TECHINOLOGY DEVELOPMENT CENTER NEWS

COMMUNICATIONS RESEARCH LABORATORY

Serial No. 18 June 2001

CONTENTS

Overview of the 18th TDC Meeting

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The 18th meeting of the Technology Development Center was held on March 21, 2001 at the Communications Research Laboratory.

Attendance

CRL members

Hisashi Iida, Tadashi Shiomi, Norihisa Hiromoto, Harunobu Masuko, Takao Morikawa, Taizoh Yoshino, Michito Imae, Mizuhiko Hosokawa, Noriyuki Kurihara, Hiroo Kunimori, Futaba Katsuo, Jun Amagai, Hitoshi Kiuchi, Toshimichi Otsubo, Yuko Hanado, Tadahiro Gotoh, Tetsuro Kondo (KSRC: Kashima Space Research Center), Yasuhiro Koyama (KSRC), Junichi Nakajima (KSRC), Mamoru Sekido (KSRC), Hiroshi Okubo (KSRC), and Hiro Osaki (KSRC)

Special members

Noriyuki Kawaguchi (National Astronomical Observatory), Hideyuki Kobayashi (National Astronomical Observatory), Yoshihiro Fukuzaki (Geographical Survey Institute), Kazuo Shibuya (National Institute of Polar Research), and Hisao Uose (NTT Information Sharing Platform Laboratories)

Observer

Shigeru Matsuzaka (Geographical Survey Institute)

The following special members could not attend: Kosuke Heki (National Astronomical Observatory), Arata Sengoku (Hydrographic Department, Japan Coast Guard), and Takahiro Iwata (NASDA)

Minutes

1. Opening Greeting

Hisashi Iida, the director of Communications Research Laboratory, made opening greetings to the meeting attendance. In his talk, he gave his recognition about the VLBI technology as it is attractive for the field of info-communications that also requires exchange of a lot of data at high speed. He also introduced a new CRL starting from April 2001 as an "independent administrative institution". Cooperation will be expected to be easier at the new CRL due to the flexible aspect of practical use of budget. He asked the special members for much more cooperation in the future.

2. CRL Technology Development Center Activity Reports

2.1 Report of the 5th IVS Directing Board Meeting (*Tetsuro Kondo*)

Kondo reported on the 5th meeting of the IVS Directing Board held at the Goddard Space Flight Center on February 15, 2001. He began with a brief introduction about the IVS for new attendance of the CRL TDC meeting. Then he introduced the contents of DB meeting mainly focused on the matter related to the CRL TDC as follows.

At first newly elected board members were introduced. The chair then reported that the letter of thanks had been sent to institutions and individuals who had contributed to the establishment of VLBI standard interface (VSI). Allan Whitney, a technology coordinator, reported that VSI had been approved by GVWG (Global VLBI Working Group). There was a report regarding measurement of the phase center of GPS transmitting antenna by using relative VLBI technique. Details will be reported in the next presentation (Koyama's report). I reported in the DB meeting that KSP would be extended for one year to monitor the after-effect of the volcanic activities that occurred south of Tokyo last summer, and that the VERA (VLBI Exploration of Radio Astrometry) project promoted by National Astronomical Observatory, Japan was going well.

Next IVS general meeting will be held from February 4, 2002 in Japan. Geographical Survey Institute and CRL are host organizations of this general meeting.

Q: What was reported about measurements of the phase center of GPS?
A: There was a report regarding the importance and difficulties of measuring the distance by relative VLBI technique (see also "Q&A" of the next report).

2.2 IVS Workshop Report (*Yasuhiro Koyama*)

First, Koyama reported on the 2nd IVS Analysis Workshop held at the Goddard Space Flight Center on February 12-14, 2001 for the purpose of the improvement of data in quality for providing a user and for the information exchange between each analysis center. His report is summarized as follows. IVS intends to provide the synthetic solution of earth rotation parameters for users, as does IGS. Discussion was made about advantages and defects of each analysis software, SOLVE/CALC, OCCAM, and MODEST. It was also discussed about the improvement in the structure of the databases. There was an inquiry about registration of Kashima and Koganei as a collocation site of IGS. Regarding the discussion about the CORE project, importance of participation of 16 observation stations was argued to employ the advantage of VLBI in the maximum efficiently. Receiving observation proposals from users was also examined.

Next he reported on the Technical Operations Workshop (TOW) held at Haystack Observatory on March 12-14, 2001 for the purpose of the improvement in quality of the data acquisition method of a network station and data itself. He reported as follows. The status of technical development at Haystack Observatory was introduced. It was also shown that 256Mbps system was being realized in Mark-IV. New data acquisition system using a hard disk drive storage (HD) was under development as Mark-V. Sending an HD instead of a tape was planned for correlation processing. The S3 system of Canada was also reported. TOW will be held during the period of the next general meeting held at Tsukuba in February 2002.

Q: Could you give more details about measurement of the phase center of GPS?.

A: VLBI can probably contribute to phase center measurement of GPS. However the parallax between GPS and QSO becomes large in case of a long baseline, and a relative VLBI technique will be difficult to adopt in such a case. Thus a short baseline like the KSP will be advantageous to carry out the relative VLBI.

Q: How about the object of NASA VLBI in the future?

A: It is argued whether continuous observation is important or accuracy is important. Among earth rotation parameters, UT1-UTC is measurable by only VLBI. Thus VLBI has an importance. But many people misunderstand as if GPS can measure it without any VLBI data. However, as long as a position on the earth is measured by GPS, true value of UT1-UTC is unnecessary.

Q: Is there any field that requires precise UT1-UTC?

C: UT1-UTC is necessary for tracking a deep space vehicle, isn't it?

A: Yes. UT1-UTC measurement by VLBI is indispensable from this point.

C: VERA (VLBI Exploration of Radio Astrometry) project promoted by the National Astronomical Observatory also requires highly precise earth rotation parameters.

Q: What accuracy is required?

C: Converting into station position, mm accuracy in an inertia coordinate system is required.

Q: I don't understand the importance of 16 station observations. To increase the session length is more effective for improving accuracy, isn't it?

A: By increasing the number of stations participating in a session the number of baselines increases. Improvement due to the increase in baselines is more effective than increasing the session length. Furthermore there is the advantage of also being able to observe any short-term variations.

2.3 KSP Report (*Taizoh Yoshino*)

Yoshino reported on the extraordinary crustal deformation observed at the KSP network due to the volcanic activities at Izu islands occurred last summer in 2000. The deformation is studied by the researchers in Japan taking the curvature of the earth surface into account and focusing the time delay difference from the source. SLR results were also reported. KSP Miura station was already closed as planned. Regarding the VLBI and SLR facilities at Miura station, he reported as follows: The VLBI system was donated to Hokkaido University in northern Japan, and the SLR telescope was also donated to Kagoshima University in southern Japan. They were disassembled and transported to each place to be rebuilt.

Q: There are some differences in the evolution of baseline length between GPS and VLBI measurements, aren't there?

A: In the case of GPS result here, the data was analysed taking the atmospheric gradient into consideration. That's the main reason here.

Q: What is the main purpose of the new antenna for Hokkaido University ?

A: They intend to use it for radio astronomical observations.

2.4 VLBI Standard Interface (VSI-H) (*Junichi Nakajima*)

Nakajima reported on the new compact VSI Gbps sampler, ADS-1000, under development.

A design of ADS-1000 intends to provide simple portable Gbps samplers. Telescope front-end mounted with AD samplers will eliminate long analog transmission in near future. Although, the current AD packages weigh 50 kg and occupy 6U in the system, the ADS-1000 weigh less than 10 kg and occupies 1/2U.
Q: Sampling jitter was a problem at a TDS sampler. Is it improved in a new system?
A: I believe so. It will be measured in the near future.

2.5 Deployment of New Gigabit VLBI System (*Junichi Nakajima*)

Nakajima presented the tactics regarding the deployment of the gigabit VLBI system with an explanation of the function of VSI involved in the system. He showed the plan of the gigabit VLBI system use in the Japan VLBI Network (J-Net). He also presented the plan of the new correlation processing system capable of 4 stations and 2 baselines processing for gigabit VLBI system.
Q: Why is the correlator for 4 stations and 2 baselines (not 6 baselines)?
A: We are developing it on the basis of the minimum requirement. We think that distributed correlation processing and/or fully software correlation will be available in the future. So the currently developed one should be OK, we think.
Q: Why does VSI adopted system attract a person in other fields, such as the Institute of Statistical Mathematics?
A: People who are making a high-speed sampler such as a GHz class know the difficulty in the design. If there is standardized system, they want to use it, I think.

2.6 Status Report of the Internet VLBI Development (*Tetsuro Kondo*)

Kondo reported on the current status of new real-time VLBI system using the Internet protocol (IP-VLBI) under development. The sampler board has been evaluated by using actual signals from radio sources. Real-time characteristics have been evaluated by using the LAN at Kashima Space Research Center. So far we could confirm the sufficient performance of “coherent sampling” up to 16 MHz sampling. Regarding the “real-time correlation processing” by using PC software, we can process 4 MHz sampled data in real-time at present time on the PC with the Pentium III (1GHz) processor by using the software written in C++. An improvemed algorithm to make correlation processing faster is in progress. Distributed processing on the network is now being considered improving the processing speed.
Q: A PC board is equipped with BNC connectors. Why do you adhere to BNC connector?
A: Because it is well distributed. But it can be changed to another connector.
Q: What is the goal of this development?
A: To realize the 256Mbps observation (16ch $\times$ 16Mbps) as same as the KSP.

