TECHNICAL DEVELOPMENT CENTER NEWS

COMMUNICATIONS RESEARCH LABORATORY

Serial No. 13 November 1998

CONTENTS

Overview of the 13th TDC Meeting

Tetsuro Kondo (*kondo@crl.go.jp*)

Kashima Space Research Center
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314-0012, Japan

The 13th meeting of the Technical Development Center was held on September 16, 1998 at the Communications Research Laboratory.

Attendance

CRL members

Kenichi Okamoto, Taizoh Yoshino, Yukio Takahashi, Hitoshi Kiuchi, Akihiro Kaneko, Jun Amagai, Toshimichi Otsubo, Masato Furuya, Futaba Katsuo, Masaharu Fujita (KSRC: Kashima Space Research Center), Noriyuki Kurihara (KSRC), Yasuhiro Koyama (KSRC), Junichi Nakajima (KSRC), Ryuichi Ichikawa (KSRC), Eiji Kawai (KSRC), Mamoru Sekido (KSRC), Tomonari Suzuyama (KSRC), and Tetsuro Kondo (KSRC)

Special members

Shoichi Ogi (Geographical Survey Institute), Seiichi Shimada (National Research Institute for Science and Disaster Prevention), Shuhei Okubo (Earthquake Research Institute, University of Tokyo), and Masayuki Takemura (Kobori Research Complex, Kajima Corporation)

The following special members could not attend: Tetsuo Sasao (National Astronomical Observatory), Noriyuki Kawaguchi (National Astronomical Observatory), Hideo Hanada (National Astronomical Observatory), Masayuki Fujita (Hydrographic Department, Maritime Safety Agency) and Kachishige Sato (Tokyo Gakugei University),

Shoich Ogi replaced Mikio Tobita as the special member of the Geographical Survey Institute. Moreover, Kosuke Heki, a proxy of the special members at the National Astronomical Observatory Mizusawa, was prevented from attending by typhoon No.5.

Minutes

1. Opening Greeting

The meeting was opened by Kenichi Okamoto, the director of IERS TDC at the Communications Research Laboratory (CRL).

2. Activity Reports by Special Members

Each special member reported on the current status of each organization's activities.

National Research Institute for Science and Disaster Prevention (*Seiichi Shimada*)

Seiichi Shimada reported the results of the comparision of the International Terrestrial Reference Frames, ITRF94 and ITRF96, using GPS site coordinates. The determined accuracy and the consistency of the ITRF96 in Japanese GPS sites are considerably improved comparing with that of the ITRF94, although such improvements not obvious for the GPS sites in Europe and North America.

Kobori Research Complex, Kajima Corporation (*Masayuki Takemura*)

Masayuki Takemura, who is investigating the strong ground motion from big earthquakes and reported his investigation at the previous TDC meeting, informed us that his investigation had been aided by the discovery of the seismograph of the 1923 Great Kanto earthquake. It is difficult to predict strong ground motion accompanied by the big earthquake, because of a lack of information about the subsurface structures, in which seismic waves propagates from the earthquake source and about the source processes of the big earthquakes. Seismic ground motions were completely recorded at a few sites in Japan, at the occurrence of the Great Kanto earthquake. It was found from the results of analyzing them that the Great Kanto earthquake consisted of two large subevents and that many big aftershocks were accompanied . He finished by saying that by accumulating such data he hopes to be able to make a prediction of strong ground motion from the big earthquakes.

Earthquake Research Institute, University of Tokyo (*Shuhei Okubo*)

Research of the Izu peninsula swarm earthquakes using new technical observations, such as gravity measurements and SAR (Synthetic Aperture Radar) was introduced by Shuhei Okubo. Although they are special earthquakes, swarm earthquakes are investigated on the basis of idea that understanding the cause of them will be of great help in approaching the cause of general earthquakes. It was shown that swarm earthquakes produce a remarkable change in gravity. This change is considered to be caused by a rise of hot water from the deep interior of the earth. Furthermore the idea was introduced that a horizontal change seen in SAR observation results is consistent with a horizontal change seen in GPS observation results.

Geographical Survey Institute (*Shoichi Ogi*)

Shoichi Ogi reported on the recent activities at the GSI. The construction of a 32-m antenna at Tsukuba has been finished. This antenna completed a VLBI domestic network consisting of five fixed VLBI stations under the Geographical Survey Institute's control. It was reported that, by performing observations on this VLBI network, the Tsukuba-Kashima baseline has been determined within an accuracy of 2 mm. Furthermore the position of Shintotsukawa equipped with the smallest antenna in the VLBI network has been determined within an accuracy of 4 mm. It was also reported that observations routinely carried out four times per year indicate a shortening in the length of the Aira-Chichijima baseline. This is consistent with a GPS observation result.

The 26-m antenna at Kashima ceased to participate in an international VLBI experiment called CORE (Continuous Observations of the Rotation of the Earth) in September, 1998, and it is to be taken over by the 32-m antenna at Tsukuba thereafter. In the next fiscal year, GSI is planning to increase its frequency of participation in the CORE experiment to once a week. It was also reported that GSI will participate as a network station and a correlator in the newly-started international VLBI organization IVS (International VLBI Service for Geodesy and Astrometry). Furthermore a GPS antenna has been attached to the top of 32-m antenna to perform collocated observations between the IGS (International GPS Service for Geodynamics) network and the VLBI network. It is thought that, by the collocated observations, two networks can be connected with an accuracy of about 5 mm. This will be used for improving the accuracy of the ITRF.

The GSI is promoting the establishment of Tokyo Datum connected with the ITRF. It is tentatively called JGD2000(Japan Geodetic Datum 2000) and will be enforced in the year 2000. In this new coordinate system, the position of the Kashima VLBI station becomes the new starting point replacing the origin in Japan used in the current coordinate system. The domestic VLBI network calibrates the GPS networks. Based on these networks, triangulation points, bench marks, and topographical maps are modified.

3. Technical Development Reports

3.1 Key Stone Project (Crustal Deformation Observation System in the Tokyo Metropolitan Area)

Announcement of GEMSTONE Workshop (*Taizoh Yoshino*)

An international workshop named GEMSTONE (GEodetic Measurements by the collocation of Space Techniques ON Earth) will be held in Japan from 25 to 28 in January, 1999. The workshop is to be hosted by CRL and is sponsored by the Science and Technology Agency of Japan. Details are announced in this issue (see page 23).

Evaluation of KSP VLBI System Reliability (*Kouichi Sebata*)

The following report was made concerning the evaluation of the KSP-VLBI system's reliability. When any fault occurs in the KSP-VLBIsystem, the operator or the person who noticed the fault report it on the bulletin board of KSP's home page. Although the faults which occurred in early stages of system development are not contained on this bulletin board and not all faults were recorded, we summarized the occurrence of faults using this bulletin board. Consequently, it is shown that Kashima station has experienced much failure owing to natural disasters (typhoons and thunderstorms). As for computer-related faults, it is conspicuous that there is frequent hard-disk failure. There are no significant characteristics of the occurrence of faults as time series.

Current Status of KSP SLR System (*Futaba Katsuo*)

The current status of the KSP-SLR system was reported as follows. Data release started on September 1, 1998. KSP-SLR data are now open to the public through NASA/ATSC. Preliminary results of collocation observation between SLR and VLBI techniques were also represented. The results show coincidence within several centimeters. A method to calibrate the origin of a SLR telescope was also reported. It can be measured by observing return signals from a corner cube reflector mounted on a reference pillar located outside the telescope dome.

Q: What is the size of the reference pillar and what is the quality of the materials it uses?

A: There are three pillars 2.5 m high (one of them at Koganei is 10 m high) around a telescope dome. There are two short pillars (bench marks) in a dome to calibrate the position in a vertical direction. The pillar is made of invar. Its coefficient of linear expansion is about one-tenth less than that of iron. The pillar is covered with a pipe made of stainless steel so as to shade it, and a basic pile is driven into the base rock.

C: Temperature change of the pillar has been a problem in the Geographical Survey Institute.

Estimation of Earth Rotation Parameters using KSP VLBI data (*Yasuhiro Koyama*)

The method for estimating earth rotation parameters from KSP VLBI observation data was reported, along with its results. Consequently, for polar motion (wobbling), an X component is determined to have a mean error of 10 mas (milli-arc-second) and a Y component a mean error of 6 mas. UT1-UTC is determined to have a mean error of 0.59 msec. The mean error for UT1-UTC estimated from the KSP-VLBI data is the same as the error of the IERS prediction (Bulletin A) for several days in advance. Hence it is shown that the KSP VLBI data can be used to estimate UT1-UTC with the accuracy as same as that of IERS rapid prediction (several days in advance).

Q: Are the two parameters of polar motion and UT1-UTC equal parameters? If so, is it possible to explain why UT1-UTC may be able to improve a prediction value?

A: The two parameters of polar motion and UT1-UTC are considered similarly because they are three independent parameters which determine the orientation of rotational axis and rotational angle of the earth in the celestial sphere. Regarding the second question, I hope to examine the details in the near future.

C: In the case of estimating polar motion, it may be better to estimate two components, one is in the direction of Japan and the other in its orthogonal direction seen from the north pole, than to estimate X and Y components.

A: Since a polar motion in the direction of Japan acts as a parallel movement to the whole KSP network, the sensitivity of detecting polar motion is thought to be minimal. Thus by estimating only the component in the direction orthogonal to Japan, a good result may be obtained. I hope to examine this point.

Q: A systematic change seems to remain in the residual plot of UT1-UTC. Do you have any idea what causes this?

A: Variation due to the short term period of ocean tides has not yet been removed. This may affect the results.

