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CRL

CONTENTS

Overview of the Ninth TDC Meeting

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The Ninth meeting of the Technical Development Center was held on September 13, 1996 at the conference room of Communications Research Laboratory.

Attendance

CRL members

Kuniaki Uchida, Taizoh Yoshino, Shin'ichi Hama, Hitoshi Kiuchi, Akihiro Kaneko, Kohichi Sebata, Hideyuki Nojiri, Toshimichi Otsubo, Michito Imae, Mizuhiko Hosokawa, Yuko Hanado, Fujinobu Takahashi (KSRC: Kashima Space Research Center), Yukio Takahashi (KSRC), Noriyuki Kurihara (KSRC), Ryuichi Ichikawa (KSRC), Yasuhiro Koyama (KSRC), Mamoru Sekido (KSRC), Junichi Nakajima (KSRC), Eiji Kawai (KSRC), Tetsuro Kondo (KSRC)

Special members

Nobuyuki Kawano (National Astronomical Observatory), Kazuo Shibuya (National Institute of Polar Research), Mikio Tobita (Geographical Survey Institute), Masayuki Fujita (Hydrographic Department, Maritime Safety Agency),

Following special members could not attend: Noriyuki Kawaguchi (National Astronomical Observatory), Kosuke Heki (National Astronomical Observatory), Hisashi Hirabayashi (Institute of Space and Astronautical Science), Yoshimitsu Okada(National Research Institute for Science and Disaster Prevention), Teruyuki Kato (Earthquake Research Institute, University of Tokyo),

Minutes

1. Opening Greeting

Fujinobu Takahashi, the vice-director of IERS TDC at Communications Research Lab., opened the meeting.

2. Progress Report on IERS Restructuring *(Taizoh Yoshino)*

Taizoh Yoshino introduced history from the beginning of the IERS to the present. He also introduced topics, such as review of the IERS services, inclusion of the crustal movement monitoring, etc., in this year's IERS workshop.

During this year, there was restructuring of the VLBI organization in IERS. There were 14 proposals from 10 countries for the Call for Proposals for VLBI participation in IERS.

The Communications Research Laboratory had proposed to continue as a technological development center. This proposal was formally accepted by the Directing Board of IERS in September, 1996. The US National Earth Orientation Service (NEOS) was selected as the IERS VLBI Coordinating Center, with Dr. Chopo Ma as representative in the Directing Board.

3. Activity Reports of Each Organization by the Special Members

The special members reported on the current status of the activities of their organizations.

National Astronomical Observatory *(Nobuyuki Kawano)*

Nobuyuki Kawano reported current status of VSOP, VERA, and RISE, which are major projects in the National Astronomical Observatory (NAO).

Budgetary request for VERA for next fiscal year (1997) could not be proposed to the ministry of finance. Therefore a new task team consisting of represenatives from VSOP, VERA and RISE group will be formed for promoting VERA. Concrete partnership with universities and RFP (Request for Proposal) must be clarified to promote VERA.

Launch schedule of VSOP was postponed from September, 1996 to January or February, 1997. The FX correlator at Mitaka started processing, and 24-hour-operation in a day and 10 stations simultaneous processing became possible. Correlation results are being tested through comparisons with data processed by the correlator NAOCO which is already in operation.

A relay satellite and a laser altimeter will be added to the RISE project, in addition to a delta VLBI mission using a lunar lander and a moon orbiter. The number of staff members at NAO/Mizusawa dedicated to each project is as follows: 10 for VERA, 16 for VSOP, 2 for RISE, and 3 for others.

Seven years have passed since NAO was establised. We hope to establish a space measuring section which combines a VSOP group and an earth rotation group in the 2nd stage of future plan that will start from the 10th aniversary of NAO (three years later). Frequent personnel exchanges among Mizusawa, Mitaka, and Nobeyama area are also planned.

Hydrographic Department, Maritime Safety Agency *(Masayuki Fujita)*

Masayuki Fujita reported operations of SLR (both portable and fixed types) and GPS in Hydrographic Department, Maritime Safety Agency.

Fixed SLR has been operated over 10 years at Shimosato. The observation schedule is becoming denser, because the number of satellites is increasing. Tracking of RIS of ADEOS will be started from October. Portable type SLR, whose purpose is to measure the first-order control point, was operated from January to March, 1996 at Choshi which is the 14th point, numbering from Chichijima Island measured in 1988. Choshi was also the last point planned to be measured. Second round of measurements begins this fiscal year. The order of measurement will be Chichijima Island, Ishigakijima Island, Minamitorishima Island, then Wakkanai. Though upgrade of the SLR system is strongly desired, it is difficult due to budgetary reasons.

Continuous GPS measurements are carried out at 7 points (Sagami Bay, Shimosato, Okayama, etc.).

Test operation of D-GPS (1.5-2 m accuracy) developed by the Aids to Navigation Department is carried out this fiscal year. It will be operated for practical use since next fiscal year. Hydrographic Department plans to make geodetic observations using reference stations of D-GPS.

Geographical Survey Institute *(Mikio Tobita)*

Miko Tobita reported activities relating GPS, VLBI and SAR as follows.

IGS pilot project which measures positions of GPS stations in the ITRF coordinate system was started. A 32m antenna dedicated for VLBI will be constructed at Tsukuba, and it will be operational in March, 1998. An accuracy of 2-3 mm in absolute satellite position is required for the SAR analysis. He therefore expressed great expectations for SLR system being developed under KSP project because it is designed to be able to measure SAR satellite position with this accuracy. He also proposed the possiblity of the calibration of SAR data by using Japanese VLBI antennas as ground targets of SAR observations because those positions are well determined through repeated VLBI observations.

National Institute of Polar Research *(Kazuo Shibuya)*

Kazuo Shibuya reported current status of Antarctic VLBI project.

Equipments necessary for VLBI will be shipped to Syowa Station, Antarctica next year (Nov. 1997) by the 39th Japanese Antarctic Research Expedition (JARE-39). Each equipment test has been started using the 5 m antenna at GSI when available. Antarctic campaigns are planned from February, 1998, with probable participation of the Australia, South Africa, and the Chilean Antarctic-station antennas. The campaign will include an S2 recording system, and correlator processing with different systems is yet to be discussed and solved.

Regarding other topics,

(1) A DORIS beacon and a superconducting gravimeter have been operating properly,

(2) 2 years' continuous GPS data was recorded with a TurboRogue system on the site, although data transmission was limited to every 10 days' data,

(3) PRARE ground station for orbit determination of ERS-2 will be shipped to Syowa Station this November,

(4) ERS-1/-2 SAR Tandem Mission over Antarctica received 70-pass pairs, and covered 1/3 of Antarctica for SAR interferometry.

4. Space Surveying in Asia

The First APSG Workshop Report *(Taizoh Yoshino)*

Taizoh Yoshino reported on APSG (Asia Pacific Space Geodynamics). Dr.Ye, the former director of the Shanghai observatory, proposed APSG considering development of space surveying in the Western Pacific region and the importance of this region in the meeting of experts at the ESCAP conference in September, 1994. It became one of the recomendations of the conference, and APSG was initiated. The APSG workshop was held in Shanghai in May, 1996. He emphasized that it was necessary for space geodetic observations in the Asia Pacific region to be accompanied by the advanced infrastructure improvement. And, there was a question on present state and prospect on observations in India.

APT(Asia Pacific Telescope) Report *(Yukio Takahashi)*

Yukio Takahashi reported on APT as follows. The purpose of APT is to establish a VLBI network in the Asia region that is useful for both astronomy and geodesy. Therefore the compatibility of recorder systems becomes a problem. The organaization of APT is not yet fixed, unlike the APSG. Joint APT and APSG workshop, TWAA96 (Technical Workshop for APT and APSG 1996) will be held at Kashima Space Research Center in December.