2.7 High Speed Internet VLBI Plan Using the Super SINET (*Noriyuki Kawaguchi*)

Kawaguchi reported on the plan of optically linked Internet VLBI system using the super SINET (Scientific Information Network) under deployment in Japan. The SINET operated by National Institute of Informatics (former NACSIS) is now planned to be increased its data transmission speed up to 10 Gbps (super SINET) and to be extended its access points in FY2001. He showed the possibility of observation system with a data producing rate of higher than the transmission rate of the network by using a distributed correlation-processing technique. The purpose of such an observation is to increase the sensitivity so as to observe a weak radio source for radio astrometry. How to connect to a network node through an access point is still a problem, however we expect to the expansion of access points in the future optimistically. He also gave information about a 32m antenna at Yamaguchi (western Japan) owned by KDD. It would be transferred to the National Astronomical Observatory without any charge in a couple of months. (*Note: It was already transferred to the NAO in May 2001*)
Q: How do you adopt the Yamaguchi antenna to a radio astronomy use?
A: Test observations at frequency of 4GHz are being carried out now to check the antenna performance as a radio telescope. We can expect the aperture efficiency of 40 % at 22GHz. There is a 6 GHz transmitting station in the same area. Interference due to this transmitting antenna is also investigated. I may ask cooperation of CRL at 8 GHz band near future.

2.8 Ionospheric Correction in Pulsar VLBI (*Mamoru Sekido*)

Sekido reported on his recent work regarding the ionospheric correction in pulsar VLBI observations. Usually pulsar VLBI observation is made at a single band at lower frequencies due to an intrinsic spectral characteristics of pulsar, i.e., the lower frequency is, the stronger intensity is. By using the

total electron content measurements of the ionosphere made by GPS receivers, ionospheric delay can be compensated. He demonstrated the capability of ionospheric correction by comparing the dual band VLBI data and calculated correction from GPS data.
Q: What is the offset seen in the comparison result of GPS and VLBI?
A: It is thought to be an instrumental delay offset between S and X band receivers of VLBI system.

2.9 Unmanned GPS Data Acquisition System at Marcus Island (*Hiro Osaki*)

Osaki reported on GPS receiver's data acquisition system developed for unmanned operation at Marcus island. The data from a GPS receiver and house keeping data are gathered by PC operating LINUX and they are transferred to Kashima via NSTAR satellite using the commercial telephone link. A solar panel (daytime) and a battery (nighttime) power all the system.
Q: Is it true that degradation of a battery performance occurs in a high-temperature environment?
A: A battery is contained in a closed up box. During summer time, it is possible to have high temperatures in such a box. It may degrade the battery performance.

2.10 Mounting 43 GHz Receiver to the Kashima 34m Antenna (*Hiroshi Okubo*)

Okubo introduced a 43GHz receiver being installed into the Kashima 34m antenna. The size of receiver including a dewar is a cube with a side 35cm long. Physical temperature of LNA is 20K.
Q: You said the noise temperature of a receiver was 300K. Why is it so high?
A: Details are not known, but some impedance mismatching may possible be occurring.
Q: Antenna pointing accuracy must be improved for an observation at 43GHz. Do you need to use a new pointing model to improve the accuracy?
C: If necessary, FS9 has a capability to implement such a new model into antenna pointing parameters. I think we can use this function to improve the pointing accuray.

2.11 H2A-LRE Tracking by KSP-SLR Station (*Hiroo Kunimori*)

Kunimori reported on the H2A-LRE (Laser Ranging Equipment) project promoted by NASDA (National Space Development Agency). The project aims to determine an orbit of LRE by using a laser ranging technique.
Q: According to your presentation materials, the size of a mirror becomes small. Is it possible to take a return from 10000km altitude?
A: Inferring from the AJISAI satellite data, I think it is possible.
Q: What is the merit in geodesy in comparison with AJISAI?
A: The number of SLR stations which track a satellite is limited. So we can not expect too much merit. However I think that it can be used for verification of the observational model from low altitude to high altitude.
Q: You mentioned the application to an optical-communications network. What does it mean?
A: There is a proposal to constitute an optical-communications network by using catoptric light from AJISAI.

2.12 Contribution of CRL Solution to ITRF2000 (*Toshimichi Otsubo*)

Otsubo introduced his work carried out during his stay in England for two years. He solved for site station coordinates of 60 stations under loose constraints using the SLR data during 1990-2000. The solution was submitted to construct the ITRF2000. He also mentioned about the determination of the scale factor of the earth using VLBI, GPS, and SLR.
Q: The scale factor changes year by year in the result of preliminary analysis. Why does it occur?
A: I think it must be a fixed value. However all stations have a vertical velocity component in their motion and the scale factor is obtained as a result of their average. That is why the scale factor changes.

3. Others

3.1 Introduction of Council for Science and Technology Policy, Cabinet Office (*Yasuhiro Koyama*)

Koyama holds concurrently the position of officer of the Cabinet Office now as a staff member of the Council for Science and Technology Policy (CSTP). He is in charge of "Infrastructure Project" and "Frontier Project". He introduced the function of CSTP as follows. The CSTP is one of the important policy councils of the Cabinet Office (e.g. another important one is Council on Economic and Fiscal Policy). In addition to the science and technology the CSTP also argues about the humanities, social science, and bio-ethics problems. The CSTP can propose technology policy to the Prime

Minister independently. Moreover, CSTP examines technology policy and resource (budget) allocations. He also explained the difference between CSTP and the Science Council of Japan, and the relation between CSTP and the Space Activities Commission.

The technology master plan is specified by the technology organic act, and the latest big change is that the technology budget, which was 17 trillion yen in the past five years, will be increased to 24 trillion yen in the coming five years. The master plan also aims at increasing the number of the Nobel Prize winners to 30 in 50 years. Moreover, it is planned to distribute budget to the info-communications field, life science, environmental research, and nano-technology preponderantly. He is taking care of two fields of the special investigating committees. The space missions, the ocean sciences, etc. are some of his fields of responsibility.

Q: Can anybody put one's opinion into the Council for Science and Technology Policy?
A: It may be difficult, because the CSTP has a top-down structure. However, it may be possible by lobbying members of the council.
Q: How does a secretariat make a draft proposal?
A: So far bureaucrats have prepared a proposal. But the CSTP intends to change the system. How and its direction is not yet decided.
Q: What is the meaning of the 30 Nobel Prizes. Is a foreigner taking the prize in Japan counted?
A: No. It means Japanese citizens. However, regarding the evaluation considering only the number of the Nobel Prize receivers, criticism has arisen.
C: It is not necessarily only American prize winners in the U.S.

3.2 Request for the Establishment of Working Group for Improving the KSP Correlation System (Yoshihiro Fukuzaki)

A request for the establishment of working group was proposed by Fukuzaki to the CRL TDC to improve the KSP correlation system. He pointed out some issues that should be settled in his prepared materials. Establishment of a working group was approved by the CRL TDC. A report will be submitted by WG at latest by the next meeting.

4. Closing Address

Takao Morikawa, director of CRL TDC, thanked all persons in attendance for their worthwhile discussions and closed the meeting.

The 18th meeting of the IVS Technology Development Center at Communications Research Laboratory was held on March 21, 2001 at the Headquaters of Communications Research Laboratory.

Comparison of Ionospheric delay between GPS and VLBI (II)

Mamoru Sekido[1](*sekido@crl.go.jp*), **Tetsuro Kondo**[1], **Eiji Kawai**[1], **and Michito Imae**[2]

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1. Introduction

Radio emission from pulsar has steep spectrum characteristics with spectrum index 2 - 3. Thus VLBI observation at lower frequency is preferable for higher signal to noise ratio (SNR), and interferometric observation of pulsar has been usually conducted in 400 MHz - 2 GHz frequency range. Although the propagation delay due to the Earth ionosphere is the most significant error source in observation below 3 GHz, since the ionospheric delay increases with inversely proportional to the square of radio frequency. Thus the contribution of ionospheric delay need to be compensated by somehow.

GPS-based ionospheric TEC measurement is thought to be a kind of technique to monitor wide range of ionosphere at rather high time and spatial resolution. Center for orbit determination in Europe (CODE), which is one of the IGS analysis center, has been generating global ionosphere map (GIM) model every two hours by using world IGS observation network. And the data is open to public by the Internet (http://www.aiub.unibe.ch/ionosphere.html). Ionospheric delay between domestic dual frequency VLBI observation data and the GIM/CODE model has been compared in the previous report [*Sekido et al.,* 2000]. It demonstrated that VLBI TEC data and GIM/CODE TEC data have correlation more than 90 % and rms difference was 0.7 TECU (10^{16} electrons/m^2), which corresponds to 47 ns at 1420 MHz. However those comparison on 100 km baseline does not shows real accuracy of the GIM/CODE. The GIM/CODE TEC data and international dual frequency VLBI data are compared and accuracy of the GIM/CODE data was evaluated here.