Correlation Analysis between KSP Baseline Length Change and Local Meteorological Measurement Data (*Tetsuro Kondo*)

It was reported that analysis of the correlation between the data concerning the KSP baseline length change and the weather yielded interesting results. The accuracy of KSP VLBI measurements was drastically improved at the end of September 1997 by changing a session length from 6 hours to 24 hours. Subsequent baseline length data were investigated, and it was found that the fluctuation of baseline length tended to become large after March, 1998. In order to investigate the cause of this, a correlation was carried out with meteorological data collected at each station. Consequently, only the fluctuation of the baseline length relevant to Kashima shows a good correlation with temperature change. To explain this result, the following explanation was proposed. Apparently, only the position of the Kashima station is affected by a change in weather conditions. This is caused by the location of Kashima, i.e., Kashima is located close to the Pacific ocean on a coast which runs in a NE-SW direction. Therefore, the distribution of water vapor is expected to be different around the station and it depends on the direction. When the temperature at Kashima is high, the wind often blows from the south west bringing humid and hot air from a sub tropical area. It passes over Kashima station and reaches the sea north east of Kashima where the temperature is lower than on land. If the air humidity is very high, saturation will occur in the lower temperature area, resulting in a decrease of the partial pressure of water vapor. This may explain the relation between fluctuation of baseline length and temperature change.

Q: It is wrong to say that it is more humid in an inland area than at sea when temperatures are high in summer, isn't it? It should be understood from the pattern of the wind in a day called a "land and sea breeze".

A: Actual weather data (wind direction) does not show a clear land and sea breeze at Kashima this year. When it was hot the wind blew from south west all day. Therefore it can be thought that hot and humid air is conveyed from the southern ocean. However another possibility should be examined. A quantitative evaluation should also be performed.

C: Please check whether there is any typical day adequate for investigating such a hypothesis.

3.2 R&D Experiment Reports

Survey Observation of Radio Sources using KSP (*Akihiro Kaneko*)

Results were reported of survey observations of radio sources currently using the KSP system. Survey observations for 167 sources extracted from the

Parkes catalogue have already been completed, and fringes were successfully detected for 104 sources. Fringes on all baselines and both X and S bands were detected for 15 of these sources. A noteworthy result is that fringes were detected for a source in an H II region which is thought to be a broad source. More observations are being planned in order to investigate a source region in detail.

Preliminary Report on a Test VLBI Experiment using Giga-bit VLBI System (*Yasuhiro Koyama*)

A test VLBI experiment using giga-bit VLBI system was carried out in July. Observations were performed using the Kashima and Koganei KSP stations. Recorded data spanning 1 second is transferred from a recorder to a computer, and correlation processing is performed on the computer. However problem remains in data transfer and it has not resulted in the fringe detection (as of September 14, 1998). (Later we detected the first fringes successfully. See page 14)

Large Virtual Radio Telescope (*Yukio Takahashi*)

A plan for a large virtual radio telescope was introduced. A large virtual antenna which has a high sensitivity can be realized by connecting several big antennas to each other using a high speed communication network. A test experiment to prove this idea has been planned. It will use the KSP network by substituting a Usuda antenna for a KSP antenna. Although human power in NTT is needed at present to change a connection of the network, it is hoped that a regular observation once a week can be carried out using automated equipment to change connections.

Q: Is remote operation available to control the automatic change equipment of network connection?

A: It is assumed that the equipment will be operated according to a schedule prepared in advance. So in this sense it does not have remote operation.

3.3 Others

Current Status of Kashima 34-m Antenna (*Eiji Kawai*)

The current status of the Kashima 34-m antenna was reported as follows. The regular maintenance of the antenna has just been finished. The surface of the sub-reflector was re-coated with an electric conducting paint during this maintenance period. The problem which occurred in the reading of the azimuth angle encoder was also fixed. Moreover, treatments to combat deterioration from old age were performed. The performance of antenna system was measured after the completion of maintenance.

Q: How many years have passed since the last re-coating of sub-reflector?

A: This is the first time but 10 years have passed since the construction of the antenna.

C: The best way to evaluate the comprehensive performance of an antenna is to measure an SEFD (System Equivalent Flux Density).

RFI Investigation of LEO Satellite Terminal on a Radio Telescope (*Junichi Nakajima*)

In order to evaluate the RFI (Radio Frequency Interference) of a LEO (Low Earth Orbit) satellite terminal on a radio telescope, L-band radio signals are actually transmitted around the 34-m antenna at Kashima within a distance of between several km and 10 km. The results are as follows. When the distance is shorter than 2 km, a low-noise amplifier of the 34-m antenna is saturated. The RFI signal level becomes as low as that which makes it possible to perform VLBI observation when the distance is longer than 15 km. However the RFI signal level is still large for a single-dish observation. Based on these results, the best method for operation of a LEO terminal is examined.

Visit to Taeduk Radio Astronomy Observatory (TRAO), Korea (*Mamoru Sekido*)

Noriyuki Kurihara and Mamoru Sekido visited the Taeduk Radio Astronomy Observatory (TRAO) in Korea in order to research the current status about a planned project for a Korea-Japan 22GHz real-time VLBI. Optical fibers have already been laid between Korea Telecom and TRAO for a high speed communication link. However,the Korean side of the VLBI project is frozen due to the economic problems in Korea. The way to promote the project will be decided after a technical report is issued in cooperation with the TRAO.

Q: Do you have plan to extend a 22 GHz VLBI network to east Asia?

A: Shanghai and Urumqi as well as Korea can receive radio signals at 22 GHz. So we want to conduct an experiment with these stations in the future.

4. Closing Address

The closing address was delivered by Masaharu Fujita, the vice-director of the IERS TDC at the Communications Research Laboratory.

Estimation of UT1-UTC and Earth's Rotation Pole Positions from the KSP Network VLBI Data

Yasuhiro Koyama (*koyama@crl.go.jp*)

Kashima Space Research Center
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314-0012, Japan

1. Introduction

The real-time VLBI system and the automated data analysis system developped for the Key Stone Project (KSP) made it possible to analyze observed data right after all the observations in a VLBI experiment finished. At present, experiments are performed once every two days with the duration about 24 hours and the precise site positions estimated from each experiment are regularly made available within 30 minutes from the last observation. By using these KSP VLBI data, a possibility to estimate Earth's rotation pole position (δx and δy) and UT1-UTC values was investigated.

2. Precise coordinates of KSP VLBI stations on the ITRF96 reference frame

To estimate accurate Earth Orientation Paramaters (EOP) from a VLBI experiment, it is very important to provide accurate *a priori* site coordinates. Since the KSP VLBI network is quite compact, EOP values and site coordinates can not be estimated simultaneously with a sufficient stability. Therefore, site coordinates of all four stations have to be fixed through the data analysis and the consistency of these site coordinates with ITRF96 reference frame is especially important. To determine accurate site coordinates of four VLBI stations in the KSP network, seven geodetic VLBI experiments have been carried out with the 34m antenna station at Kashima, as shown in Table 1.

As mentioned in the table, three experiments do not have sufficient data quality and the estimated site coordinates have large uncertainties. Figure 1 shows the estimated site position of KSP Kashima VLBI station obtained from the seven tie VLBI experiments listed in the table 1. Error ellipses of three experiments are relatively large compared with the other four experiments reflecting poor data quality of the experiments. Repeatability of the estimated site coordinates from other four good-quality VLBI data is quite good and therefore the site coordinates of the Kashima KSP VLBI station is considered to be reliably determined on the ITRF96 terrestrial reference frame. Site coordinates of the other three sites were then determined from the accumulated KSP VLBI data spanning more than three years.

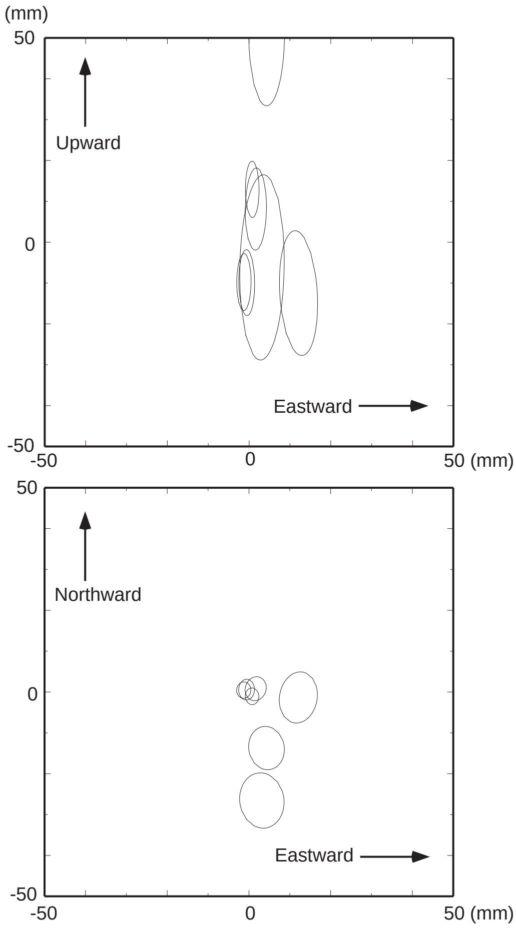

Figure 1. Estimated site position of the KSP Kashima VLBI station. Error ellipses are 1σ formal errors.

3. Estimation of earth's rotation pole positions and UT1-UTC

By using the 6 months of KSP VLBI data, earth's rotation pole position (δx and δy) and UT1-UTC were estimated. As in the regular data analysis, CALC (version 8.1) and VLBEST softwares were used. Site coordinates are provided as *a priori* information and fixed through the parameter adjustment process. No *a priori* information was used for δx, δy and UT1-UTC, so that these values were assumed to be zero before the parameter adjustment. The results are shown in Figure 2.