5. Technological Development Reports

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

Current Status of VLBI *(Noriyuki Kurihara)*

Noriyuki Kurihara reported current status of KSP VLBI as follows.

The construction of facilities was started in 1993. Daily observations were started on the Kashima-Koganei baseline in January, 1995. Miura joined the daily observations in December, 1995. In September, 1996, daily observation by the full network of 4 stations (Kashima, Koganei, Miura, and Tateyama) was started. Unmanned observations are carried out at each station, except for the guard (operator) performing tape changes.

There was a question whether there was any trouble in the unmanned operation. He replied "No trouble so far". In addition, there was an inquiery about the daily observation schedule. The answer was that presently the observation local time range is fixed for 5 hours from midnight through the early morning at present, as long as there are no special circumstances.

Real-Time VLBI Hardware *(Hitoshi Kiuchi)*

Hitoshi Kiuch reported regarding the hardware on the present state of real-time VLBI. Main points were as follows.

It has already succeeded in test operations. It was also used for fringe tests to check the system performance. The improvement of the software for stable operation is being made. An advantage of real-time VLBI is not only its immediacy but also the increased reliability by not using a recorder (mechanical equipment). Moreover, there is no difference in the specifications between a tape-based VLBI correlator and real-time one, because unification of the data was attempted from the point of view of the correlator.

Real-Time VLBI Software *(Mamoru Sekido)*

Mamoru Sekido reported regarding the software R-KATS for real-time VLBI correlation processing. The R-KATS aims at semi-unmanned operation in correlation processing, and it is still under development. Debugging of the software was entering its final phase for practical use.

There was a question regarding earth rotation parameters used in the real-time VLBI correlation processing. The answer was that the predicted values of IERS were used.

5.2 Next Generation VLBI System

A Plan of Development of Multi-ch High-Speed Correlattion Unit for Exclusive Use of Geodetic Survey *(Hitoshi Kiuchi)*

A development plan for a high-speed correlation unit was shown by Hitoshi Kiuchi. It processes 32 ch $\times$ 64 Mbps data, and is designed exclusively for use with geodetic obseravtions. The correlation unit will be developed by using an extension of conservative technology. No custom made ICs will be used for the planned correlator. As for the video band width, it was shown that 32 MHz band width (corresponding to 64 Mbps when 1 bit sampling is adopted) was limiting, considering the flatness of amplitude-frequency characteristics. There were some comments from a special member as follows: the purpose of technical development was ambiguous, and clear motivation and target are necessary to obtain budget for development. Some discussions followed, and are summarized as follows.

Why will it be developed for exclusive use with geodetic observations? The answer was that "exclusive use with geodetic observation" means that the correlator should measure group delay accurately. This is different from astronomical applications, which are mainly concerned with accurate fringe phase.

There were requests for the technical development as follows. Please consider comaptibility when the data aquisition system is developed, because it becames important in international VLBI experiments. Also develop an infrastructure that includes data transfer through satellites, which is necessary for a remote site as in the Antarctic.

Development of Gigabit Recorder *(Junichi Nakajima)*

Junichi Nakajima introduced current status of a fast-sampler and a high-density recorder under development.

In his report, the importance of achieving high sensitivity by extending the bandwidth under limited antenna diameter was indicated.

In addition, the recorded signal could be monitored on a TV display, since the equipment was developed on the basis of that for TV. Therefore an operator could check the system easily.

Following comment was given from a special member. Since the price of the K4 equipment does not drop, price might become a limiting factor for the popularization of this equipment. The gist of the discussion concerning this matter is as follows: the cost becomes almost equivalent to that for the VLBA recorder when peripheral equipment is included. A key to future popularity is the future price.

There was a comment that increased sensitivity is an important factor, and is not a wrong direction for technological development.

5.3 Others

GPS+VLBI Meteorology *(Ryuichi Ichikawa)*

Ryuichi Ichikawa reported on GPS meteorology by utilizing GPS observations as a meteorological instrument for measuring the water vapor content of the atmosphere. Evaluation of GPS observations using the KSP-VLBI data, with feedback to the VLBI data analysis toward higher precision was also reported.

The importance of the consideration in the analysis of azimuth angle dependence of the water vapor content was indicated from the comparison of VLBI and GPS observations in cases where large anisotropy is seen in the neutral atmosphere. There was a question from a specialist: Why are highly precise geodetic observations expected from GPS meteorology? The answer includes two major points. One is improvement in the meteorological, while the other is the density of GPS observations.

Further comment was given by the reporter after the meeting as follows.

Information concerning water vapor with a high space-time resolution is indispensable for the compensation of the wet delay. At present, the only way to obtain this information is either to use radiosonde obseravtions, whose time resolution is 12 hours and space resolution is about 300 km, or to use radiometer data on board a satellite which observes the same ground point every several days. A highly dense GPS observation network may be able to realize water vapor observations with a high space-time resolution (horizontal 20km and about 10 minutes in time) which is never attainable by any other method. This is expected to make clear the mesoscale phenomena, and to improve numerical prediction models in meteorology. By applying an improved numerical model to compensation of wet delay, improvement in the accuracy of geodetic observations are expected.

Asteroid Radar Observation *(Yasuhiro Koyama)*

On the international cooperation radar observation of the asteroid (Near Earth Asteroid) which approaches the earth, the principle of observation and results of last year were reported by Yasuhiro Koyama. In the observation in last year radio wave was emitted from the 70m antenna at Goldstone, USA, and reflected wave from the asteroid was received by each antenna at Goldstone, Evpatoria in Ukraine and Kashima in Japan. The asteriod was named Golevka which combines initial two or three letters of 3 station names joined the obseravtion. There was a question from the special member about the reflection coefficient of the radio wave from the asteroid. There was the comment from another member as follows. Actual comaprison was made using the sample brought back from the moon by Apollo project. Regarding the measurement of size and shape, there was a question of why radio wave is used. The repoter answered that the resolution of the radar was higher than that of the optical observation.

Expectation to VLBI Technological Development *(Mizuhiko Hosokawa)*

Mizuhiko Hosokawa proposed ideal way, significance, and expectation to the development of VLBI by every objects, every purposes, and every development directions. He classified each item as follows. Objects are classified into natural cosmic radio source and artificial radio source. Purposes are calssified into astronomy, geodesy, navigation, and physics. Development directions are classified into accuracy, sensitivity, and immediacy.

Up to present time natural cosmic radio sources are major objects of the VLBI measurement. From now on artificial radio sources will become important objectives, because a number of space vehicles will be launched for the moon and for planets. As for the purposes, if it becomes possible to measure source position with an acuraccy of better than 10 micro arc second, measurement of star mass and fluctuations of standard coordinates system which is predicted by CRL theory group will be verified. It also becomes possible to make a 3-D map of our garaxy which is an important astronomy problem.

As for the divelopment directions, he stressed expectations as follows. Keeping the leading in the present state with respect to the immediacy like real-time VLBI, TDC/CRL should promote not only sensitivity improvement by expanding the band width but also other technological development, in particular higher precision to examine theoretical prediction.