Table 1. Intercontinental VLBI experiments used for TEC comparison.

Date	Experiment name	Station name
2000/7/5-6	NEOS-A375	Algonquin, Fortleza, Kokee, Wettzell, Gilcreek
20007/10-11	CORE-1001	Algonquin, Gilcreek, Hartrao, Hobart, Matera, Tsukuba
2000/7/11-12	NEOS-A376	Algonquin, Fortleza, Kokee, Nyales, Wettzell,
2000/7/12-13	CORE-3001	Gilcreek, Kokee, Onsala, Westford, Wettzell
2000/7/18-19	NEOS-A377	Algonquin, Fortleza, Kokee, Wettzell, Gilcreek,
2000/7/25-26	NEOS-A378	Algonquin, Fortleza, Kokee, Nyales, Wettzell

2. Comparison of the GIM/CODE and intercontinental geodetic VLBI data

Simultaneous dual frequency observations are performed in geodetic VLBI for ionospheric delay measurement. Since the frequency separation of VLBI observation (from 2 to 8 GHz) is larger than that of GPS (1227.60 MHz/1575.42 MHz), the accuracy of VLBI TEC measurement is higher than that of GPS. Thus the GIM/CODE TEC can be evaluated by comparison with dual frequency VLBI data. The actual accuracy of TEC measurement was around 0.5 - 1 TECU according to the intercontinental VLBI data.

The intercontinental VLBI experiments data conducted in July 2000 (Table 1) were obtained from International VLBI Service (IVS) products at http://ivscc.gsfc.nasa.gov/service/products, and were used for comparison. Total 36 baselines 38845 scans of VLBI data were used for the statistical comparison.

Figure 1 shows a typical example of TEC comparison between VLBI data and the GIM/CODE on Algonquin - Wettzell baseline. The offset difference between the GIM/CODE and VLBI will be due to hardware signal transmission line offset between S-band and X-band in dual frequency VLBI observation. The correlation coefficients were close to 100 % at long baselines (Figure 2), since the variation range of TEC difference between two stations increases as the baseline length increases. However the difference between them increased with baseline as shown in Figure 2. This is understood as follows: the GIM/CODE model errors were cancelled in shorter baseline, but they came out in longer baseline where ray paths of observations were no

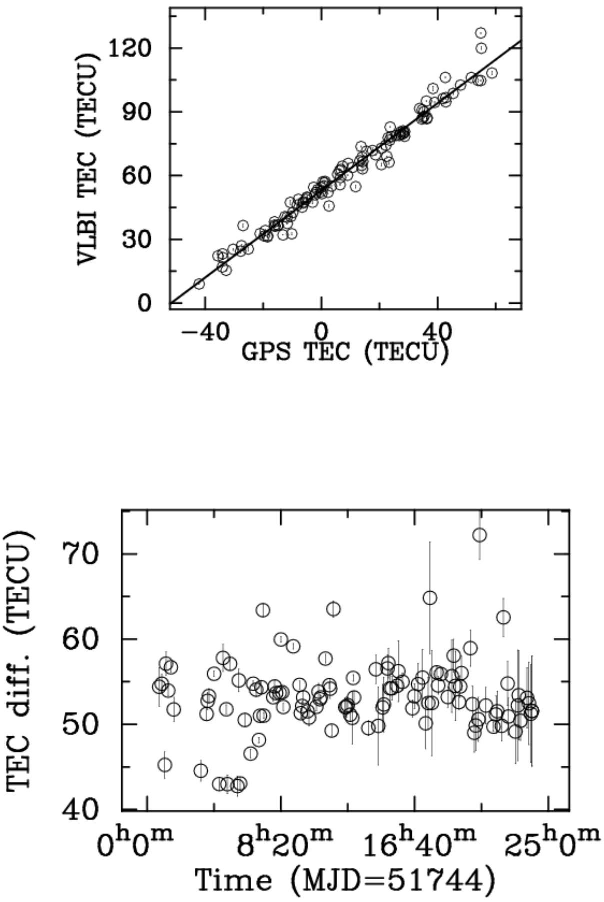

Figure 1. Comparison of the ionospheric TEC measured by VLBI and the GIM/CODE model on 18 July 2000 for Algonquin - Wettzell about 6000 km baseline. Upper panel shows scattered plot of TEC measured by VLBI and GPS. The correlation coefficient, proportional coefficient, and offset were respectively 0.99, 1.03, and 52.7 TECU. Lower panel is difference residual plot of the VLBI-measured TEC and the GIM/CODE model. The RMS of the difference was 4.2 TECU.

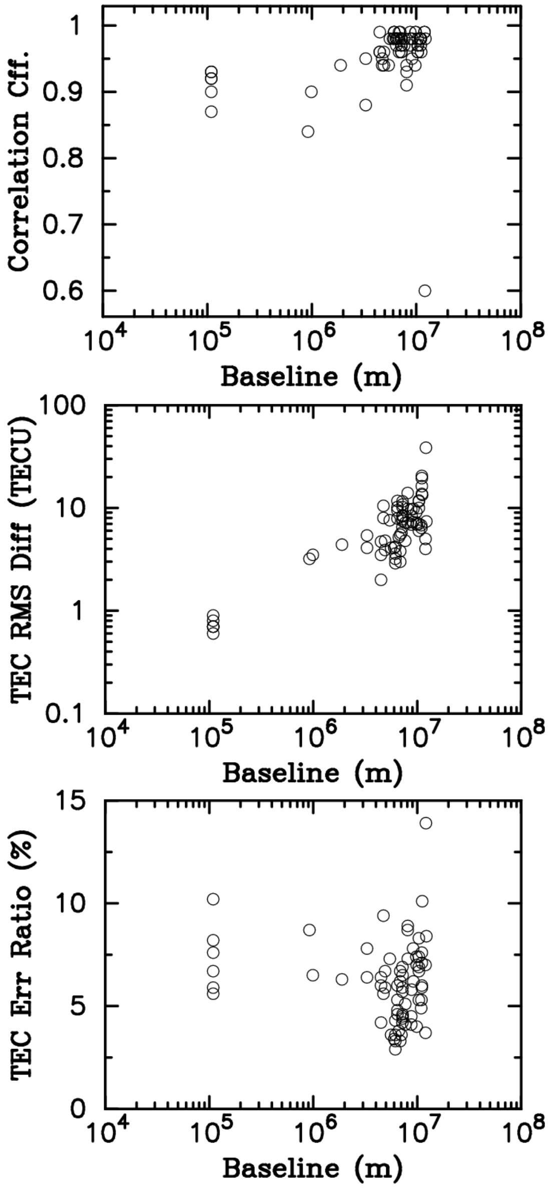

Figure 2. Correlation coefficients of TEC value between VLBI and the GIM/CODE model are plotted respect to baseline (Upper panel). Baseline dependency of the rms line-of-sight TEC difference between VLBI and the GIM/CODE are plotted as a function of baseline length (Middle panel). Ratios of the rms TEC differences to the TEC variation ranges on each VLBI experiments are plotted with respect to baseline length (Lower panel).

more shared by two stations. The ratio of the error respect to the TEC variation range is plotted in lower panel of Figure 2. It indicates that the relative accuracy of ionospheric delay correction by using the GIM/CODE is almost constant (3 - 10 %) for any baseline lengths. The precision of the GIM/CODE can be evaluated by using baseline and elevation dependency of the difference of the GIM/CODE TEC from VLBI TEC data.

Root mean square of difference between VLBI derived TEC and that computed from GIM/CODE are plotted respect to the baseline length or elevation angle in Figure 3. It indicates the rms difference increases with baseline length with regardless of elevation cutoff angle. Since these rms differences represents TEC map errors difference at spatially distant points, the lower panel can be called a kind of structure function of GIM/CODE error.

From these data, the accuracy of GIM/CODE can be estimated as 3 - 4 TECU. More detailed discussion on the comparison of GIM/CODE and VLBI data can be found in *Sekido et al.* 2001.

Acknowledgements. Authors thanks Stefan

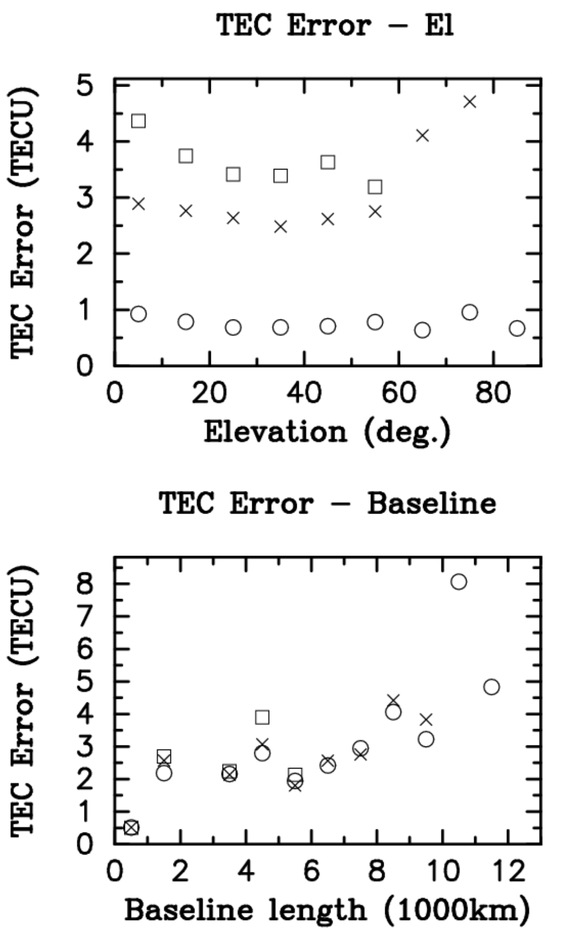

Figure 3. The rms difference of the GIM/CODE and VLBI (in zenith direction) are plotted in respect to baseline length after correction of mapping function. The data was divided into subset by 1000 km interval of baseline length. Elevation cut-off test was also performed at elevation limit 20 (◯), 40 (×), and 60 (□) degrees. Larger error at longer baseline is due to error of mapping function and deviation due to small number of averaging.