Table 1. List of seven tie VLBI experiments with the 34m antenna station at Kashima.

Date	Stations	Remarks
Jan. 19, 1995	Kashima(34m), Kashima(KSP), Koganei(KSP)	low data quality
May 1, 1997	Kashima(34m), all KSP stations	
Oct. 7, 1997	Kashima(34m), all KSP stations	low data quality
Nov. 18, 1997	Kashima(34m), all KSP stations	short duration
Feb. 16, 1998	Kashima(34m), all KSP stations	
May 1, 1998	Kashima(34m), all KSP stations	
Jun. 20, 1998	Kashima(34m), all KSP stations	

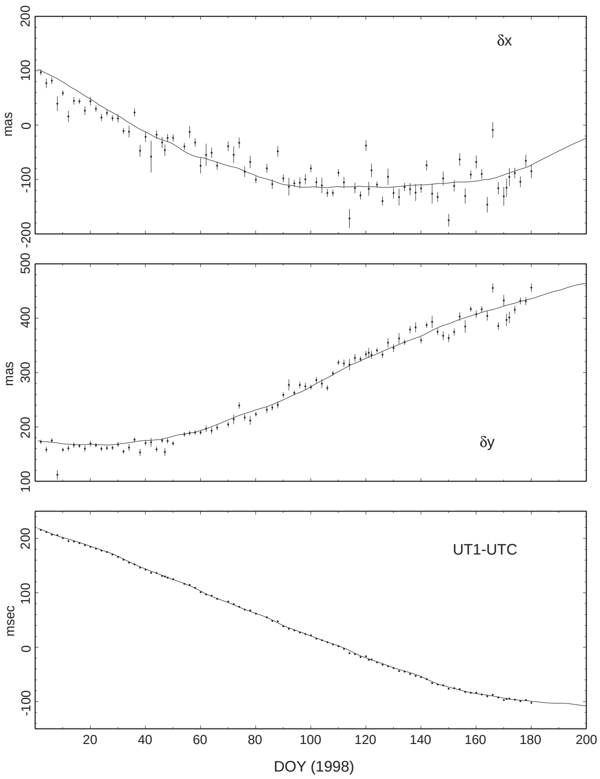

Figure 2. Estimated earth's rotation pole position (δx and δy) and UT1-UTC from the KSP VLBI data. Solid lines are indicating EOP97C04 values provided by IERS.

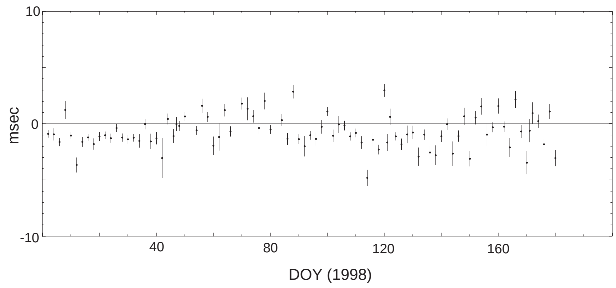

Figure 3. Deviation of the estimated UT1-UTC from the EOP97C04 values provided by IERS.

Estimated values are compared with the EOP97C04 data series maintained by IERS. Since the KSP VLBI network is compact compared to the size of the earth, there should be strong correlation between the estimated values of δx and δy. Neverthless, the estimated values are consistent with the EOP97C04 which has been obtained by combining several datasets estimated by various space geodetic techniques. Figure 3 shows the difference between the estimated UT1-UTC and the UT1-UTC values from EOP97C04 data series. Table 2 shows the statistic characterlistics of the estimated EOP values from the KSP VLBI data.

4. Discussions and future remarks

As shown in the figures 2 and 3, a possibility to estimate UT1-UTC and earth's rotation pole positions from the KSP VLBI data was demonstrated. To compare the obtained estimation errors shown in table 2 with the currently available accuracies of

Table 2. Statistic characteristics of the formal errors of the estimated EOP.

	Average	Minimum
δx	10.0 mas	4.8 mas
δy	6.0 mas	3.1 mas
UT1-UTC	0.59 msec	0.29 msec

the EOP predictions, predicted δx, δy, and UT1-UTC values in the IERS Bulletin A published in 1996 were compared with the EOP90C04 data set. From this comparison, RMS errors of the predicted EOP values were eveluated as $\sigma_{\delta x} = 0.81mas$, $\sigma_{\delta y} = 0.65mas$, and $\sigma_{UT1-UTC} = 0.23msec$ for the day when the Bulletin A was issued. And, these prediction errors increased to $\sigma_{\delta x} = 2.23mas$, $\sigma_{\delta y} = 2.10mas$, and $\sigma_{UT1-UTC} = 0.82msec$ when the predictions were compared at 5 days later than the day when the Bulletin A was issued. Since the IERS Bulletin A is issued twice a week and the interval between the publications is either 2 days or 5 days, the later prediction errors can be considered as they are representing worst case at present. The fact that the formal error of the estimated UT1-UTC from the KSP VLBI data is better than the predictions at 5 days after the Bulletin A is issued suggests that the KSP VLBI data have a possibility to improve currently available UT1-UTC. Estimation of the EOP values are being automated and the resuts are now available at `http://ksp.crl.go.jp/eopdata.html`.

The estimation accuracies can be improved by simply expanding the baseline lengths of the network. There is no technical difficulty to do so if a high speed digital communication network is available. A newly developped STM-1 interface for real-time VLBI can be used on 156 Mbps public ATM (Asynchronous Transfer Mode) network. The interface have a large data buffer which can absorb any delay which can be introduced through satellite links. Although there is no definit plan for the international real-time VLBI experiments at present, opportunities to use international high speed digital links are becoming feasible.

Influence of Local Weather Conditions on the Fluctuation of Baseline Lengths Measured on the KSP VLBI Network

Tetsuro Kondo[1] (*kondo@crl.go.jp*), Kouichi Sebata[2], Jun Amagai[2], Masato Furuya[2], Noriyuki Kurihara[1], Hitoshi Kiuchi[2], Yasuhiro Koyama[1], Mamoru Sekido[1], Akihiro Kaneko[2], Yukio Takahashi[2], Ryuichi Ichikawa[1] and Taizoh Yoshino[2]

[1] *Kashima Space Research Center*
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314-0012, Japan
[2] *Communications Research Laboratory*
4-2-1 Nukui-kita, Koganei, Tokyo 184-8795, Japan

Abstract: Since 1995, VLBI measurements using four fixed VLBI stations (Kashima, Koganei, Miura, and Tateyama) located around the Tokyo metropolitan area have been continually producing data of station positions and baseline lengths. Continuous improvement both in the system hardware and in the observation method have resulted in a remarkable improvement in measurement accuracy. Repeatability of baseline length, which is conventionally defined as a standard deviation of baseline lengths obtained by five continuous sessions, has been, since October 1997, about 2-mm level in baseline length in our VLBI network. However the repeatability tends to degrade in the summer season. To investigate the reason for this degradation, correlation analysis between the measured baseline lengths and local meteorological measurement data was carried out. We investigated the correlation between the fluctuation of baseline lengths and the daily averages of temperature, pressure, humidity, wind direction, and wind speed. A good correlation can be seen only for the relation between Kashima-related baselines and temperature. If we assume that the only the position of the Kashima station is affected by temperature changes in the summer season, the results are well understood.

1. Introduction

Since September 1996, we have been carrying out routine VLBI observations to monitor the crustal deformation around the Tokyo metropolitan area. The measurements are taken at four stations: Kashima, Koganei, Miura, and Tateyama (Figure 1). The project, called the Key Stone Project (KSP), is run by the Communications Research Laboratory. Until the end of September 1997, routine observations were made for about 6 hours on a daily basis. By introducing a real-time VLBI technique [*Imae et al.*,1996] we could extend the length of each session to 24 hours. This has brought a remarkable improvement in measurement accuracy. Routine observations spanning 24 hours started on September 30, 1997, but the frequency is set at a lower value every other day in order to avoid overloading the system.

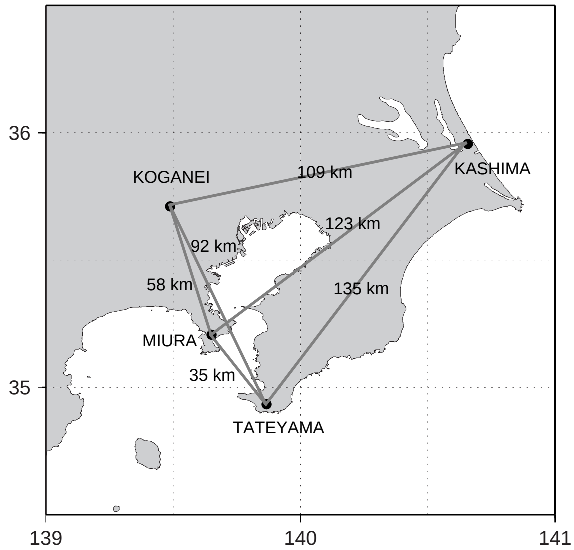

Figure 1. Configuration of the Keystone Project VLBI network.

Repeatability of baseline length, which is conventionally defined as a standard deviation of baseline lengths obtained by five continuous sessions, has been, since October 1997, about 2-mm in baseline length in KSP VLBI network [*Kondo et al.,* 1998]. However the repeatability tends to degrade during the summer months. To investigate the reason for this degradation, correlation analysis between the fluctuation of the measured baseline lengths and local meteorological data was carried out.