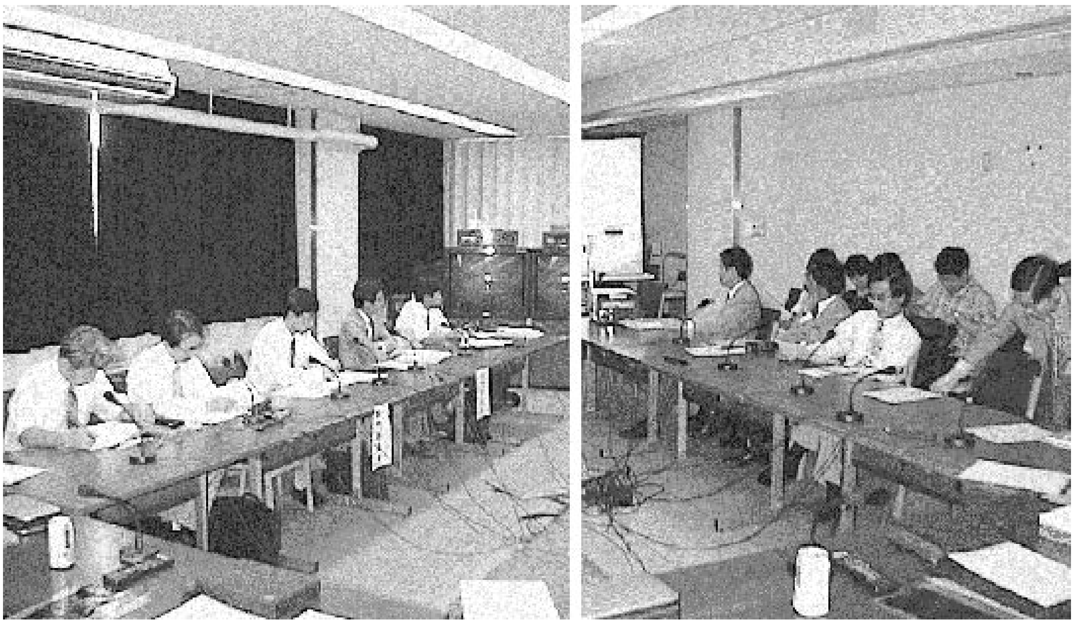
KaRAS (Kashima Radio Spectrograph for Low Frequency Natural Radio Wave Observation) *(Tetsuro Kondo)*

The current status of KaRAS (Kashima Radio Spectrograph) (20-70MHz) which was installed at Kashima Space Research Center for monitoring the sun and Jupiter was introduced by Tetsuro Kondo. Although the observation at lower frequency band became difficult due to artificial noises, it was shown that to some extent radio interferences could be removed by applying a simple algorithm on a spectrogram. In the future, an interferometer will be constructed between Kashima and Hiraiso (about 40km baseline length). The special member pointed out that the purpose of KaRAS. The reporter replied as follows. The purpose is to obtain data available to use theoretical work to evaluate proposed radio wave generation models of the sun and Jupiter. There also was a comment on possibility and significance of carrying out such observation in the polar region which can monitor the objects for long time a day.

6. Closing Greeting

The greeting of the closing was addressed by Kuniaki Uchida, the director of IERS TDC at Communications Research Laboratory.

After the conference a short inspection of SLR and VLBI facilities of the KSP Koganei station was carried out.



Special members (left) and CRL members (right) atttended the ninth TDC meeting held at the headquaters of Communications Research Laboratory on September 13, 1996.

Review of Reorganization of the IERS VLBI and APSG Workshop

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Review of Reorganization of the IERS VLBI

In the beginning, the aim of reorganization of the IERS VLBI is explained referring to the policy of IERS to be discussed at the 1996 IERS Workshop in October (See; Report on the IERS Directing Board Meeting No.18). Reorganization and particpations were decided by the members of Directing Board in a vote by correspondence after the meeting held at Baltimore in May, 1996. It is decided that the VLBI Coordinating Centre is NEOS (National Earth Orientation Service) with Dr. Chopo Ma as representative in the Directing Board. Then, it is informed that the proposal of CRL to continue to work as a VLBI Technical Development Center (TDC) is formally accepted by the letter from Prof. Ch. Reigber (Chairman of the IERS Directing Board) to Dr. Y. Furuhama (Director General of the CRL). The TDC consists of seven institutes from six countries.

APSG Workshop

The APSG (Asian Pacific Space Geodynamics) Project is based on a recommendation of the symposium on Space Technology and Applications for Sustainable Development held during the ESCAP (Economic and Social Commission for Asia and the Pacific) Ministerial Conference on Space Applications for Development in Asia and the Pacific (19-22 September, 1994). It is also recommended as the IAG Resolution #4 adopted at the XXI General Assembly of the International Association of Geodesy in July 1995.

The first APSG workshop was held in Shanghai in May 1996. Objectives of the APSG discussed at the workshop is reported. As an APSG structure, it is decided to have a Program Secretariat, a Technical Coordinating Center (TCC), and a Data Processing and Archiving Center under a Management Board. The TCC consists of five Technique Working Groups (TWG). Since CRL is expected to contribute to the APSG as a VLBI Technical Development Center of the IERS, T.Yoshino (CRL) is designated as a convenor. In order to understand the tectonic condition surrounding Japanese islands, we should cooperate with the countries in Asia-Pacific region for the study of future earthquakes.

Technical Workshop for APT and APSG 1996 (TWAA96)

10-13 December, 1996 Kashima, Japan
hosted by
Kashima Space Research Center
Communications Research Laboratory

Kashima Space Research Center of the Communications Research Laboratory will host an international workshop which will highlight technical issues related with Asia-Pacific Telescope (APT) and Asia-Pacific Space Geodynamics (APSG) Project from Tuesday, December 10 through Friday, December 13, 1996. In the 4th APT workshop held in Australia last year, it was agreed to hold general APT workshop every two years. Instead of expanding the workshop interval from original one year to two years, it was also agreed that technical work group members should be gathered in between the biennial general workshops and Japan was suggested as a venue of the first technical meeting of APT. It is our pleasure to be able to announce that the meeting will actually take place with a full support from Science and Technology Agency (STA) and Japan International Science and Technology Exchange Center (JISTEC). Since there are many technical respects which are common for APT and a VLBI part of APSG, we decided to make the meeting to a joint technical workshop for APT and APSG.
More information is available on Web Site **"http://apollo.crl.go.jp/index.html#TWAA96"** or from Workshop Secretariat:

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The Compatibility of VLBI Terminal in APT

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In 1980's, VLBI observations were conducted using Mark-II, Mark-III VLBI terminal, or the VLBI terminal which is completely compatible with Mark-III type. Therefore, the VLBI terminal is unified by Mark-III type in 1980's. In 1990's, many types of VLBI terminal have been developed.

First is K4 VLBI terminal which was developed by CRL(Communications Research Laboratory) in Japan. This recording system is a cassette type and it uses a rotating recording head. The tape running is very stable, and there is no bit shift and the parity error is very small. The recording modes of 64 Mbps, 128 Mbps and 256 Mbps are available now. The recording duration of each K4 tape is 50 minutes in the rate of 256 Mbps, and 200 minutes in the rate of 64 Mbps. The automatic tape changer for 24 tapes is also available. Therefore, any operator for the tape change is not necessary in normal VLBI experiment during 24 hours in the rate of 256 Mbps mode, and during about one week in the rate of 64 Mbps. We have also developed the video converter and formatter. The size of K4 VLBI terminal is compact (1/3 of Mark-III type) and the weight is light (1/4). The K4 system is used in the domestic VLBI experiments in Japan, KSP system and mobile experiments. Recently, NAO (National Astronomy Observatory) set K4 system at Urumqi station. VSOP terminal had been developed based on K4 system. Recorder and formatter is the almost same as K4 system for KSP system. However, it needs the time control units. Japan has five correlation system for K4 system; 1)KSP correlater (6 baselines), 2) Kashima correlater (one baseline), 3)GSI correlater, 4)NAO mizusawa correlater, 5)VSOP correlater.

S2 VLBI terminal developed by Canada. It combines a few home video decks, and the price is cheap. The maximum recording rate is 128 Mbps. It is used in AT(Australia Telescope) VLBI network and in many countries. The correlation for S2 system is available in Canada, and at ATNF in Australia. VLBA terminal whose maximum recording rate is 256 Mbps is used worldwide. Mark-IV which will be available for 2 Gbps mode is developed in USA and the correlation center has been established in JIVE and other country. Mark-IV is upper compatible with VLBA. These two systems use open reel tapes. In Japan, we have developed the new VLBI terminal which is available for 1 Gbps mode and uses cassette tapes.