Schaer at Bern University for kindly providing GIM data and related subroutines. This research has made use of international geodetic VLBI data provided by the international VLBI Service for Geodesy and Astrometry.

References

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Second IVS General Meeting
February 4-6, 2002
Tsukuba, Japan

IVS 2002 General Meeting

hosted by
Geographical Survey Institute and Communications Research Laboratory

The IVS holds a technical meeting, called the General Meeting, every two years. The purpose of the meeting is to assemble representatives from all IVS components to share information, hear reports, and plan future activities. The meeting also provides a forum for interaction with other members of the VLBI and Earth science communities.

All IVS Associate Members, representing all of the IVS components, are encouraged to attend the General Meetings. Non-IVS members are cordially invited to attend the meeting. The content of the meeting will be of interest to a broad spectrum of IVS members as well as to the wider VLBI and Earth science community.

The second General Meeting will be held at Tsukuba International Congress Center (Epochal Tsukuba) in Tsukuba City, Ibaraki, Japan.

The goal of the meeting is to provide an interesting and informative program for a wide cross section of IVS members, including station operators, program managers, and analysts. The program will include reports, tutorials, invited and contributed papers, and poster presentations.

The third IVS Analysis Workshop will be held on February 7-8, following the General Meeting.

The calls for papers for both meetings will be announced later. More information will appear on Web Site **"http://ivs.crl.go.jp/mirror/meetings/gm2002/"**.

Installing 43-GHz Receiver on Kashima 34-m Radio telescope — Status Report —

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1. Introduction

Kagoshima University, the National Astronomical Observatory, and Communications Research Laboratory (CRL) have been installing a new 43-GHz receiver for the Kashima 34-m radio telescope.

This radio telescope has a unique feed trolley band interchange system to enable multi-frequency observation. However, space for receivers and other instruments have been limited. Therefore, a newly installed receiver must be small and have a simple configuration. Considering these restrictions, the new receiver (dewar) was designed to be small (H: 272 W: 246 D: 130 (mm)), as shown in Figure 1.

The configuration of the receiving system is shown in Figure 2. The RF signal is fed to an HEMT amplifier made by Nihon Tsushinki Co. The HEMT amplifier exhibits its best performance below a physical temperature of 20 K. To achieve a cooled temperature below 20 K, a helium cryogenic system is used and two LNAs and four isolators are attached to the 20 K cryogenic stage. Each LNA is composed of 4 HEMT amplifier chips. The measured LNA performance is shown in Table 1. The RF signal from the dewar passes through a 40-GHz highpass filter and an isolator, then proceeds to the mixer.

Table 1. Measured HEMT performance (frequency = 43.0 GHz).

	Gain (dB)	Noise temperature (K)
HEMT 1	22.14	36.4
HEMT 2	21.34	41.3

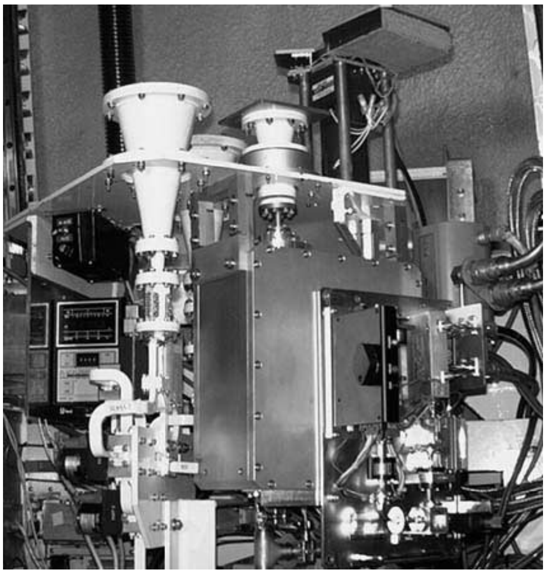

Figure 1. 43-GHz receiver installed on Kashima 34-m radio telescope.

The gunn oscillator and controller are also made by Nihon Tsushinki Co. The local frequencies (Lo1) are selectable from among 37.3, 37.5, 37.7, and 37.9GHz and are locked to a hydrogen maser frequency standard. Converted IF signal is amplified (gain=30 dB) and passes through a bandpass filter (pass band=5-7 GHz), then amplified again (gain=30 dB) and sent to a fiber optic transmitter. This transmitter converts the electric signal to an optical signal and transmits the converted IF signal to the observation room. In the observation room, the optical signal is converted back to an electric signal. The converted 5-7 GHz IF signal passes through a wide converter, for which the local frequency (Lo2) is selectable from between 4.5 or 5.0 GHz or external source. For calibration purposes, a hot load switcher is installed beside the feed horn and is available for local or remote (from the observation room) operation.

During the installation procedure, the cryogenic system was redesigned. The previously installed cold head CTI M-220 was converted to a CTI M-350 to improve the cryogenic capacity and maintainability. With this modification, the cold head attachments inside and outside the dewar were then redesigned.

2. Noise measurement

The noise temperature of the receiver was measured using an ambient (300 K) microwave absorber and an absorber immersed in liquid nitrogen (77 K). The data was obtained with an HP8366B spectrum analyzer and an HP-E4419B Power Me-

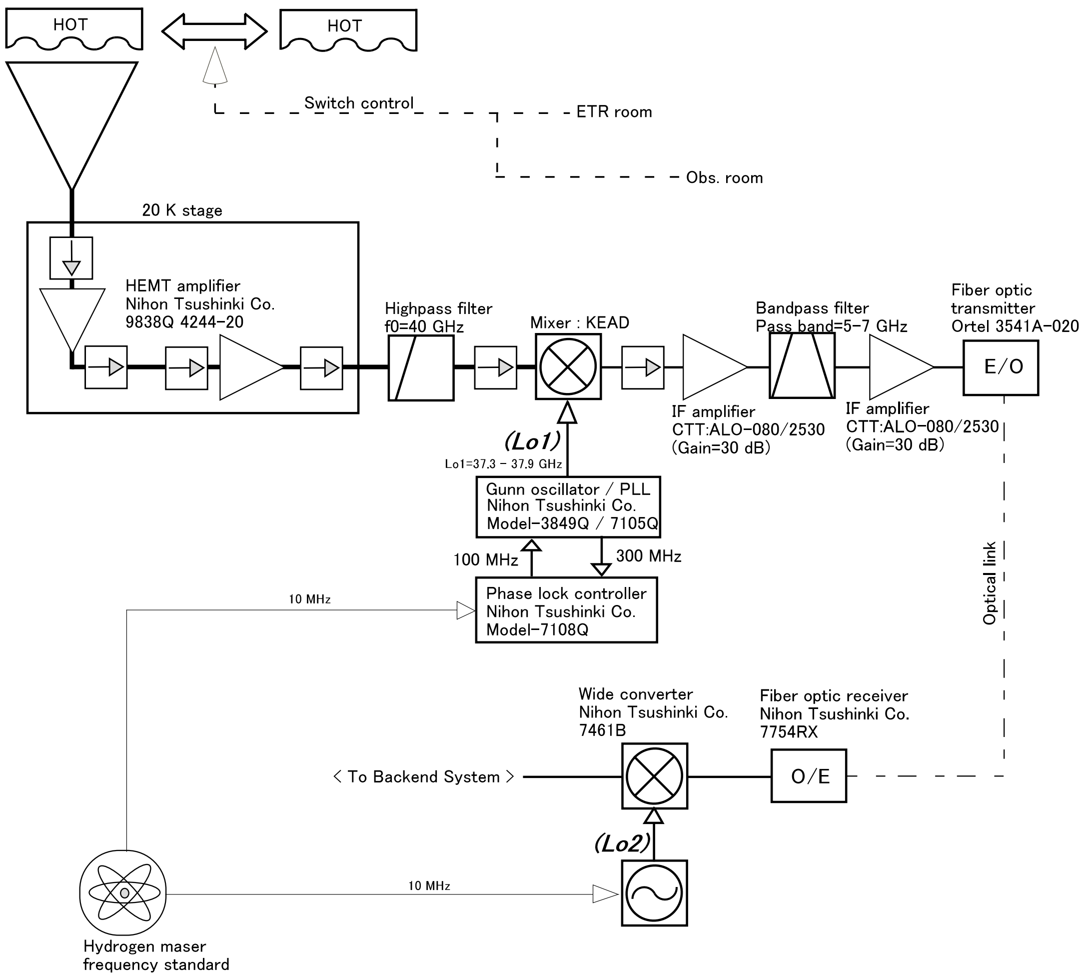

Figure 2. 43-GHz receiver configuration.

ter in the observation room. For these measurements, the local frequency at the wide converter (Lo2) was set to 5 GHz.