We investigated the correlation between the fluctuation of baseline lengths and the daily averages of temperature, pressure, humidity, wind direction, wind speed, and partial pressure of water vapor. Among these meteorological components, temperature and wind direction show a good correlation with the fluctuation of baseline lengths, but only for the Kashima-related baselines. Assuming that the only position of the Kashima station is affected by the temperature change in the summer season, the results can be well understood.

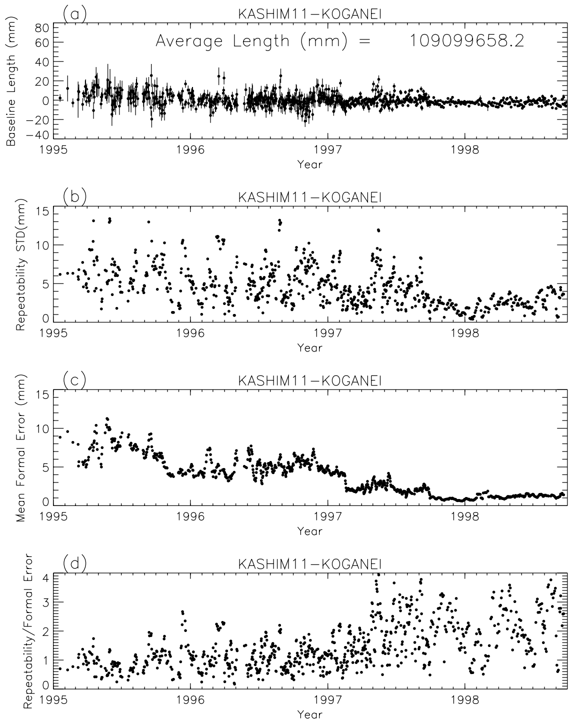

Figure 2. Evolution of baseline length between Kashima and Koganei (a), repeatabilities (b), mean formal errors (c), and ratio of repeatability to mean formal error (d) of five consecutive samples of baseline length.

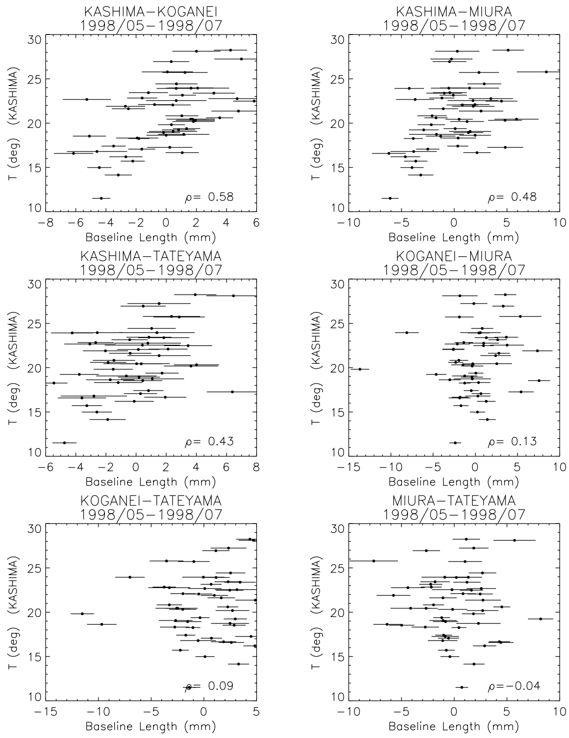

Figure 3. Scatter plots of temperature and the fluctuation of baseline lengths for the period May 1998 to July 1998.

Because Kashima is located close to the Pacific ocean, and the coast runs in straight line from nothewest to southeast, it is supposed that the spatial distribution of water vapor is strongly affected by the weather conditions in the summer. We carried out further analysis based on this assumption.

2. Correlation analysis

Figure 2 shows, for the period from January 1995 to September 1998, the evolution of measured baseline lengths for the Kashima-Koganei baseline, the standard deviations, the mean formal errors of the five continuous samples, and the ratio of repeatability to mean formal error of the baseline length data. It can be seen that the accuracy significantly improved at the end of September 1997 when the 24-hour sessions started. However, even though we limited the data period to that after October 1997, the accuracy tends to degrade in the summer season. Actually, the simple average of all baselines for repeatabilities for the winter season (here we define the period as October 1997 - March 1998) is 1.8 mm, and that for the summer season (April 1998 - September 1998) is 2.9 mm. We have made a correlation analysis between the fluctuation of baseline lengths and local meteorological data in order to investigate the cause of this degradation.

Meteorological components, such as temperature, pressure, humidity, wind direction, and wind speed, are obtained every one minute at each KSP station by the automatic monitoring system [*Iwata et al.,* 1996]. The KSP VLBI network is very compact, so it is expected that each component will be highly correlated between stations. Indeed, as shown in Table 1, they are highly correlated to each other. In fact, for temperature and pressure, correlation coefficients take a value of unity. Therefore, we used the weather data of Kashima as representative of the KSP stations for the correlation analysis described below. As for wind direction and wind speeds, there was less correlation, suggesting that they are affected by local topographical features.

A correlation analysis was made between the fluctuation of baseline lengths and meteorological data. Routine VLBI observations start at 01h UT and last for 24 hours. Thus the period of one VLBI session almost corresponds to a full UT day. Hence, the meteorological data were simply averaged for 24 hours starting from 00h UT on the UT day a VLBI session was carried out. We define the fluctuation of baseline lengths as residuals after the linear trend is removed. In this study the period of analysis was limited from May 1998 to July 1998.

Table 1. Correlation of meteorological data between KSP stations by meteorological component (May 1998 – July 1998).

	Baselines					
	Kashima – Koganei	Kashima – Miura	Kashima – Tateyama	Koganei – Miura	Koganei – Tateyama	Miura – Tateyama
Temperature	0.92	0.94	0.94	0.97	0.95	0.99
Pressure	1.00	0.99	0.99	0.99	0.98	1.00
Humidity	0.81	0.76	0.79	0.92	0.84	0.93
Wind Direction	0.38	0.58	0.72	0.64	0.22	0.60
Wind Speed	0.61	0.77	0.54	0.56	0.36	0.67

Table 2. Correlation coefficient between the fluctuation of baseline lengths and meteorological data (May 1998 – July 1998).

	Baselines					
	Kashima – Koganei	Kashima – Miura	Kashima – Tateyama	Koganei – Miura	Koganei – Tateyama	Miura – Tateyama
Temperature	0.58	0.48	0.43	0.13	0.09	-0.04
Pressure	-0.15	-0.33	-0.22	-0.11	0.05	0.15
Humidity	-0.14	0.04	-0.01	0.05	0.00	-0.03
Wind Direction	0.64	0.44	0.38	0.21	0.21	0.00
Wind Speed	0.46	0.40	0.31	0.16	0.22	0.10
Watervapor Partial Pressure	0.47	0.42	0.39	0.14	0.11	-0.02

Figure 3 shows examples of scatter plots of temperature and the fluctuations of baseline lengths. The same analysis was applied for other meteorological components. We also investigated the relation for the partial pressure of water vapor, which we computed from temperature, pressure, and humidity data.

The correlation coefficients obtained by the analysis are summarized in Table 2 by meteorological component for all baselines.

As shown in the table, considerably high correlation can be seen in the items for the baselines related to Kashima (such as Kashima-Koganei, Kashima-Miura, and Kashima-Tateyama), in particular for the temparature, the wind direction, the wind speed, and the partial pressure of water vapor.

If the fluctuation of temperature, after the linear trend is removed, is used as a temperature parameter, the correlation coefficients for Kashima-related baselines become higher: 0.68, 0.57, and 0.51 for the Kashima-Koganei, Kashima-Miura, and Kashima-Tateyama baselines, respectively.

3. Discussion

In a routine baseline analysis, the position of Kashima is fixed at a priori values. In other words, the positions of other stations are estimated as positions relative to Kashima. Therefore, we can not investigate the change in Kashima position directly from the routine analysis results. However, considering that the fluctuation of Kashima-related baseline lengths shows a good correlation with the change of the weather conditions, it can conclude that only the position of Kashima is affected by the weather conditions.

The largest error source, at the present time, in the baseline analysis is the propagation delay difference caused by the asymmetrical distribution of the water vapor in an azimuthal direction in the lower atmosphere, the troposphere [*MacMillan,* 1995]. Figure 4 shows the ray paths projected on the earth surface from each KSP station to radio stars during a VLBI session. The ray paths along the line-of-sight at each station are plotted in the figure. The altitude of the ray paths is less than 4

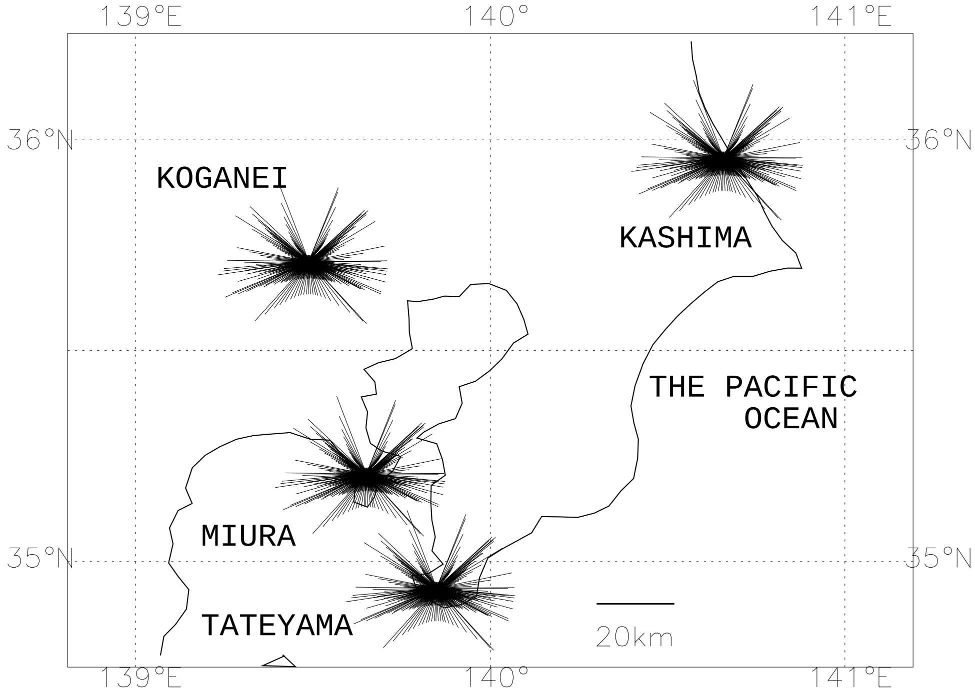

Figure 4. Ray paths projected on the earth surface during a VLBI session at each KSP station. The ray paths plotted have altitudes less than 4 km.

km, corresponding to the troposphere.