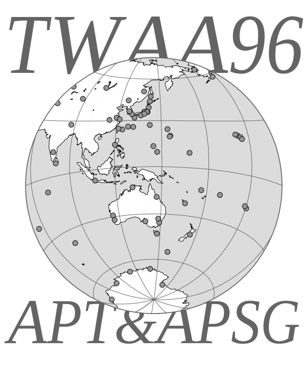
There are many types of VLBI terminal in the Asia and Pacific VLBI network. Australian VLBI network is unified by S2 system. Japanese VLBI network is unified by K4 system (or VSOP system). However, the global VLBI experiments were conducted by Mark-III, and in future Mark-IV will be used. JIVE adopted Mark-IV system. VLBA system is most popular now, and it is the standard type in VSOP project. It is very complex situation to conduct the collaborated VLBI experiment in Asia and Pacific network. VSOP group in Japan has the copy equipments among VSOP K4, S2, VLBA system, and some institutes in Japan have plans to make a copy equipment. It is necessary to make an standard method how to conduct the joint experiment using copy equipment and to establish the standard format of the future VLBI terminal.

In this December, the technical workshop for APT and APSG will be held at Kashima, CRL in Japan. These themes were discussed in this workshop.

Technical Workshop for APT and APSG 1996 (TWAA96)

10-13 December, 1996 Kashima, Japan
hosted by
Kashima Space Research Center
Communications Research Laboratory

See Page 7 for Detail!



The Extension of the Asia VLBI Networks by CRL (the Results in Japan-Urumqi VLBI Experiments)

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(being appeared in the proceedings of APT'95 (Asia Pacific Telescope meeting 1995))

1. Introduction

The Asia and Pacific VLBI network makes the widest VLBI network which cooperation with Australia, China, Japan, Russia and Hawaii. The east and central Asia is very interested to study the crustal dynamics. This area is on the Eurasian Plate. The India Plate collides to the central Asia, and Himaraya Mts. are created on the front of the collision. The central Asia are pressed by the India plate motion, and the East Asia is pushed out toward the east direction, that is, toward the Japan archipelago. This movement is related with the crustal deformation in Japan archipelago. It is recently considered that the deformation of east Asia makes the micro plate (Amur plate) on the Eurasian plate and the other micro plate (Ohotsuku Sea plate) on the North American plate. Figure 1 shows the crustal deformation in Asia area. Four plates, such as North American plate (or Ohotsuku Sea plate), Eurasian plate (or Amur plate), Pacific plate and Phillipin Sea plate, collide together near the Japan archipelago, and the big earthquakes occurred repeatedly. The deformation near Japan archipelago should be studied as the deformation of the whole Asia area.

As concerning that the Asia area is important, we promote the Asia and Pacific VLBI experiment. The joint VLBI experiments with Urumqi conducted in 1994 and 1995. The results in these experiments are described.

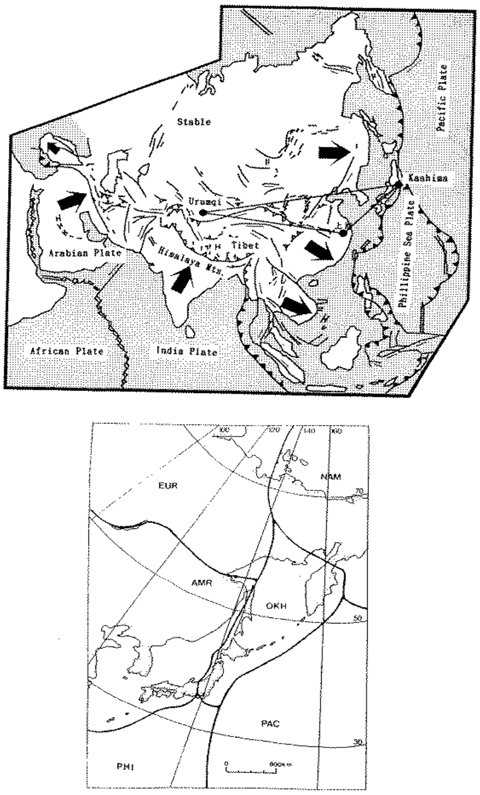

Figure 1. The deformation in the Asia and near Japan Archipelago.

Furthermore, we conducted the pulser VLBI observation with Russia in 1995, and we will conduct the VLBI observation in the spring, 1996 again. We also have the plan to set the K4 VLBI terminal to Shanghai in China, Kalyazin in Russia and Wettzel in Germany. Therefore, we can extend the VLBI network in Asia.

2. Joint Experiments with Urumqi

The results of Japan and Urumqi experiments in 1994 and 1995 are described. Table 1 shows the overview of the experiments in 1994, 1995. In 1994, the phase calibration is not good, and we do not used the phase calibration data. The phase information among the channels was fixed to the phase relationship of one observation near the middle of experiment. The observation used the strong source, and the SNR is very large and the phase fluctuation is stable for each channel. In this method, the other observations has pseudo delay by the incorrect phase information. The phase relationship among channels is changeable during the experiment, and its change was equal with the clock change. We need many changes in clock. The residual was very large.

Table 1. Residual of Urumqi experiment

	Date	Remarks	GOOD/CORR.	Residual Delay
1994				
1st	1994/2/28	PCAL NO GOOD	121/191	590 ps
2nd	1994/3/ 3	PCAL NO GOOD Shanghai	165/222	406 ps
1995				
1st	1995/3/19	PCAL GOOD	166/215	382 ps
2nd	1995/4/18	PCAL GOOD	171/306	649 ps

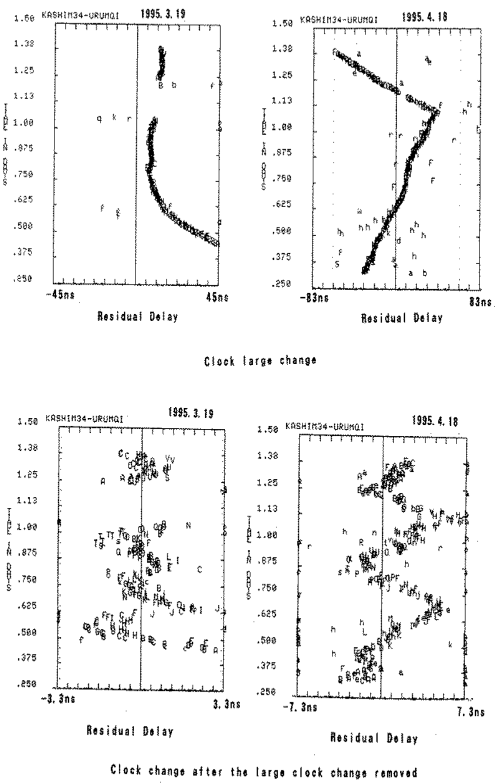

Figure 2. Residual of Delay in 1995.

In 1995, the phase calibration was considered to be well, but the residual was also large. Figure 2 shows the change in the clock of Urumqi in 1995. The change in clock was very large and we needed many changes in clock almost every hours.

The coherence loss was checked for these experiments. The whole observation is divided into the several segments shorter than 1 minute (a few 10 seconds). The correlated amplitude are calculated for each segment. The coherence correlated amplitude is obtained from an average as the complex values over the all segments to include the phase information. On the other hand, we can obtain the incoherence correlated amplitude from the average of correlated amplitude for each segments, that is, it is averaged without the phase information between the segments. The ratio of two correlated amplitudes means the coherence loss caused by the phase stability, such as atmospheric scintillation, the stability of reference signal and the stability of system. The noise affects on the ratio of two correlated amplitude in the case that a single noise ratio (SNR) is less than 10, and the pseudo coherence loss appears for the small SNR. Therefore, we can estimate the coherence loss only for large SNR. However, SNR for almost all observation in our experiments is large and our estimation of coherence is correct.