The receiver noise temperature T_{RX} and modified system noise temperature T^*_{Sys} are given by the following equations.

$$T_{RX} = \frac{T_{Hot} - (YT_{Cold})}{Y - 1} \quad (1)$$

$$T^*_{Sys} = \frac{T_{Hot}}{Y' - 1} \quad (2)$$

WhereT_{Hot} andT_{Cold} are the physical temperatures of the hot and cold loads. Y and Y 'correspond to the following relations:

$$Y = \frac{P_{Hot}}{P_{Cold}}$$

$$Y' = \frac{P_{Hot}}{P_{Sky}} \quad (3)$$

Where P_{Hot}, P_{Cold}, and P_{Sky} are the receiver output powers corresponding to the hot, cold, and sky, input signals, respectively.

Figure 3 shows the measured Y-factor for the 43-GHz receiver in the frequency domain. The averaged Y-factor was approximately 2 dB, which corresponds to a receiver noise temperature of 304 K.

The receiver noise temperature and modified system noise temperature of the total power bandwidth (0.1-2.0 GHz) are listed in Table 2. The measurements for total power bandwidth tended to show better results. The modified system noise temperature was measured at a relatively higher value because of the weather at that time (cloudy and rainy). We concluded that the receiver exhibits reasonable performance.

Table 2. Total power bandwidth noise temperature.

T_{RX}(K)	T^*_{Sys} (K)
251	620

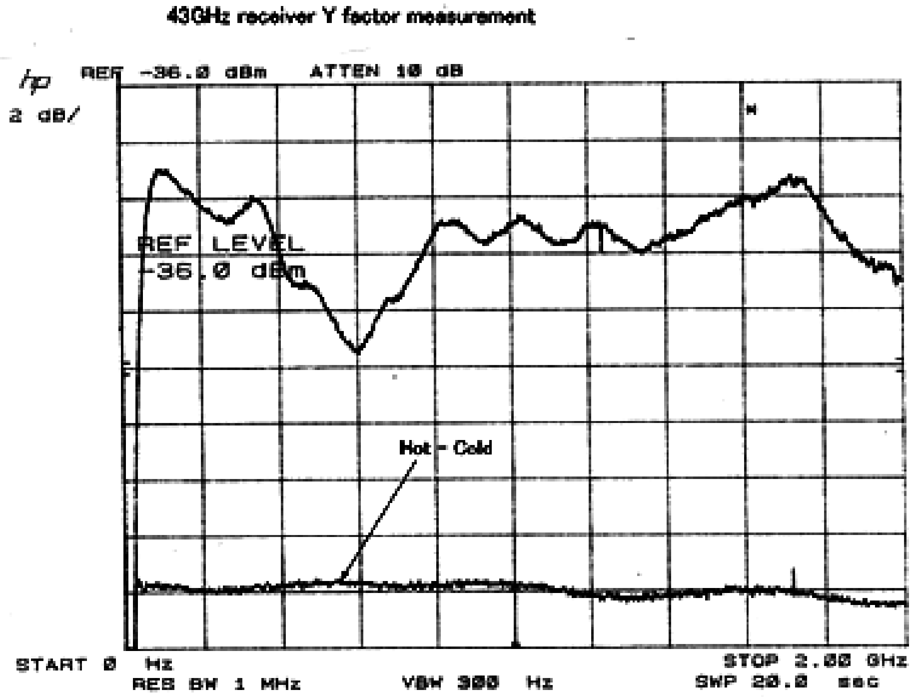

Figure 3. Y-factor for 43-GHz receiver (Lo1=37.7 GHz, Lo2=5.0 GHz).

3. Current status and future plan

After the receiver noise measurements, overhaul and maintenance on cryogenic cold head is currently being carried out. Considering the schedule for the Kashima 34-m radio telescope annual maintenance, the 43-GHz receiver will be reinstalled in September. We expect to be able to detect signals from celestial bodies by late September or October.

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VSI 2-Gbps AD sampler evaluation, now in Gbps VLBI

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1. Introduction

The development of ADS1000, the new Gigabit samplers, was completed and their performance has been measured. We have conducted the experiment under 1 and 2-bit sampling mode. Compatiblity to the former TDS-784, the DSO-modified sampler, has been checked, and it is confirmed that the overall performance of this sampler is better than that of the former sampler. They can be used for both Geodetic and Astronomical VLBI observations. The ADS1000 was introduced in *Nakajima et al.* [2000]. The small compact sampler is designed in a small chasis (WHD 42 × 4 × 45 cm) and its weight is 7 kg. Power consumption of the unit is only 20 W. Compared to the TDS sampler system which includes an external synthesizer, the weight of the ADS1000 is reduced to 20% (1/5) and the volume is suprisingly decreased to 7%. The compactness of the AD samplers will be advantageous when they are mounted at an antenna front end.

2. Sampler Evaluation

The AD sampler has a performance of 1024 M sample-per-second and 2-bit quanatization. Thus the total data rate is 2048 M-bps and the output is the VSI (VLBI Standard Interface). To evaluate samplers in the VLBI application, most severe performance test were conducted, focusing on the phase stability over long durations in a variable temperature environment. For this evaluation two samplers are connected to a correlator. Since the VSI provides a common interface at any point of the VLBI system, the direct connection of samplers and the correlator UWBC-GICO are possible. A common noise source was connected to the samplers and relative phase stability was measured. It is confirmed that under controlled temperature and for short durations, the phase variation among the samplers is equivalent to the 0.5 ps jitter of the AD. When there are phase variations, they largely arise in the Phase Locked Oscillator, strongly depending on its ambient temperature.

3. The Feature of Optimized VLBI Sampler

To highlight the ADS1000 new features, the sampler is optimized for VLBI observations. It was started as the first sampler equipped with VSI interface, but other useful functions were added.

- **VSI DAS (Data Acquisition System)**
  The ADS-1000 includes all VSI functions currently expected by the specifications. The sampler has 1PPS input and it keeps an internal UTC clock. By transmitting UTC information and accurate 1PPS synchronized to the external station reference signals, the sampler works as a master clock of successive backend system. Remote controls from RS232 and ethernet are possible. All aspects of the sampler status can be obtained remotely, and the process is operator friendly, producing visual information. For the international compatibility, TVG (Test Vector Genarator) in introduced as the internal function. The firmware is going to be adjusted to the finalzed VSI-S (Software Specification).

- **Bit bias display**
  ADS1000 can display the sampling bit distribution using a statical method. In the former low speed VLBI system, AGC in front of the AD sampler controlled the amplitude of input signals. As for the VSOP-Terminal and the new-K4 interface, they remove the DC bias by digital filters. When the baseband bandwith is increased, designing an AGC amplifier covering DC to 2 GHz becomes difficult. In this sampler the functions are separated prior to the AD, depending on the application. To avoid complex hardware, the sampler just monitors the bit distribution of sampling using the statical characteristics of noise, and the bit distribution is displayed in a front LCD. The information is also transmitted through the VSI interface. From the measured distribution one can adjust the bit bias under 1% accuracy when sampling the noise data.

- **Expansion to multi channel system** Although the unit is integrated as a 2 Gbps 1 channel sampler, the sampling frequency generated in the PLO unit can distribute signal to the another unit. This will reduce jitter among the channels in multi channel operation.

To enumerate the reasons for observation failure and to inherit the merit of the TDS samplers, we have introduced the functions to the ADS1000 sampler which are never seen in other astronomical samplers. In the rear panel of the ADS-1000,

