To begin or discontinue the receipt of the TDC News, please send a message to the following address. Comments, questions and /or suggestions can be also sent to the following address.

Taizoh Yoshino
IERS VLBI Technical Development Center
Communications Research Laboratory

Nukui-kitamachi 4-2-1
Koganei, 184 Tokyo
JAPAN

(FAX) *+81-423-27-6077*
(Please use the above number. The old number +81-423-21-9899 is effective only at the moment.)
(MarkIII) *CRL*
(Internet) *yosh@frex.cc.crl.go.jp*