In the 1st experiment, the coherence at X band is almost greater than 85 % shown in Figure 3. Abscissa is sources in the experiment and ordinate is the coherence. The coherence at X band is about 60 % in the second experiment shown Figure 4. The coherence at S band is about 80 %. The coherence loss by the atmospheric scintillation is less than 5 % at X band. This large coherence loss in the second experiment may be caused by the stability of phase calibration or reference frequency (5 MHz) for the short period.

We show the position of Urumqi. Table 2, 3 show the estimated position XYZ components and Horizontal & vertical movements of Urumqi station in ITRF93 (International Terestial Reference Frame 1993).

The estimated vertical component of the second experiment in 1994 may be incorrect. The XYZ positions of Urumqi station estimated by 1995 experiments may be correct in the precision of 2 cm. The position of horizontal component was measured in the precision less than 5 cm. Figure 5, 6 show the horizontal position (easterly and northterly movement) in ITRF93 obtained from the results of the experiments in 1994 and 1995.

We corrected the movement of Urumqi station on Eurasian plate in ITRF93, and we obtained the position of Urumqi station at Epoch 1994.3.1 on the Eurasian plate from the results of 1995 experiments. If the Urumqi station moves on the

Table 2. Position of Urumqi station in ITRF93

Experiment	X (cm)	Y (cm)	Z (cm)	L (cm)
1994.2.28	22831077.6±8.7	463192287.0±12.6	436706395.4±11.9	448425745.1±6.9
1994.3. 3	22831083.7±3.3	463192273.9± 5.8	436706394.9± 5.5	448425746.9±3.2
mean	22831082.9±2.9	463192276.2± 7.0	436706395.0± 0.3	448425746.6±1.0
ITRF93				
1995.3.19	22831077.3±5.0	463192286.5± 5.8	436706403.6± 5.6	448425747.1±4.4
1995.4.18	22831074.9±3.7	463192284.1± 4.3	436706407.7± 4.2	448425744.8±3.2
mean	22831075.8±1.6	463192284.9± 1.6	436706406.2± 2.7	448425745.6±1.6
Kashima				
1994.3. 1	−399764924.9	327669075.2	372427887.0	
1995.3.19	−399764925.7	327669073.6	372427887.1	

Table 3. Horizontal and vertical position of Urumqi station

Experiment	East (cm)	North (cm)	Vertical (cm)
1994.2.28	6.1±9.1	-6.3±3.1	9.3±16.9
1994.3. 3	-0.6±3.4	2.1±1.7	-0.3± 7.8
mean	0.2±3.1	0.2±5.0	1.4± 5.2
ITRF93			
1995.3.19	6.4±5.2	0.0±1.7	14.6± 7.8
1995.4.18	-0.9±8.2	2.8±3.1	13.1±15.4
mean	4.3±4.7	0.6±1.7	14.3± 0.8
Position at 1994.3.1 on Eurasian Plate from 1995 results			
mean	1.0±4.7	1.5±1.7	14.3± 0.8
Reference position of Urumqi station			
X=22831083.2 cm Y=463192275.6 cm Z=436706706.3 cm			

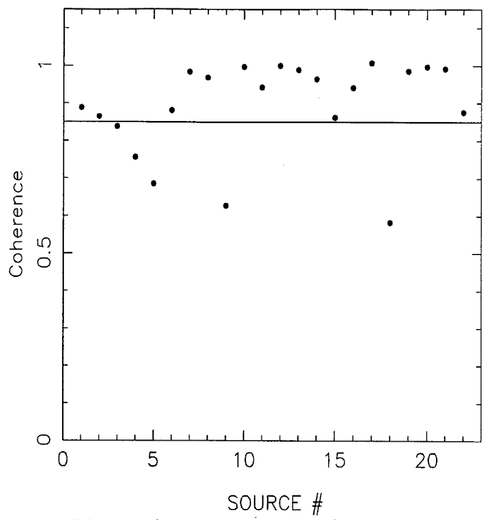

Figure 3. Coherence of 1st experiment in 1995 (The solid line means 85%)

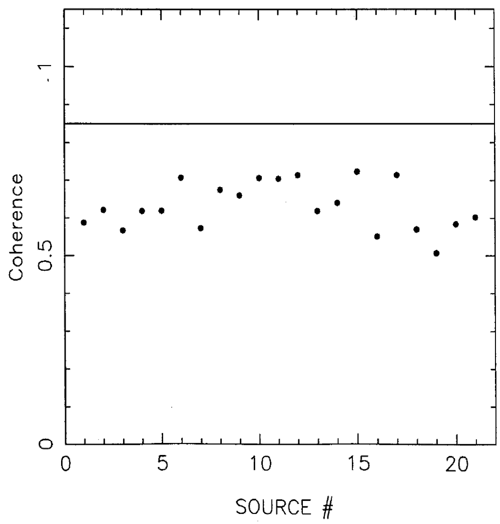

Figure 4. Coherence of 2nd experiment in 1995 (The solid line means 85%)

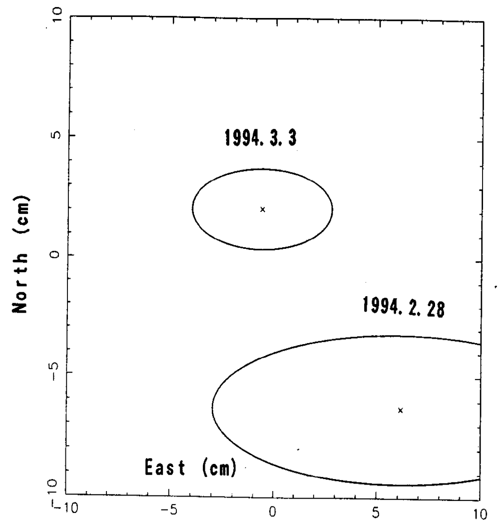

Figure 5. Horizontal position of Urumqi station in ITRF obtained from the experiments in 1994.

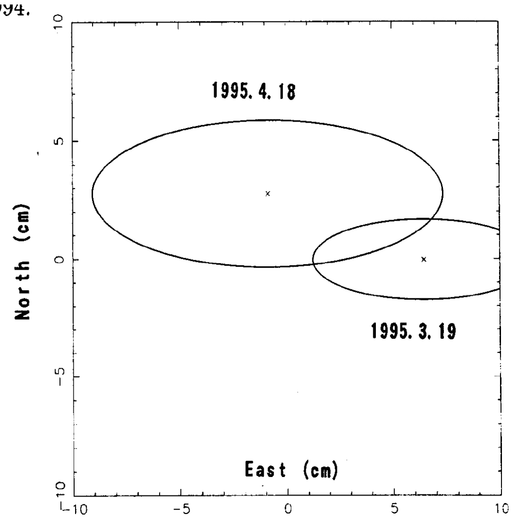

Figure 6. Horizontal position of Urumqi station in ITRF obtained from the experiments in 1995.

Eurasian plate due to the crustal deformation, this corrected position becomes different with the results of 1994 experiment. These positions of horizontal components agreed the positions obtained by the 1994 experiments in the precision of 1 cm. This result might mean that the Urumqi station on Eurasia plate and the deformation was not large though the error was a few cm. The positions are shown in Table 3. Figure 7 shows the corrected position obtained from 1995 experiments.

3. Japan-Russia Pulsar VLBI Experiment

We conducted the pulsar VLBI experiment since the spring 1995. The station in Russia is Kalyazin 64m antenna. The purpose of these experiments are to measure the precise pulsar position and proper motion of pulsar. We deliver K4 terminal to Kalyazin, and we continue experiments for a few years.

4. Conclusion and Future

We conducted the VLBI experiments with Urumqi or Russia. We succeeded the first experiment with Urumqi station. The Urumqi positions can be estimated in the precision of a few cm. The Urumqi station has some problems yet. However, it is proved that Urumqi station can be used as the VLBI station. We hope to extend the Asia and Pacific VLBI network step by step.