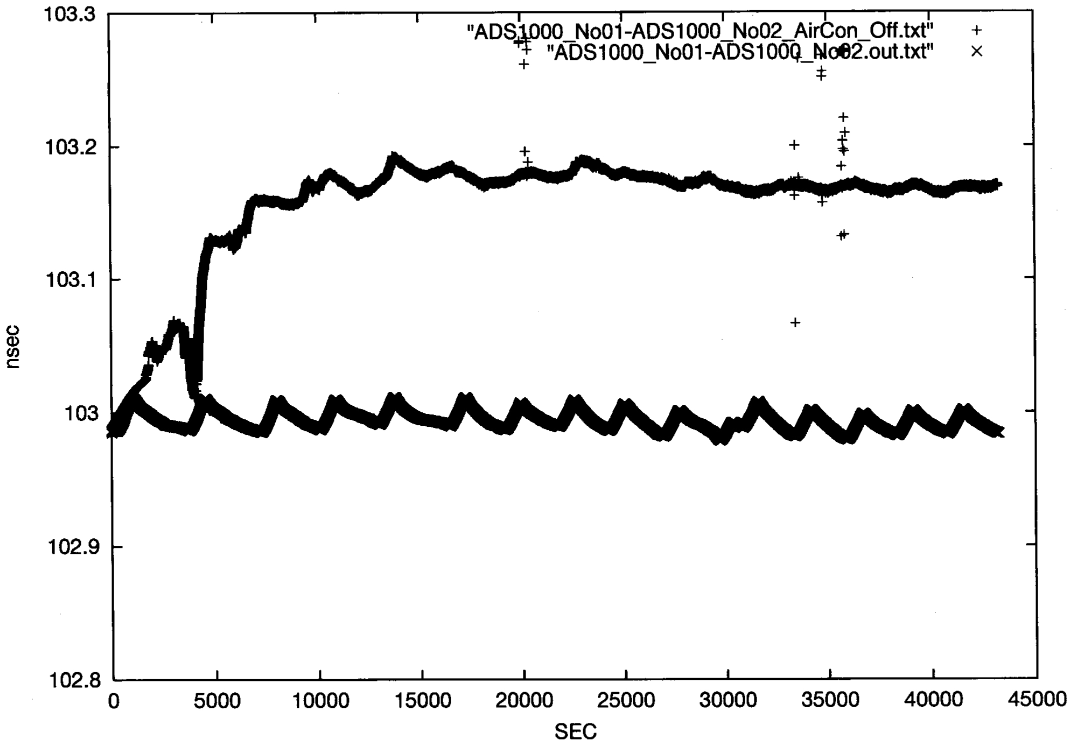

Figure 1. An example of measured proto-type sampler phase under variable temperature. The samplers phase shows periodical behaviour, when they are placed near an air-conditioning air flow.

two MDR-80 defined in the VSI-H specifications are placed to output LVDS signals. Clip-type connectors are used and we have confirmed their reliability. We have used the samplers in astronomical VLBI observations in May 2001. As the next step of the sampler evaluation we will carry out higher order sampling up to 2 GHz.

Reference

Nakajima, J., M. Sekido, and T. Suzuyama, "Another Giga-bit Sampler Prototype, Nearly Completion" IVS CRL-TDC News No.17, pp.18, November 2000.

Gbit VLBI Network observation started

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1. Introduction

Since 1998, we have conducted Gbit VLBI sessions 12 times. These began as experimental observations, but since last year we have started regular Gbit-VLBI observations both in radio astronomical VLBI and Geodesy. All the observations before 2001 were single baseline observations. In May 2001, we have carried out the first multi-baseline Gbit observation, and it was recently successfully finished.

2. The J-Net domestic astronomical VLBI

One of Japanese domestic VLBI networks is the J-Net. The VLBI network is a proposal-based VLBI observation network running under the National Astronomical Observatory. Telescopes in Nobeyama, Mizusawa, Kagoshima and Kashima participate in sessions. The network is equipped with VSOP-terminal and 128/256 Mbps observations have been carried out, mainly in 22GHz band. The observation tapes are correlated at Mitaka FX correlator. We have added Gbit VLBI terminals to the 3 J-Net stations (Nobeyama, Mizusawa and Kashima) and simultaneous data acquisitions were made. At these observation sites common 5-7GHz IF from the telescopes was down-converted to baseband IF from DC to 512MHz. Some telescopes did not provide IF between DC to 100MHz due to the system design. Thus the common bandwidth among these telescope is about 412MHz.

3. Automatic Gbit Observation System

To automate long observations, Kashima station is equipped with an automatic robot to change the cassette. At other remote stations, operators change the tapes. In the Gbit observation tape change occurs every 1.5 hour to 2.5 hours depending on schedule and source selection. During continuous 50 hour observation, no major problems occurred.

Figure 1. The Mizusawa 10m telescope joined first time the Gbit VLBI. Large dish behind the 10m is the VERA telescope under construction.

Minor troubles related to cassette and sensors will be fixed in the next observation. The Gbit system is operable without no special knowledge of Gbps VLBI.

4. Portable Gbit System in Remote Site

In the J-Net 3 observations, we have deployed the Gbit-system to Mizusawa and Nobeyama, as the first set up at the sites. The entire Gbit-package weighs about 150kg and is divided into 5 packages for transport to the station. We need 1.5 hours to start up the system and less than one hour to remove it. At the end of 2001, our new Gbit-recorder will be reduce in weight, and VLBI interface will disappear since the recorder will be equipped with the VSI and UTC control functions. Total weight for the Gbit observation equipment will then be less than 100 Kg.

When we carry out the Gbit network observation for a certain objective, installing the recorders permanently at all stations wastes VLBI resources. In addition the Gbit recorders need maintenance. Asking for maintenance of recorders will impose a burden on the site staff. Thus recorders are sent to the stations only when they participate in a session. This will make the network configuration very flexible. In any case we need tape transportation. Thus to send the system together will not have a major impact on operational cost. In every observation the ftp fringe check will confirm the validity of data written on tapes immediately. With the operation principle, institutes can start the Gbit VLBI with a small number of recorders.

Domestically, the Gifu 11m, Hokkaido 11m, Fukui 10m and Yamaguchi 34m telescopes will start operating in the near future. Including these telescopes, Gbit VLBI observation proposals accompanied by a scientific target will be gatherd worldwide.

Figure 2. The Gbit recorder installed at the Mizusawa station temporaly. Currently two portable PC are used to control. One is for the observation and another is for the ftp-VLBI. These PC-based field system will be unified.

Development of Advanced Precise Positioning System (APPS) — Preliminary report —

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1. Introduction

The most accurate positioning using GPS can be achieved by the analysis of the small number of geodetic specialist. State of the art GPS data analysis can achieve 2-5 mm horizontal and 1-3 cm vertical accuracy over baselines 1-1000 km. To obtain these kinds of results, multi-hour static data sets of high quality dual-frequency GPS data, the use of high quality GPS orbits and earth rotation parameters, highly sophisticated software, and a high level of data processing expertise are required [*Rocken and Johnson,* 1999].

We developed the advanced precise positioning system (APPS) to enable anybody to obtain precise positioning information. Users can submit static single point or multi-station network GPS data to the APPS analysis server by e-mail and receive the analyzed results back by e-mail after a few minutes.

The APPS consists of two parts. One handles data automatically and includes the database, a quality check of the data set, and a process for extracting the RINEX files and orbit files. This part is a modifed version of the GARDII (GPS Automatic Remote Data Processing II) developed by Hitachi Zosen Information Systems Co., Ltd. The other part is the GPS analysis using the Bernese software [Rothacher et al., 1996], which is the one of the best-known GPS analysis packages. The Bernese software reliably achieves the highest accuracy because of its robust data editing and cycle slip correction algorithms, and its sophisticated models of the GPS observations and orbits. While the software has a menu-driven user interface it still requires significant time to master.

In this short report we present the results of a 10-day preliminary analysis using an APPS prototype.

2. Analysis and Results

We estimated the coordinates of four stations in our GPS network (KSMV, KS34, KGNI, MRCS) and one station in the GPS Earth Observation Network of Geographical Survey Institute (3041) (Figure 1). The data set from these stations was processed automatically with a data set of three IGS stations (i.e., TSKB, USUD, GUAM) using the precise orbits and earth orientation parameters produced by IGS. Here, the IGS station coordinates are fixed.

To investigate the effect of the time length of the submitted files, we submitted five different-length RINEX files (24, 12, 6, 3, and 1 hour) for each

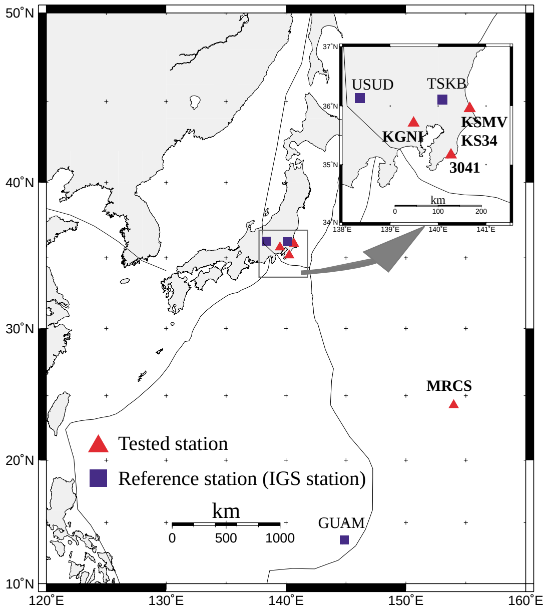

Figure 1. Distribution of tested stations used in this study.

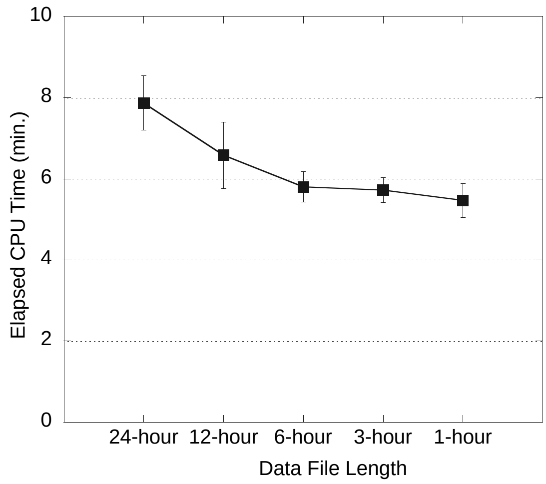

Figure 2. Elapsed CPU time of APPS analysis for different file lengths in hours (24, 12, 6, 3, and 1).