Because the Koganei station is located in an inland area (at least 40 km from the sea), the tropospheric ray paths are all on the ground. However, because the other three stations are located close to the sea (within ~km), some part of the ray paths pass through the troposphere over the sea. In particular all of the ray paths in the northeast area of Kashima pass through the troposphere over the sea (the Pacific ocean). Considering from ray paths at each station, it is thought that the azimuthal asymmetry of the water vapor distribution could be larger at Kashima than at other stations. Because the azimuthal asymmetries of water vapor distribution are not modeled in the current KSP VLBI baseline analysis, this might affect our baseline analysis results. As for the distribution of dry air, it has a large spatial scale (~ 100 km). It is therefore considered to be uniformly distributed on the KSP VLBI network because of the compactness of network (~100km).

Propagation delay corresponds to the integral of the refractivity of medium over the ray path. In the VLBI observation, if propagation delay from a certain direction is larger than that from other directions, the antenna position will be observed to shift towards the opposite direction. Applying this to the Kashima-Koganei baseline and assuming the change in the baseline length is caused only by excess propagation delay, we conclude that for Kashima there exists a large excess delay region in the area opposite the Koganei direction seen from Kashima (i.e., the sea side) when apparent baseline shortening occurs, and there exists a large excess delay region in the Koganei direction when apparent baseline lengthening occurs.

We propose a hypothesis accounting for the above phenomenon as follows. A positive correlation between the fluctuation of baseline lengths and temperature means that the apparent baseline length increases with increase of temperature. The relation between temperature and wind direction at Kashima shows good correlation (the result is not shown here). That is, temperature is high when the wind blows from the southwest and it is low when the wind blows from the northeast. Hence, when the temperature is high, humid hot air is conveyed from a far south subtropical zone. The humid and hot air passes through the Tokyo area without any loss of humidity and proceeds to

Kashima, because there is no obstacle (such as a high mountain) that would generates clouds and rainfall on the way to Kashima. Because a cold current flows from the north, the sea surface temperature at Kashima is lower than that of the southern sea. The humid and hot air meets this lower temperature area after passing through Kashima, and the partial pressure of water vapor exceeds its limit because saturated water vapor pressure decreases with a decrease in temperature. Consequently, the partial pressure of the water vapor becomes low compared with that when it was on the ground. Since a larger partial pressure of water vapor has a larger refractive index, it will result in the shortening of the Kashima-Koganei baseline.

5. Conclusions

A correlation analysis between the fluctuation of KSP baseline lengths and local meteorological data has been made in order to investigate the cause of accuracy degradation in the summer season. The results show a considerably good correlation between baseline fluctuation and temperature change. The explanation for this takes into account the propagation delay effect caused by the azimuthal asymmetric distribution of water vapor around the Kashima station. According to our hypothesis, when it is hot and wind blows from the southwest, the partial pressure of water vapor should be higher in inland areas than that above the sea around Kashima. This point should be clarified. We are planning to use a WVR (water vapor radiometer) to verify our idea. Other possible explanations should be also examined.

References

Imae, M., S. Hama, and T. Yoshino, 3.3.1 The concept of real-time VLBI system for the Key Stone Project, *Rev. Commun. Res. Lab., Vol.42, No.1,* pp.73-77, 1996 (in Japanese).

Iwata, T., Y. Takahashi, N. Kurihara, H. Takaba, Y. Koyama, K. Heki, and A. Kaneko, 3.2.5 Automatic monitoring system, *Rev. Commun. Res. Lab., Vol.42, No.1,* pp.55-61, 1996 (in Japanese).

Kondo, T., N. Kurihara, Y. Koyama, M. Sekido, R. Ichikawa, T. Yoshino, J. Amagai, K. Sebata, M. Furuya, Y. Takahashi, H. Kiuchi, and A. Kaneko, Evaluation of repeatability of baseline lengths in the VLBI network around the Tokyo metropolitan area, *Geophys. Res. Lett., 25,* 1047-1050, 1998.

MacMillan, D. S., Atmospheric gradients from very long baseline interferometry observations, *Geophys. Res. Lett., 22,* 1041-1044, 1995.

The First Fringes from the Giga-Bit VLBI System

Yasuhiro Koyama[1] (*koyama@crl.go.jp*), **Junichi Nakajima**[1], **Mamoru Sekido**[1], and **Moritaka Kimura**[2]

[1] *Kashima Space Research Center*
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314-0012, Japan
[2] *Tokyo University*

1. Introduction

On October 9, 1998, we have found the first fringes from the Giga-Bit VLBI System. The test observations were performed between Kashima and Koganei by using the Key Stone Project VLBI Network 11m antennas on July 10, 1998. Following the test observations, correlator related software developments had been continued with the recorded data.

2. The Giga-Bit VLBI System

The developments of the Giga-Bit VLBI System started in 1995 to improve sensitivity of the VLBI system. The concept is to use state-of-the art high speed A/D sampler and data recorder to realize the 1024Mbps VLBI observations which is 4 times faster than the maximum recording speed of the K-4 VLBI system (Nakajima et al., 1996). Figure 1 shows the schematic diagram of the system configuration at an observation site.

GBR-1000 is a high speed digital data recorder originally developed to record high definition TV (HDTV) signals. The original GBR-1000 recorder has a recording capability at 958 Mbps and the internal clock speed was increased by 7% to achieve the recording at 1024 Mbps for the Giga-Bit VLBI system. DRA-1000 is a VLBI interface unit which controls GBR-1000 and record the sampled digital data and associated timing information. TDS784 unit is a high speed digital oscilloscope which can digitize four analog data channels at 1 Gsps with 2 bits per sample. From the TDS784 sampler unit, 1 channel is selected and the 1 Gsps 1bit per sample data are transfered to the DRA-1000 VLBI interface unit through 32 parallel ECL cables running at 32 MHz. This interface is compatible with the K-4 VLBI system.

Figure 2 shows the schematic diagram of the system configuration at the time of VLBI data correlation processing. In this configuration, DRA-1000 controls the GBR-1000 data recorder unit and reproduce 32-parallel-32MHz digital signal which was recorded at the time of observations. The data is synchronized to the external 1 PPS signal provided by the master clock unit. UWBC (Ultra Wide Band Correlator) is a correlation processor originally developed for the Nobeyama Millimeter Array of the National Astronomical Observatory. The processor is an XF type correlator which has a capability to produce the 256 lags of cross-correlation function at 2048 Mbps. Half of the maximum capability of the correlator unit is used for the Giga-Bit VLBI System, and the same unit is called GICO (Giga-Bit COrrelator). Since the correlator processing unit does not support huge delay buffer which is required to process long baseline inter-

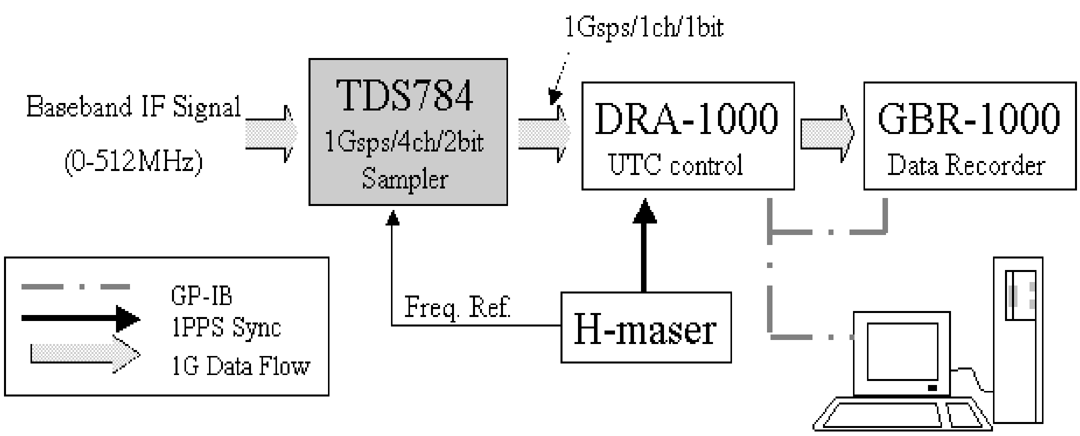

Figure 1. Schematic diagram of the system configuration for observations.