We have a plan to deliver K4 system to the station in the area, such as Kaliazin (Russia), Shanghai (China), Wettzel (Germany). NAO (Narional Astronomical Observatory) delivered K4 system to Urumqi (China) and Crimea. NIPR has a plan to establish the anterctica VLBI network around souther hemisphere using K4 system. Therefore, we can conduct the VLBI experiments in Asia and Pacific area using K4 system.

We also have new VLBI network in Tokyo metropolitan area. We observe sources everyday. Figure 8 shows the change in the correlation amplitude on the baseline between Kashima and Koganei since 31th January 1995. If we find the burst change for some sources in our VLBI network, we will propose VLBI observation in this Asia and Pacific VLBI network.

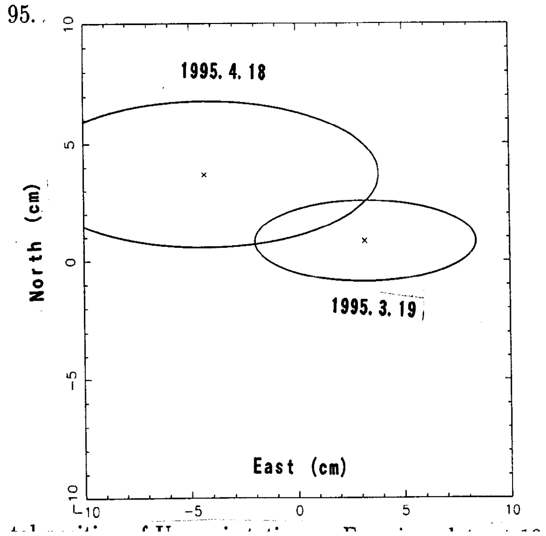

Figure 7. Horizontal position of Urumqi station on Eurasian plate at 1995.3.1 obtained from the experiments in 1995.

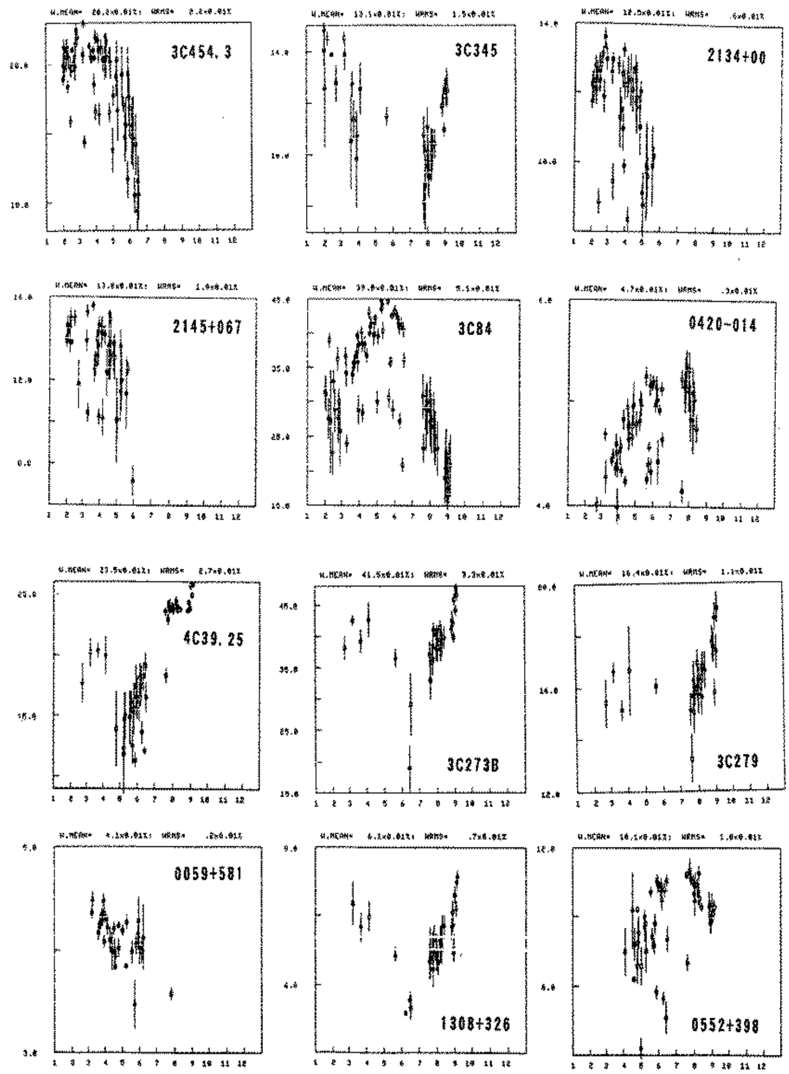

Figure 8. The change in correlated amplitudes in KSP new project since 31th 1995.

Current Status of the Key Stone Project(KSP)

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Communications Research Laboratory has been developing a Crustal Deformation Monitoring System for the Tokyo Metropolitan Area named the Key Stone Project "KSP" system. The four VLBI stations, Koganei, Kashima, Miura and Tateyama, are distributed around the Tokyo Metropolitan Area to form the VLBI network dedicated to the prediction of earthquakes occur there. In August, 1996, construction of the fourth (and last) station (Tateyama) was completed. Since September, 1996, VLBI daily observation started including Tateyama VLBI station. An antenna at Tateyama and station building are shown in Photos 1 and 2. Daily VLBI observation at the four station is automatically carried out by commands from the central control system at Koganei central station or at the Kashima sub-central station. Daily operation is quite going well. In May, 1996, the first real-time fringes were successfully detected between Koganei and Kashima station. The VLBI signal data (with a rate of 256 Mbps) were also successfully transmitted from Kashima to Koganei central station using the optical fiber link (*see IERS TDC News No.8, June 1996*). The results of KSP daily VLBI observation were opened to public through the World Wide Web (URL http://ksp.crl.go.jp/).

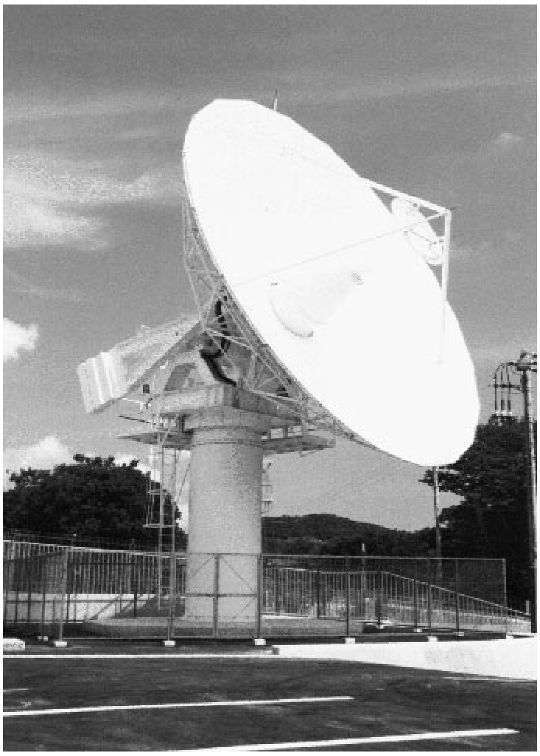

Photo 1. An 11 m antenna at Tateyam.