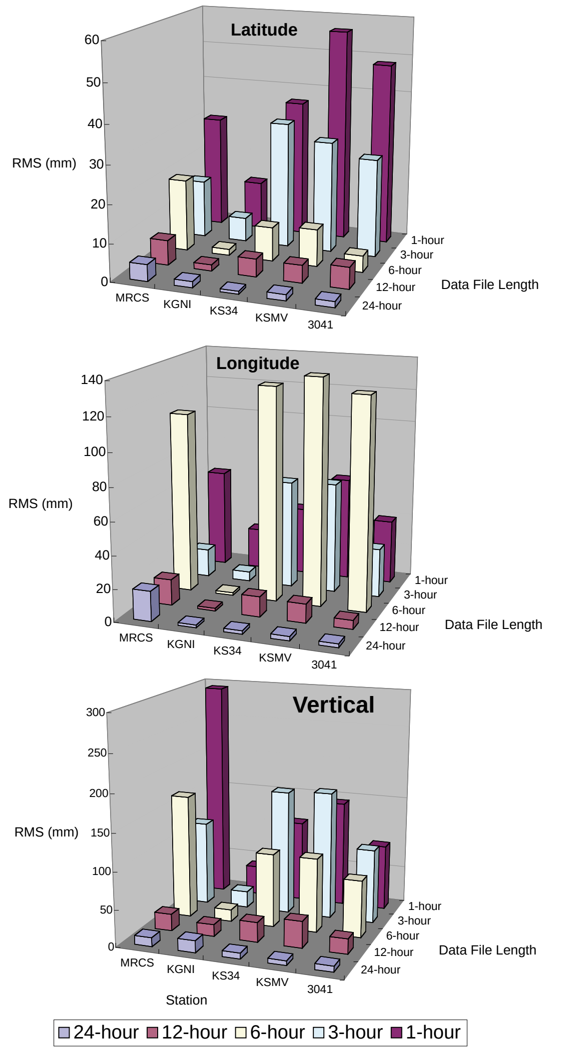

Figure 3. The lat/lon/hgt repeatability for processed data sets of different file lengths in hours (24, 12, 6, 3, and 1).

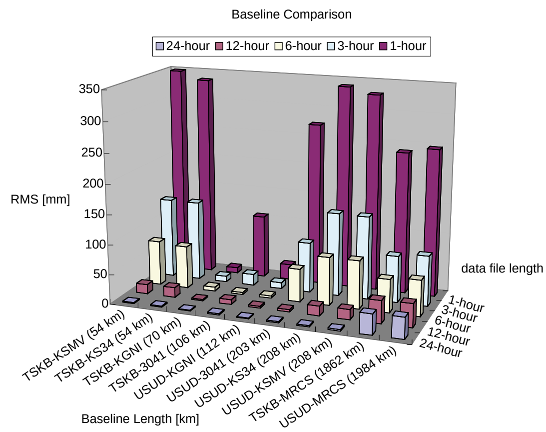

Figure 4. The baseline length repeatability for processed data sets of different file lengths in hours (24, 12, 6, 3, and 1).

station and test day. We used a 850-MHz Pentium III-based computer running Linux OS with 512-MB RAM for test the APPS. Figure 2 shows the elapsed CPU time for analyzing files of various lengths.

The users received a report by e-mail after the analysis. We summarise The analyzed network results in this report. The data length, the station coordinates, coordinate formal errors, and an error log are e-mailed to the user. Results for a single station are typically mailed within 5 minutes, and a multi-station network may take 10 minutes. The coordinates and baselines are currently provided in cartesian (x,y,z) and geodetic (latitude, longitude, height) representation in ITRF97. Other information such as baseline length and tropospheric delay will be added in the future.

Figure 3 shows the lat/lon/hgt repeatability for the processed data sets. Depending on the data quality, the file length, and the station/network location, the precision assessment of the APPS solutions shows 10-day repeatabilities of 1 to 130 mm in horizontal components and 6 to 300 mm in vertical ones.

Figure 4 shows the baseline-length repeatability of 1.3 to 350 mm for baseline lengths ranging from 54 to 1862 km. Our processing resolves phase ambiguity parameters to integer values using the quasi ionospheric free (QIF) method described by *Rothacher et al.* [1996]. Ambiguity parameters of data longer than 12 hours can generally be resolved successfully. However, large scatter values of over 50 mm for the 6-, 3-, and 1-hour baseline solutions were caused by failing to resolve the carrier phase ambiguities for shorter files.

3. Summary and Outlook

APPS will enable everybody to obtain accurate GPS solutions without requiring geodetic understanding, the operation of the sophisticated GPS software, or complicated data handling. Moreover, given the explosive accumulated GPS data taken by non-experts, we expect that APPS will contribute to GPS R&D fields, such as monitoring crustal deformation, retrieving the variability of precipitable water vapor and ionospheric electron content, and fixing phase center correction patterns of antennas.

We will continue to evaluate minimum data length to obtain at least a 1 cm accuracy of estimated site coordinates and baseline lengths based on several more tests. We will also evaluate the APPS solutions for three types of orbit data (final, rapid, and ultra-rapid products). In addition we will compare the solutions from the APPS with those using RTK (Real Time Kinematic) and the VRS (Virtual Reference Station) positioning techniques. We are now planning to let a limited number of users to access an APPS test version to help construct a more reliable system.

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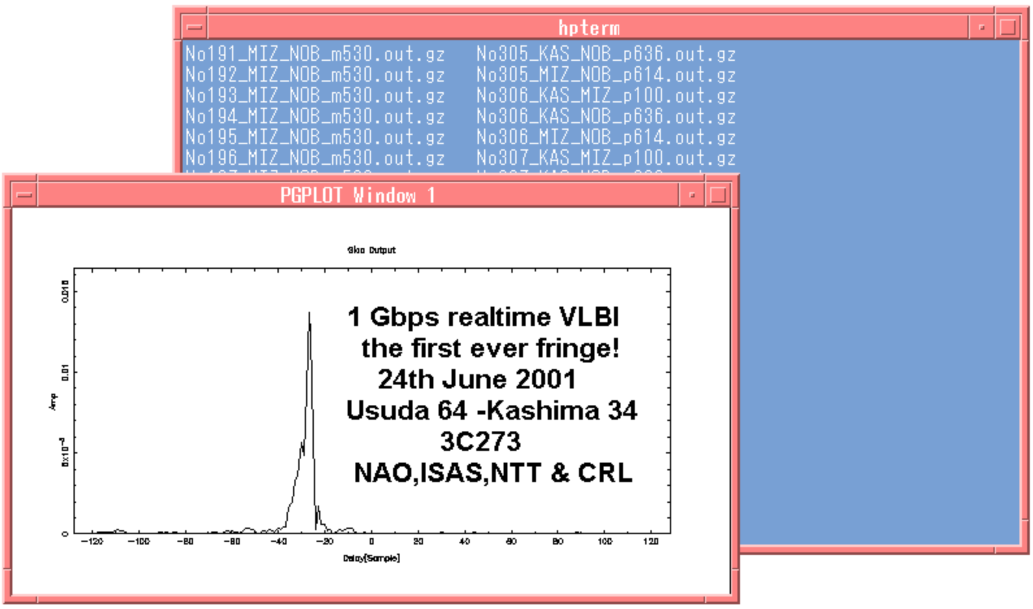
Successful Detection of 1-Gbps Realtime VLBI Fringes

A joint team consisting of the members from NAO, ISAS, NTT and CRL motivated to perform real-time VLBI has been trying to establish the Gbps real-time VLBI system since 1999.

On 24th June 2001, the team successfully detected 1-Gbps (1024 Mbps, a world record speed) realtime fringes between Usuda 64m and Kashima 34m radio telescope (about 200 km baseline). After several trial of the digital optical fibre transmission, we could detect fringes from quasars at last.

Detailed story will be appeared in the next issue of CRL TDC News.



CRL's Contribution to ITRF2000

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1. Introduction

The International Terrestrial Reference Frame (ITRF) is used as a de facto standard terrestrial reference frame. It is a combined solution of multiple space geodetic techniques including VLBI, GPS, SLR, LLR and DORIS. The International Earth Rotation Service (IERS) has just assembled its newest version, ITRF2000, from more than 30 contributions. The new version newly adopts loose constraints, an effective method for comparing and combining multiple solutions. At CRL, we have gathered our experiences in analysing orbit determination from developing our own software package, CONCERTO [*Otsubo,* 1994]. We developed the terrestrial reference frame using laser data obtained in the last ten years, and submitted the solution to the ITRF2000 project in April 2000, the first time we have submitted a solution.