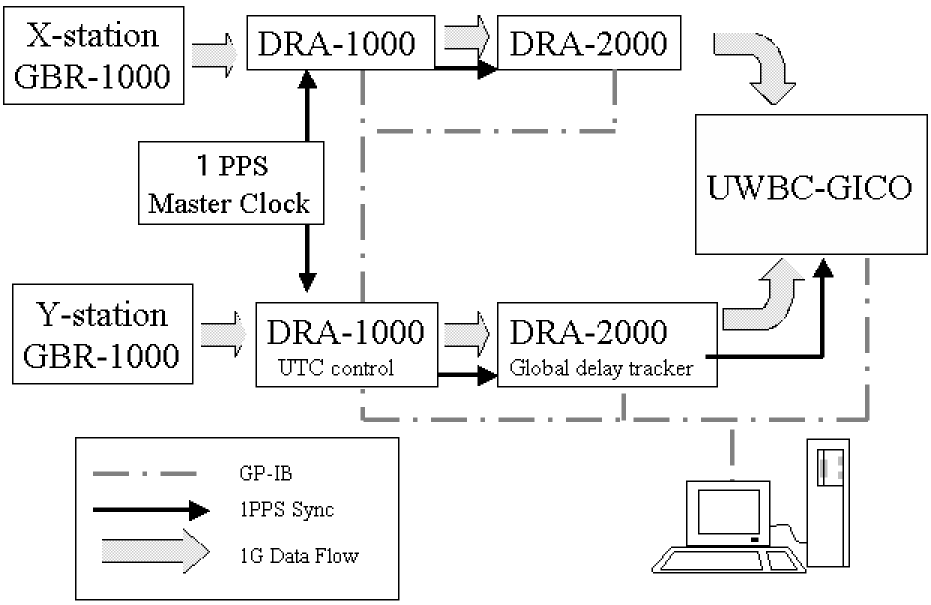

Figure 2. Schematic diagram of the system configuration for correlation processing.

ferometry data, DRA-2000 unit was developed. The DRA-2000 unit has an 1024 Mbit buffer memory to remove large delay which can not be removed by the internal buffer of the UWBC-GICO correlator unit. DRA-2000 unit converts 32-parallel-32MHz digital signal to 64-parallel-16MHz signal which is appropriate for the correlator unit. All the devices except for the TDS784 sampler unit have GP-IB data communication interface and are controlled by unix workstation.

3. Observations

The first VLBI observations using the Giga-Bit VLBI System were carried out on July 10, 1998. Two 11m antenna stations of the Key Stone Project (KSP) VLBI Network at Kashima and at Koganei were used. The observed data are recorded by the Giga-Bit VLBI System and also transfered to the real-time VLBI correlator system at Koganei to monitor the fringes at 256 Mbps. The X-band IF signal of the KSP VLBI system (500-1000 MHz) was converted to the baseband signal by using a frequency mixer and a 500 MHz local frequency signal provided by a synthesized signal generator. The baseband signal was then sampled by the TDS784 sampler unit. Developments of correlator control softwares and data processing softwares continued by using the real data and the first fringes were detected on October 9, 1998.

Figure 3 shows an example of the detected fringes. Figure 4 shows another example which was produced from an observation towards NRAO530 with narrow bandpass filters applied to the baseband signal at both stations. The fringe peak in the figure 4 is broad as a result of the bandpass filter. On the other hand, the steep peak in the figure 3 is demonstrating the fine delay determination capability of the wide band VLBI observations with the Giga-Bit VLBI System.

4. Future Remarks

The detections of the first fringes with the Giga-Bit VLBI system became an important milestone to improve the sensitivity of the VLBI observation. The impact of the wide band VLBI system is quite large and the use of the new system will lead us a variety of applications. We are now planning to use KNIFE (Kashima-Nobeyama InterFErometer) baseline to observe weak radio sources by using the Giga-Bit VLBI System. On the other hand, for the geodetic purposes, a possibility to investigate the short time variations of the tropospheric delay by using the high time resolution capability of the wide band VLBI observations is being considered. These observations will become possible soon when the developments of the correlator softwares are completed.

Acknowledgments

The Giga-Bit VLBI system has been developed under a cooperative efforts by Communications Research Laboratory, National Astronomical Observatory, Tokyo University, Toshiba Corporation, Yamashita Engineering Manufacture Inc., and Oki Electric Industry Co., Ltd. The authors would like to express deep appreciations to colleagues in these organizations.

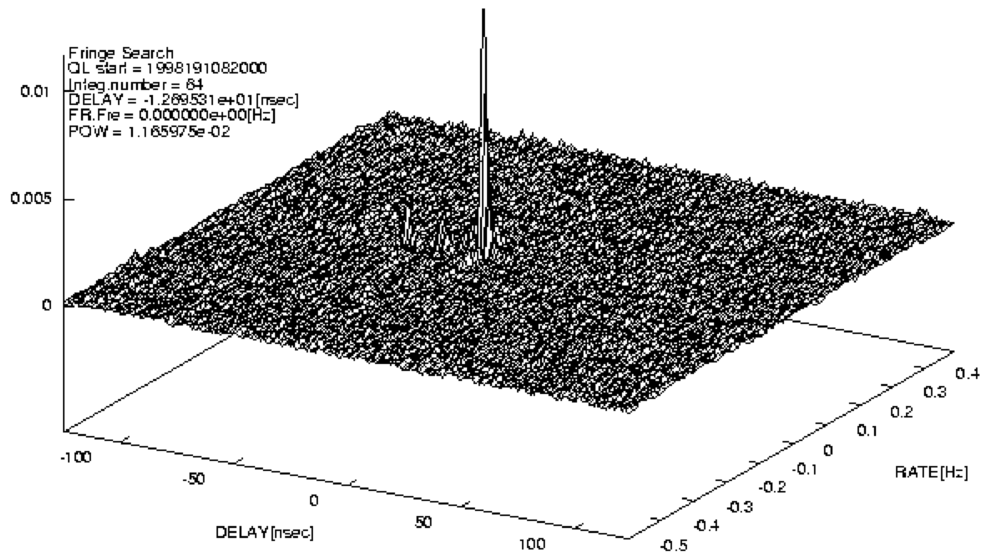

Figure 3. Detected fringe from the observation towards 3C345. The integration time is 64 seconds (July 10, 08:20:00-08:21:04 UT). The X-band IF signal from the Key Stone Network antenna (8100-8600MHz) was converted to the baseband (0-500MHz) and sampled by the TDS784 sampler unit.

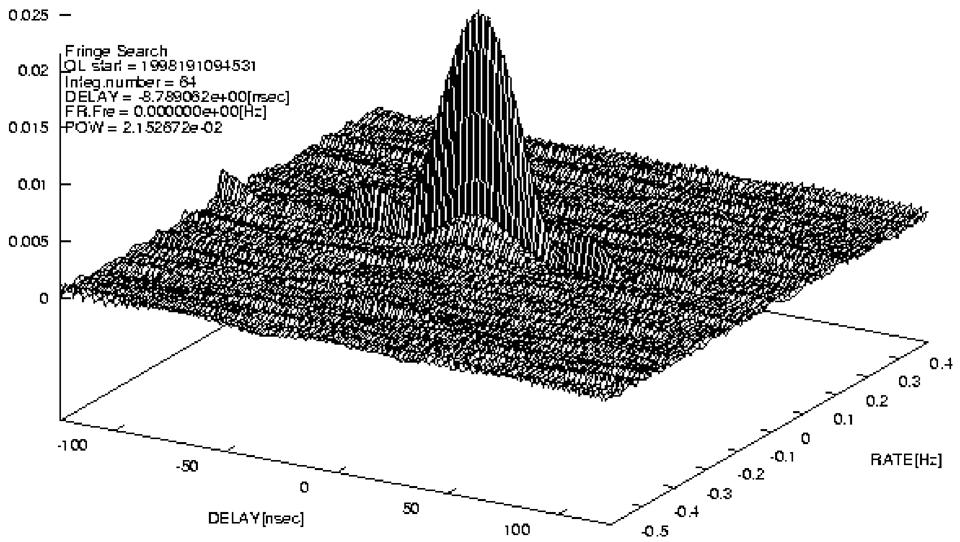

Figure 4. Detected fringe from the observation towards NRAO530. The integration time is 64 seconds (July 10, 09:45:31-09:46:35 UT). The X-band IF signal from the Key Stone Network antenna (8100-8600MHz) was converted to the baseband (0-500MHz). And a bandpass filter (bandwidth : 25 MHz, center frequency : 212 MHz) was used before the baseband signal was sampled by the TDS784 sampler unit.

Reference

Nakajima, J., A. Kaneko, Y. Koyama, M. Sekido, H. Kiuchi, T. Kondo, N. Kurihara, Y. Takahashi, H. Chikada, M. Miyoshi, and N. Kawaguchi, "1024Mbps VLBI Data Recorder", proceedings of the Technical Workshop for APT and APSG 1996, p. 171, 1996

The plan of the big virtual telescope using the high speed communication network

Y.Takahashi[1](*takahashi@crl.go.jp*), **H.Kiuchi**[1], **A.Kaneko**[1], **S.Hama**[1], **J.Nakajima**[2], **N.Kurihara**[2], **T.Yoshino**[1], **T.Kondo**[2], **Y.Koyama**[2], **M.Sekido**[2], **J.Amagai**[1], **K.Sebata**[1], **N.Kawaguchi**[3], **H.Kobayashi**[4], **M.Iguchi**[4], **T.Miyaji**[3], **H.Uose**[5], and **T.Hoshino**[5]

[1] *Communications Research Laboratory 4-2-1 Nukui-kita, Koganei, Tokyo 184-8795, Japan*
[2] *Kashima Space Research Center Communications Research Laboratory 893-1 Hirai, Kashima, Ibaraki 314-0012, Japan*
[3] *National Astronomical Observatory*
[4] *Institute of Space and Aeronautic Science*
[5] *NTT*

1. Introduction

The area near Tokyo within the range of 200km has some big antennas, such as Usuda 64m telescope of the Institute of Space and Astronautical Science (ISAS), Nobeyama 45m telescope of the National Astronomical observatory (NAO), Kashima 34m antenna of the Communication Research Laboratory (CRL), Kashima 26m antenna and Tsukuba 32m antenna of the Geographical Survey Institute (GSI). The big virtual antenna with the high sensitivity is established using the high speed communication networks, and we can observe the very week radio sources. The available data rate of the current network is less than 256Mbps, but the communication network is advanced day by day and more than 2Gbps will be realized in the near future. Figure shows the outline of this plan.