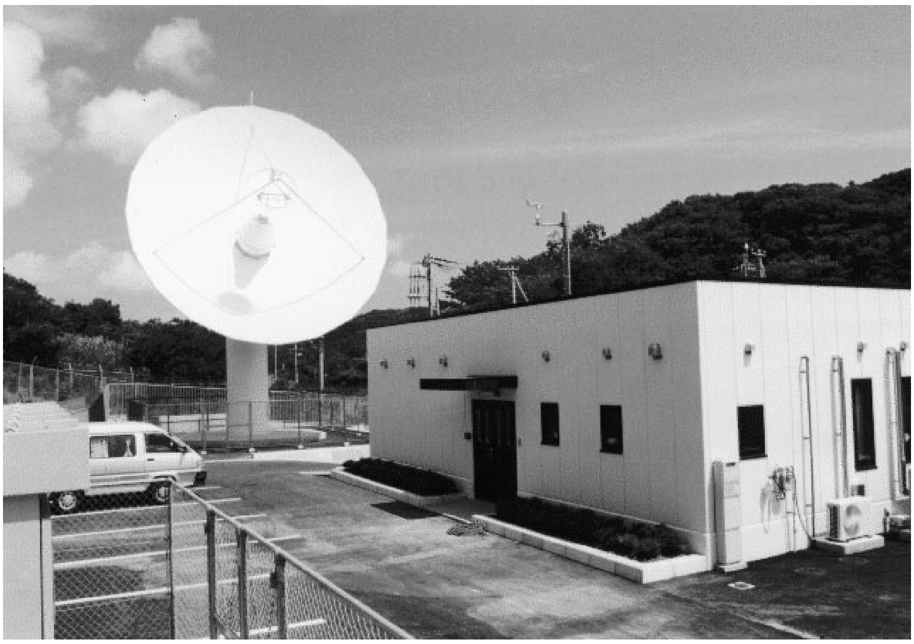

Photo 2. Tateyama VLBI station.

Crustal Deformation Measurement in the Metropolitan Area Real-Time VLBI System Software — RKATS

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Abstract: Real time VLBI data processing software RKATS is under the development by Communications Research Laboratory and Kety Co. Ltd. It is designed as automatic VLBI data processing management software. The overview is described in this article.

1. Introduction

Key Stone Project (KSP) is a trial to catch the pre-seismic crustal deformation around Tokyo metropolitan area by using VLBI and SLR techniques (Figure.1). Daily observation with 4 VLBI stations has started as test run from this summer.

In normal VLBI experiment, the observed data have to be recorded on magnetic tapes and they have to be correlated after transportation to central correlation center. In the earliest case in the KSP, 1-2 days were necessary for data processing and analysis of the data. Now the correlation system of KSP is semi-automated by DMS (tape auto-changer) and data processing and analysis software, but it even needs a support by operator for transportation of tapes, tape mounting to auto-changer, and correlation setup.

Recently, real-time data transportation by using Asynchronous Transport Mode (ATM) with high speed optical fiber link has become available in laboratory level. We have started Real-time VLBI based on co-laboration between CRL and NTT (Nippon Telegraph and Telephone Corporation). Data transfer with communication network gives a possibility of full-automated VLBI observation system. It release an operator from transportation of magnetic tapes and treatment of them.

Now a software RKATS (Real-time KATS) is under development for full automated VLBI data processing system, which controls real-time 6 baselines correlation, Bandwidth-synthesis treatment, and Mark-III database creation.

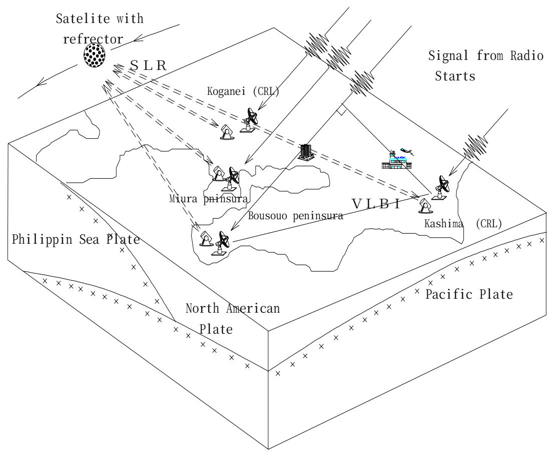

Figure 1. Overview of Key Stone Project

2. Functions of Real-Time-KATS (RKATS)

The RKATS is developed from a tape base VLBI data processing software KATS, which assist a operator in the work of correlation processing, database creation, and data backup. Both RKATS and KATS run on HP-UX workstation. Figure 2 shows a over view of the flow of data processing. The functions of RKATS are as follows:

1. The observed data are sent to correlation center through ATM communication system. RKATS has already loaded the schedule file of the experiment before the start time with referring to its workstation clock. The time of the workstation is synchronized with UTC(CRL) through ntp (Network Time Protocol).

2. The RKATS collects clock information of each observation station and earth orientation parameter (prediction) through network. A few minutes before the start time of observation, information for correlation (source and station positions information, observation start time, and so on.) are send to the correlators.

3. Output data from correlators are transferred to hard disk drive of the workstation with PC-NFS (Network File System) on Ethernet. Just

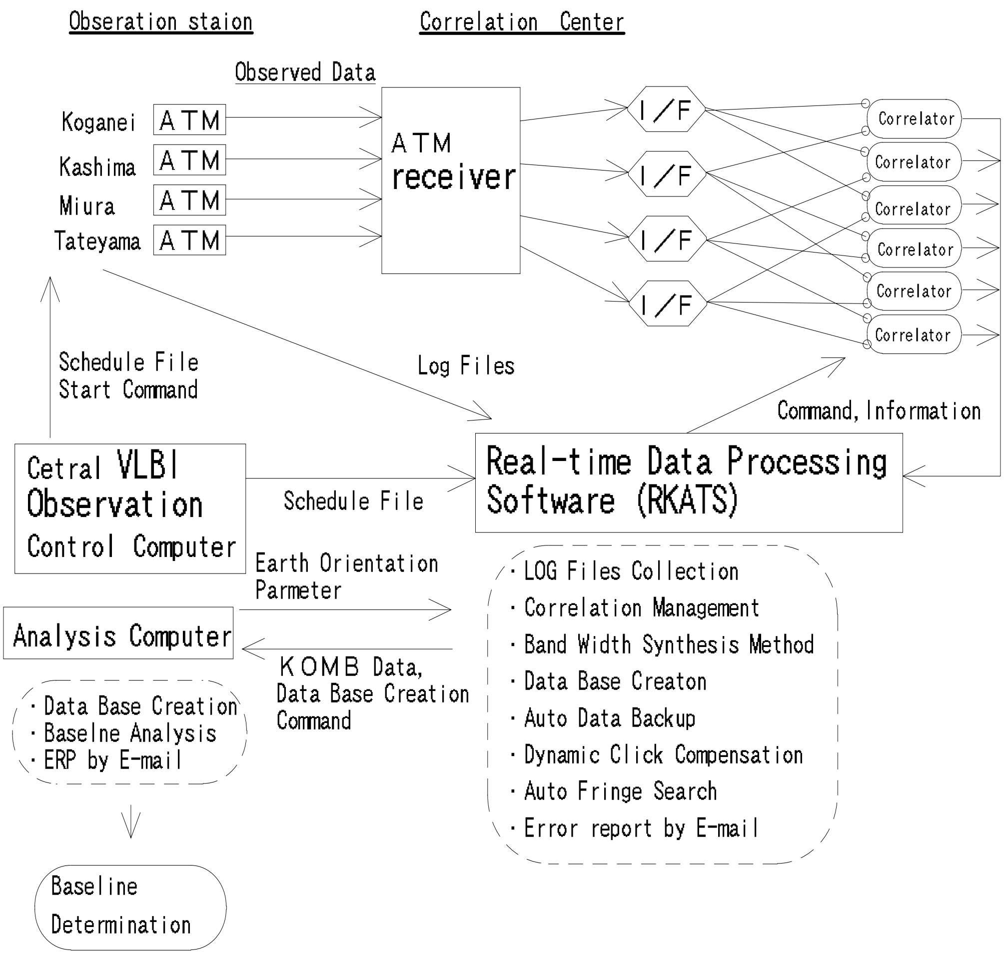

Figure 2. Real-time VLBI data flow

after that, Bandwidth synthesis treatment is done on the data.

4. After the experiment has finished, the RKATS collects weather data and delay calibration data from each observation station through network. And invoke data base creation procedure.