2. Analysis Strategy

In the CRL solution we used global laser ranging data to LAGEOS-1 and LAGEOS-2 over ten years (MJD 47900 - 51500). The set included data from 60 stations worldwide. Since solving all the parameters at once is impossible, we divided the whole sequence into two stages. First, we divided the ten-year span into 73 sets of 50-day spans and we loosely solved for the satellite orbits, EOPs, station coordinates. Next, we assembled the 73 sets and derived the 3-dimensional positions and velocities of the 60 stations, applying loose constraints: 10 m for positions and 1 m/year for velocities. The solution, SSC(CRL)00L02, was submitted to the ITRF2000 project. Because a loosely estimated solution can rotate greatly, the formal error becomes very large and the solution cannot be directly compared with other ones. Therefore, we generated another set of solution, SSC(CRL)00L01, with a tight constraint. For "good" stations, i.e. stations providing consistently high-quality data in large quantities, the formal errors of the estimated positions were 0.5-0.8 mm for horizontal and 1.5-2.0 mm for vertical components. Velocity errors were 0.2-0.3 mm/year for horizontal and 0.3-0.8 mm/year for vertical components. In comparison to ITRF97, the positions agreed within 1 cm and the velocities within 2 mm/year. Fig 1 shows a comparison of the horizontal velocity vectors. The velocity field in eastern stations in China and Russia seems to become more realistic than the one in ITRF97.

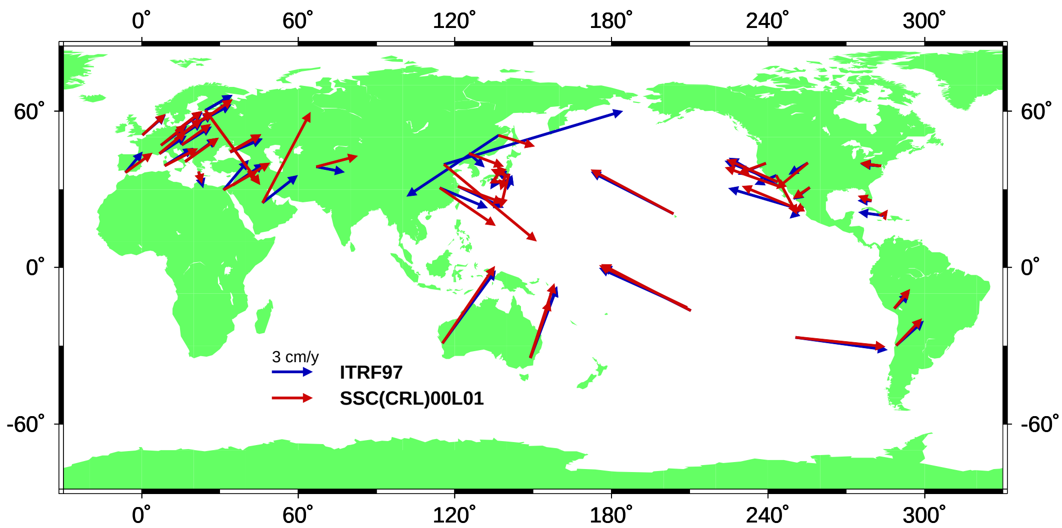

Figure 1. Horizontal velocity vectors, SSC(CRL)00L01 and ITRF97.

Table 1. Contributions to the ITRF200 project. Those marked '' were included in the final product.*

Technique	Institutes
VLBI	GIUB*, GSFC*, SHA*
LLR	FSG*, UTXMO
SLR	AUS*, CGS*, CLG, CRL*, CSR*, DEOS*, DGFI*, GSFC, JCET*
GPS	CODE*, GFZ*, IGS*, JPL*, NCL*, NOAA*
DORIS	AUS, GRGS*, IGN*
Multi-technique	GRIM*, CSR*
GPS Densification	DGFI*, EUR*, EUVN, GIA, IGN*, JPL*, IGN(Antarctica)* NIMA, CORS*, REGAL*, SCAR*, TURK

3. ITRF2000 Project

An ITRF2000 workshop was held at IGN, France in November 2000. An analysis of preliminary result was presented and a new definition of the datum was discussed. The solutions submitted to the project are listed in Table 1. The ITRF2000 project adopted a minimum constraint concept to reduce the numerical errors caused by removing constraints. We usually apply tight constraints when solving for a set of station coordinates, but loosely constraining every solution was recommended. Another new ITRF2000 feature is the new datum definition. The scale of the Earth is defined by selected VLBI (50%) and SLR (50%) solutions, and the origin is defined by selected SLR (100%) solutions. The rotation is fixed to the previous version, ITRF97, and the rotation rate is defined so no net rotation with respect to NNR-NUVEL1A occurs. The IERS team is aiming at realising a terrestrial reference frame stable to the 1 mm level [*Altamimi,* 2001]. Three VLBI solutions, GIUB, GSFC and SHA, were chosen for the VLBI datum, and five SLR solutions,CGS, CRL, CSR, DGFI and JCET, were chosed for the SLR datum. For the results over the last ten years, their scales agreed within 2 ppb, and the origin of SLR solutions agreed within a few mm. Recently (after the 18th TDC meeting), the ITRF2000 was finally released and is now available at:

http://lareg.ensg.ign.fr/ITRF/ITRF2000/

4. Conclusion

We contributed to the International Terrestrial Reference Frame for the first time. The ITRF2000 project showed that our solution was fairly consistent with that of other institutes, and, as a result, the ITRF datum was partly defined by our solution. This suggests that our CONCERTO orbit analysis package is sufficiently reliable for establishing a terrestrial reference frame. We plan to look into the final ITRF2000 solution and compare it with our solutions so we can contribute more precise solutions in the future.

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IVS Receives Award from Japanese Ministry on "Radio Day"

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GSFC Code 920.1
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The IVS Directing Board received an award from the Japanese Ministry of Public Management, Home Affairs, Posts, and Telecommunications on June 1, 2001. Within the ministry, the month of June celebrates events related to radio waves and June 1 is known as "Radio Day". Awards are presented on this day to begin the month-long celebration.

In February, Dr. Tetsuro Kondo of Communications Research Laboratory (CRL) submitted the nomination of IVS for consideration for these annual awards. CRL strongly supported the nomination, and it was announced in late April that we won! It is a great honour for IVS, and we have to thank Tetsuro Kondo for the initiative and his activity. The international and interdisciplinary cooperation of the group around Alan Whitney and the strong contribution of CRL and personally from Kondo-san resulting in the releasing of the VSI-H specifications has been regarded as an important step in VLBI and worthy for an award. IVS expresses its appreciation and gratitude to the VSI working group, in which IVS and related groups are involved, and explicitly to Alan Whitney and to Kondo-san for the success.

CRL invited Wolfgang Schlueter, IVS Chair, and Nancy Vandenberg, IVS Coordinating Center Director, to Japan to participate in the ceremony and receive the award on June 1. The ceremony and other events of the day were held in the Imperial Hotel in Tokyo. First, the award recipients were instructed (Photo 1) about proper actions to be taken during the formal ceremony. Next the official photograph was taken of award recipients with the Minister, Toranosuke Katayama. The ceremony itself included speeches by the Minister, the Chairman of the Radio Day events, members of the Japanese Diet, and the Chairman of NHK (the largest Japanese television station). Each award recipient received his award from the Minister (Photo 2). There were more than 1500 persons in the audience for the ceremony.

At the reception following the ceremony there was lots of food and drink. Wolfgang Schlueter and Nancy Vandenberg met many of the CRL officers and thanked them for their long-time support of VLBI and IVS (Photos 3 and 4).

The award consisted of a certificate (Photo 5) and a packet containing a cash award. Photo 6 shows the ribbon worn by Wolfgang at the ceremony.

We are looking forward to returning to Japan in February for the second IVS General Meeting, to be held at Tsukuba and hosted by CRL and GSI.

Photo 1. Nancy Vandenberg and Wolfgang Schlueter having tea in the instruction room.

Photo 2. Wolfgang Schlueter accepting the award from the Minister.

Photo 3. Meeting CRL President Takashi Iida. (left to right: Nancy Vandenberg, Tetsuro Kondo, Wolfgang Schlueter, Takashi Iida).

Photo 4. Meeting CRL Vice President Yasuyoshi Sakai. (left to right: Wolfgang Schlueter, Fujinobu Takahashi, Yasuyoshi Sakai, Nancy Vandenberg).

Certificate of Commendation

Awarded
To
The Directing Board of the
International VLBI Service
for Geodesy and Astrometry

I commend you for your work in developing an international interface standard that enables data to be interchanged among different types of VLBI observation systems.
Your achievement has greatly contributed to the progress being made in the use of radio waves, such as the improvement in VLBI observation accuracy, and will contribute to the precision measurement technology of the future.
In appreciation of your efforts, I commend your achievement on this Radio Day.

June 1st, 2001
片山虎之助
Toranosuke KATAYAMA
Minister of Public Management, Home Affairs, Posts and Telecommunications, JAPAN

Photo 5. Certificate of Commendation.

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Toranosuke KATAYAMA

Minister of Public Management, Home Affairs, Posts and Telecommunications, JAPAN

Photo 6. Award ribbon with "VLBI" and "IVS" inscription.

"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/"**.

IVS CRL TECHNOLOGY DEVELOPMENT CENTER NEWS No.18, June 2001

International VLBI Service for Geodesy and Astrometry
CRL Technology Development Center News
published by
Communications Research Laboratory, 4-2-1 Nukui-kita, Koganei, Tokyo 184-8795, Japan