CRL develops the techniques of the multi-media virtual laboratory (MVL). This virtual telescope is an application techniques and the new advanced techniques of MVL.

CRL had developed the crustal deformation monitoring system for Tokyo metropolitan area. We call this project "KSP". This system has realized the real time VLBI observation of the 256Mbps mode using the high speed communication network. NAO & ISAS also has the real time VLBI network of 256Mbps (OLIVE). If we connect the both networks, we can do the test experiments of the big virtual telescope using the high speed communication network.

2. Science purpose

This is the techniques united the astronomy with the high speed communication techniques. It is possible to bring the new results of astronomy and the precise measurements for earth science. We describe the items of the expected results as follows.

2.1 Faint radio source

The communication network has no limitation of the observed data volume and the observed data rate. We can do the long observation, and it is useful for the observation of faint radio sources.

- **Stellar radio observation**

We challenge the radio observation of star. There are some bright star, such as Arcturus, Capella and Sirius. These stars are located closer than 40 light-years. The information of the temperature of the corona, the surface temperature of star, the size of star are very useful to study the stellar evolution. We try to observe the stellar corona of those bright stars.

- **Far away radio source**

We challenge to observe the radio sources of $Z > 4$ (further than 15 billion light-years). The age of these sources are a few billion years, and we can get the useful information of the universe evolution and of the deceleration coefficient. Furthermore, it is possible to study the element of early universe by molecular observations of far-off giant galaxies. However, Those sources is faint, and it is difficult to observe them by the usual observation. This techniques has a potential to observe them in future. The center core of galaxy and the pulsars are also target sources.

2.2 High sensitivity observation

We demonstrate the fine mapping. The big antenna is very busy. The communication network is available for the flexible observation. We add the big antenna into the observation network whenever it is available, and the mapping becomes fine. The antenna of KSP is 11m antenna. If the Usuda 64m antenna is added into the KSP network, the mapping becomes fine. We show the improvement of mapping using the high speed network. In this case, the software transformed from the data base or the correlation file of the geodetic VLBI to the data file of the mapping software "AIPS" is necessary. The data file of AIPS is FITS IEI format

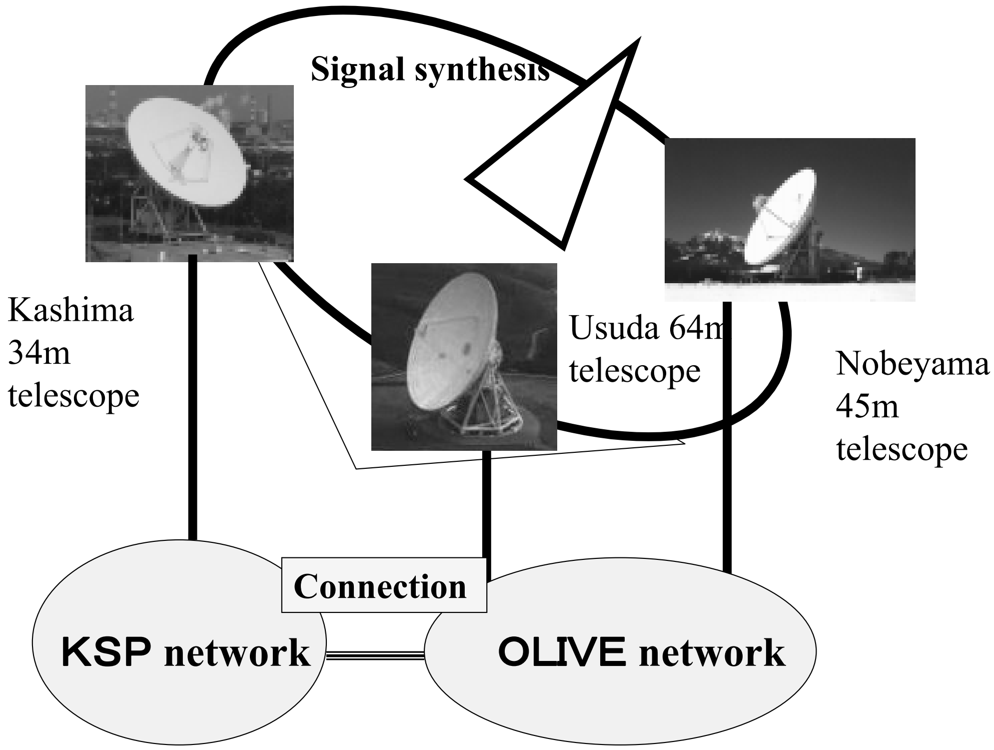

Figure 1. Outline of virtual telescope using high speed communication

(Interferometry Exchange Input format) or FITS file for other mapping software "Caltec Difmap". This software is important since the many geodetic VLBI experiments are used for the mapping of the source structures.

2.3 Why is VLBI needed ?

Why do we use the VLBI technique? The single dish observation is considerably affected by the atmospheric scintillation and the system noise fluctuation. For the VLBI techniques, the independent noise at site is reduced in an interferometric method. Furthermore, VLBI is useful to measure the size of the radio sources. Therefore, we use the VLBI technique.

3. Plan of experiments

CRL and NAO&ISAS will have the experiments of the big virtual telescope using the high speed communication network in this year. CRL and NAO&ISAS have the KSP and OLIVE observation networks of 256Mbps mode, respectively. We connect the both networks, and we can do the experiment. NTT (Nippon Telegraph and Telephone Corporation) collaborate with this projects. NTT and CRL will develop the software to automatically change the connected link of the networks, that is from the independent networks of KSP and OLIVE to the connected network of KSP and OLIVE. We can do the respective experiments of KSP and OLIVE, and the connected experiments any time.

4. Simulation of the synthesis of antenna signal

We make the simulation of the antenna signal synthesis using the computer. The noise is in random and independent for time and the station. On the other hand, the signal of radio source is in random for time, but it is common for the station. The expectation of radio source signal is dependent for the antenna performance. We consider the case of three antennas (1,2,3), and one (3) of them is the big antenna. The expectations of the radio source signal at antenna 1,2,3 for a parameter period that is the minimum duration of correlated integration are 20%, 20%, 50% of the noise expectation, respectively. The radio source signal and noise and total signal of i'th data at an antenna k are indicated as $S_k(i)$, $N_k(i)$, and $A_k(i)$=$S_k(i) + N_k(i)$. The correlation on the baseline between antennas 1 and 2 is indicated as $\rho_{12}(i) = A_1(i)A_2^*(i)$. In usual VLBI, we search the delay and delay rate parameters to maximize the $\rho_{12}(i)$. The SNR is obtained as the ratio of radio source signal to noise when these parameters. $\Sigma_i\rho_{12}(i)\rho_{23}(i)\rho_{13}^*(i)$ is almost constant, and we can not use this value to detect the signal. We compare $\Sigma_i\rho_{12}(i)\Sigma_i\rho_{23}(i)$ $\Sigma_i\rho_{13}^*(i)$ (method 1) and $\Sigma_i(\rho_{12}(i)+\rho_{23}(i)+\rho_{13}(i))$ (method 2) with $\Sigma_i\rho_{23}(i)$ of a single baseline. The SNR of method 1 is not improved as compared with one baseline. The SNR of method 2 is improved as $\sqrt{(SNR_12)^2 + (SNR_13)^2 + (SNR_23)^2}$. In both methods, the parameter search needs considerable computations since we must search the four parameters of delay and delay rate in the constrain of the closure of delay and delay rate. The reason why the method 1 does not improve the SNR is the large cross term between noise and signal.

If antennas 1 and 2 are small, the SNR on the baseline between antennas 1 and 2 becomes small. We can not observe the faint source on the baseline. Kawaguchi propose the idea to use the other big antenna 3. We compare the SNR of combination of two baselines (antennas 1 and 3, antennas 2 and 3) with the SNR of one baseline between antennas 1 and 2. We estimate the SNR of $\Sigma_i(\rho_{23}(i)\rho_{13}^*(i))$ (method 3) and $\Sigma_i(\rho_{23}(i)+\rho_{13}(i))$ (method 4) with $\Sigma_i\rho_{12}(i)$. The method 1 does not improve the SNR, but the method 4 improve the SNR. The antenna synthesis is also useful in this case. We will develop the synthesis software.

5. Other system of MVL

Lastly, we introduce other system of MVL which we are developing now. One is the remote monitoring system of antenna using the stereophonic image. Second is the data base system for the image data of radio source. Third is the transformation software from the two dimensional color or contour mapping data of the radio source to three dimensional image. The data will be available anywhere and any time using WWW. These system are useful for other purpose. If you have a particular system and we want to propagate this system for an education and practice, you can easily disseminate the information of the system using this system. The transformation system from color mapping to three dimensional image is useful to make the three dimensional image easily.

The Kashima 34-m Antenna Status Report

Eiji Kawai (*kawa@crl.go.jp*)

Kashima Space Research Center
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314-0012, Japan

We repaired the radio wave reflection paint on the subreflector (Figures 1 and 2). The antenna's performance was restored its original level (S band Tsys:69K, X band Tsys:62K). The problem of the real azimuth angle and the encoder angle not matching was caused by mechanical discordance. We adjusted the mechanical block, and angles were accordant. The antenna is now too old to work properly. When yearly antenna maintenance was carried out, holes due to corrosion were found at the radial truss on the back structure of the main reflector. We reinforced simply and repainted that place. The circuit breaker was tripped because of defective insulation on the power cable, and to correct this, we replace the power cable. We replaced a part of the nut plate which fasten the main reflector to the back structure with a stainless one (Figures 3-5). We plan to equipped a 43 GHz receiver in November.

Figure 1. Hanging the subreflector.

Figure 2. Placement of the subreflector in a normal position.

Figure 3. Corroded nut plate which fasten the main reflector to the back structure.

Figure 4. Removing main reflector panel for replacing the nut plate.

Figure 5. Measuring the removing main reflector panel with theodolite which placed at the center part of the antenna.

Report on LEO terminal nearby RFI effect to a radio telescope

Junichi Nakajima[1](*nakaji@crl.go.jp*),
Mamoru Sekido[1], **Yasuhiro Koyama**[1],
Eiji Kawai[1], **Kurihara Noriyuki**[1],
Rocky Sebori[2], **Katsunori Shibata**[3],
and Hiroyuki Torigoe[4]

[1]*Kashima Space Research Center*
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314-0012, Japan
[2]*Global Star Japan*
[3]*National Astronomical Observatory*
[4]*Ministry of Posts and Telecommunications*

Introduction

RFI (Radio Frequency Interference) to radio astronomical telescopes become severe problem in this decade. Especially in the lower microwave band like L and S, communication demand to the convenient wavelength are rapidly increasing. The LEO (Low Earth Orbit satellite) terminal is one of candidate need frequency resources in the L-band. There are three major providers in LEO communication in near future. These are Iridium, Global Star, and ICO. Their systems are different by orbit, number of satellite, link gateway control method and frequency. Although the satellite communication system will be a convenient communication tool, the Global Star system(Here after GS) is directly conflicted its frequency allocation to radio astronomy. The one third of their ground-based up-link frequency overlapped radio-astronomy band. The band between 1610.6-1613.8 is preserved for Hydroxyl line observation. Ministry of Posts and Telecommunication asked CRL voluntarily experiment and advice to settle this issue at a council.

Experiment

RFI measurement was performed collaboration with Global Star Japan Co., Ltd. The GS prepared an experimental transmitter which could emit 0.7W with a mobile whip. This could be assumed as a handy phone terminal in their actual service. The mobile station move around the telescope. We defined 300 RFI measurement points of various distance between 0 to 20 km. The experiment was done in mid-night to avoid other interference. Kashima 34m radio telescope equipped a cooled HEMT L-band receiver in focus was used to measure the RFI level. Since the RFI is not coupled to the telescope main-beam, the RFI level could not be estimated from its distance and telescope gain. It is thought that the RFI signal is mixture result of irradiation and diffraction from telescope structure. In addition there is a direct coupling possibility to the feed horn. A spectrum analyzer monitoring the telescope IF(converted Intermediate Frequency) is used check the whole receiving system. Most of the measurement was done by telescope zenith. To evaluate telescope operation angle relative to the RFI point, two point was chosen(2 and 15km). At these point telescope azimuth was aligned toward the terminal and elevation dependence was measured.

Results

1) LNA(Low Noise Amplifier) of the telescope is saturated, when the transmitter is located within 2km radius from telescope. Any observation is impossible.
2) When the transmitter is located more than 2km from telescope, the interference is still strong and harmful for observation.
3) When the transmitter is being separated from the telescope, gradually the interference level is decreasing. The level of RFI and decrease tend is depend its direction. Toward hilly direction with surrounded thick green the RFI level is 10dB lower than populated plain area with few green (Figure 1).
4) When the terminal is separated 15km from telescope, still the RFI signal is detectable. But the strength of terminal is almost comparable to VLBI Phase calibration-tone.Thus it is less harmful to VLBI observations.
5) There was elevation dependence in RFI strength. If the telescope is faced to the transmitter the strength of RFI is increased 20dB at 2km and 10dB at 15km.

Conclusion

There was very strong interference from the experimental LEO transmitter. Further discussion of this nearby interference nature is continued. It is clear the best way to share the band is time-based sharing between the radio telescope and the LEO communication system. Based on this experimental result, an agreement is prepared between the GS and Japanese radio-astronomy sites.

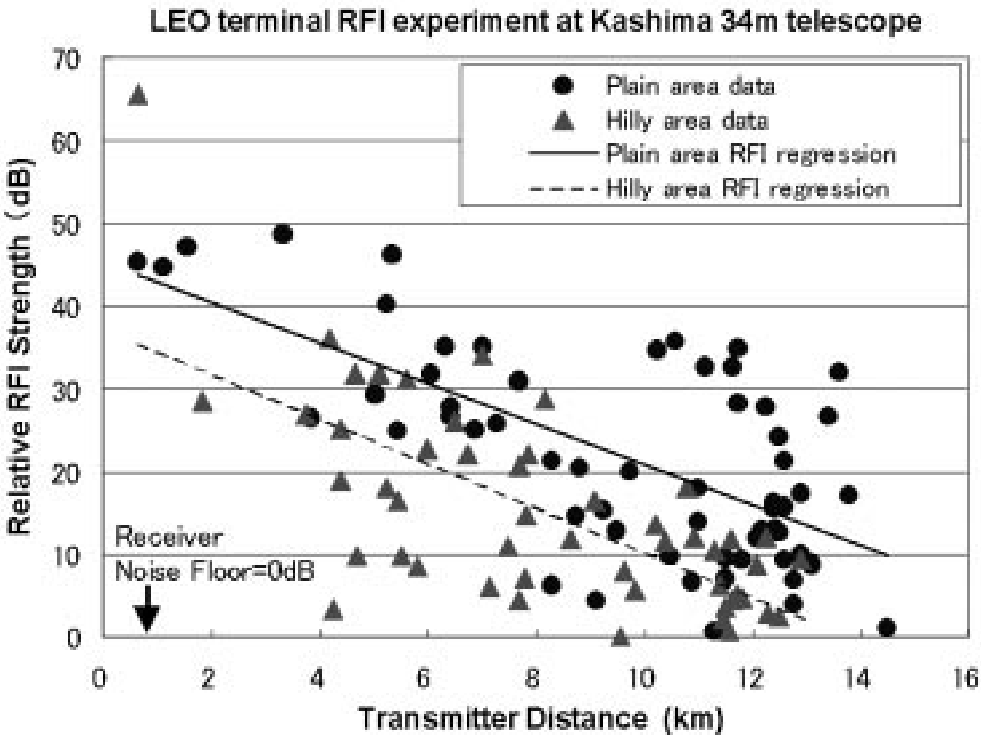

Figure 1. LEO terminal RFI experiment at Kashima 34 m telescope.

International workshop on GEodetic Measurements by the collocation of Space Techniques ON Earth (GEMSTONE)

supported by
the Science and Technology Agency

January 25-28, 1999
hosted by
at the Communications Research Laboratory (CRL)
Koganei, Tokyo, Japan

Space geodetic techniques are now widely accepted in many fields. Although individual technique is still being improved, it is strongly recognized that the benefits of collocation and the combination of space techniques are significant. These studies will lead to improvements in the terrestrial and celestial reference frames. We can also use collocation to study systematic errors that may be invisible to only a single technique. The CRL has the honour to host the GEMSTONE international workshop in January 1999. An APT(Asia Pacific Telescope)/APSG (Asia Pacific Space Geodynamics) meeting will also be held in conjunction with the workshop. This workshop will focus on the technical aspects of collocation and on its contribution to geodesy and astrometry.

Scope:

- observations at the collocated stations
- data analysis combining the space geodetic techniques
- technical problems of collocation, including local surveying
- terrestrial reference frames
- technical issues in the APT and APSG, including celestial reference frames

Information of the workshop is available from the following URL:

http://ksp.crl.go.jp/gemstone.html

Invited Speakers (tentative)

J. Bosworth (GSFC, USA), Z. Altamimi (IGN, France), G. Beutler (Bern, Switzerland)
T. Herring (MIT, USA), J. Ray (USNO, USA), J. Manning (AUSLIG, Australia)
W. Schlueter (BKG, Germany), S. Ye (Shanghai Observatory, China)

Local Organizing Committee

Taizoh Yoshino (Communications Research Laboratory)
E-mail: yosh@crl.go.jp, Tel: +81-42-327-7560, Fax: +81-42-327-6077

VLBI Technical Development Center (TDC) at the Communications Research Laboratory (CRL) is supposed to do

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

2) the promotion of research in Earth rotation by advanced methods in VLBI,

3) the distribution of new VLBI technology.

The 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 TDC newsletter is published biannually by CRL to inform the IERS community its current activities.

This news was edited by Tetsuro Kondo and Yasuhiro Koyama, Kashima Space Research Center, who are editorial staff members of TDC at the Communications Research Laboratory, Japan. Inquires on this issue should be addressed to T. Kondo, Kashima Space Research Center, Communications Research Laboratory, 893-1 Hirai, Kashima, Ibaraki 314-0012, Japan, TEL : +81-299-84-7137, FAX : +81-299-84-7194, e-mail : kondo@crl.go.jp.

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/"**.

TECHNICAL DEVELOPMENT CENTER NEWS No.13, November 1998
International Earth Rotation Service - VLBI Technical Development Center News
published by
Communications Research Laboratory, 4-2-1 Nukui-kita, Koganei, Tokyo 184-8795, Japan