5. RKATS return to the first state and load the next experiment schedule. Then it wait for the next experiment start time.

The new data is analyzed by auto baseline analysis software. Then the baseline and station positions are determined. Final analysis is performed after the final value of Earth orientation parameter is provided from IERS.

Additionally RKATS has automatic data backup function by using DAT auto-changer. The capacity of it is about 12GB, which gives capability of more than 10 days of 24 hour experiment data storage.

3. Summary

Automatic Real-time VLBI data processing software RKATS is being developed for Key Stone Project. It is expected to run from the end of this year.

Acknowledgments

We appreciate Dr. Watanebe, Dr. Uematsu, and Dr. Hoshino in NTT Optical Network System laboratory for the assist of high performance ATM system for this project.

Current Status of the Gigabit VLBI Recorder System

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1. Introduction

In the end of 1994, joint Japanese VLBI development group has decided to employ TOSHIBA GBR-1000 recorder for the next generation VLBI system. The project started from 1995 and we have completed the first 1-Giga-bit cassette type data recorder in 1996. Prof. Chikada, Prof. Kawaguchi, Dr. Miyoshi (NAO), Mr. Hama, Mr. Kaneko,Mr. Kiuchi and Nakajima (CRL) are the contributed persons in this recorder project.

2. Gigabit Recorder System Function Test

The next generation recording system consists of two major parts. One is VLBI data interface unit (DRA-1000) and another is Gigabit Recorder itself (GBR-1000). VLBI data from any kind of A/D samplers are connected to the VLBI data interface (DRA-1000). These data are transferred to the recorder(GBR-1000) according to its HDTV data recording procedure. The random data including radio star noise are recorded as a part of uncompressed HDTV flame format. The 1024 Mbps cassette recorder now available in the market needed slight speed up modification. It has been completed before summer. Currently we are debugging the VLBI data interface unit which is designed for VLBI and other scientific data recording. The three major features of this DRA-1000 are

1. REC/PLAY BACK data conversion between VLBI bit stream and HDTV flame.
2. Data independent recorder UTC synchronization including rotary-head phase control.
3. Time line command could be defined for event procedure control.

The gigabit recorder UTC sync. recording test was carried out with recorder company TOSHIBA, YEM (Yamashita Engineering Manufacture), NAO and CRL staff in August. Two GBR-1000 units are prepared. In this experiment test ramp generators are used instead of noise from radio telescope. At defined certain UTC 1 PPS, the generated ramp pattern switched to the other. We are investigating the position of data change point on the tape and confirming whether the recording is accomplished with correct UTC flame in the tape. The DRA-1000, VLBI interface is handling the 1024 Mbps data with 32 MHz clock 32 parallel signal lines. Thus we need 31.25 ns digital accuracy for recording/play back logical sequence. This Gigabit Recorder does not depend on inserted time code as well as K3 (Mk-IIIa), this function test is most important step though the other longtitudal system does not need. Gigabit recorder refer (or generate) its tape UTC control track both in longtitudal and helical tracks.

Here I introduce the UTC sync. functional test with photo. This will let you understand the next generation recorder system concept.

Photo 1 shows the test bench. GPIB command PC, Ramp data generator, DRA-1000, digital oscilloscope and GBR-1000 are prepared for function test. Photo 2 is DRA-1000, the VLBI interface is disassembled under the test. The interface receive GPIB commands from observation computer or correlation process control computer. This interface convert the VLBI sampled bit stream and GBR-1000 HDTV format in both direction. Photo 3 shows the change of recorded ramp patterns on the tape. In this case the assigned REC start UTC is located in the middle of the certain GBR-1000 HDTV flame. Since the GBR-1000 is produced for the high-definition television originally. The data is visualized by PC multi-scan monitor during both in observation and correlation processing. This is one of great advantage. We will be able to check the recording condition through the monitor. For example, an AD sampler is saturated and send biased data, or an AD sampler is malfunction and no data, apparently the monitor screen will show corresponding single color. This feature is useful when non-skilled operator must diagnose the system in each VLBI station. In actual radio astronomical observation, the data should be seen as random pattern(like TV sand storm) from the assigned recording start point.

In addition all kind of time line command are examined. The “time line command” is a recorder command with defined execute time. When we carry out the observation, we need several REC/STOP commands before a tape run comes to

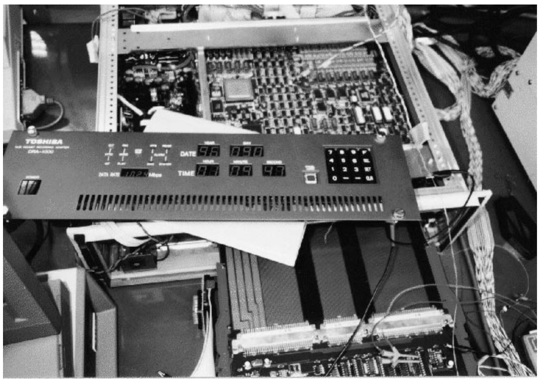

Photo 2.

Photo 3.

the end. These sequence are programmed in DRA-1000 CPU intelligent interface as time line events. When we correlate the data, also the same play back sequence are programmed several recorders in advance. This will reduce communications between recorders and controller .

Sampler and recorder interface test is planned in October. Samplers are already completed. We will carry out 1 Gbps domestic VLBI experiment as soon as possible to obtain test correlation data for 1 Gbps VLBI correlator. All equipment for 1 Gbps VLBI hardware will be available by the middle of 1997.

3. Future schedule

Photo 1.

GPS Meteorology in Japan and its Implications to VLBI

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At present, GPS meteorology are considered to be a powerful method for an understanding of atmospheric variations (Bevis et al., 1994). Moreover, we expect that GPS meteorology will also contribute an improvement of the precision of space geodetic techniques.

Japanese cooperate study supported by Science and Technology Agency of Japan, which is titled "Establishment of Water Vapor Information Database by GPS Meteorology and its Applications to Numerical Weather Prediction, Earthquake Prediction Research and Hydrology", have been started as feasibility study in 1996 Japanese budget year. The main objective of the study is to improve the precision of both the numerical prediction for mesoscale phenomena and the detection of crustal movement. Achievement of the objective is attributed to the interaction of two systems: the dense permanent network of GPS sites of Geographical Survey Institute (GSI) and the numerical prediction data with high resolution (20 km grid intervals and 36 vertical levels) of Japan Meteorological Agency (JMA). As of April 1996, there are 610 GPS sites of GSI. By the end of 1996 fiscal year, 250 GPS sites will be added to the present network.

Ohtani et al. (1996) preliminarily reported the estimation of precipitable water vapor (PWV) by GPS. They confirmed that PWV can be estimated within 3 - 4 mm rms by GPS comparing with radiosonde data sets as shown in Figure 1. However, there are several study fields which must be carried out to realize the main objective. These are planning in the cooperate study as follows.

1. Evaluation of PWV by GPS measurements
    a. Estimation and Evaluation of PWV obtained by GPS data analyses
    b. Study on numerical prediction based on GPS PWV
    c. GPS PWV in continental and oceanic region
2. Study on improvement of precision of space geodetic techniques

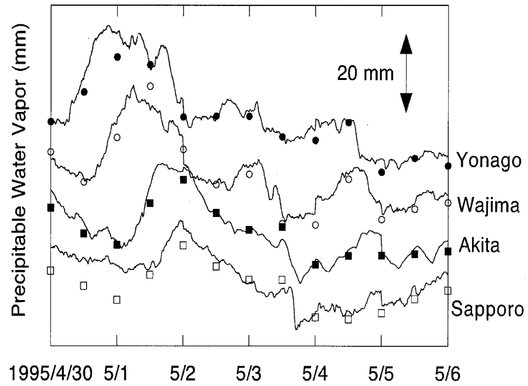

Figure 1. Comparisons of PWV obtained by routine radiosonde data sets of JMA (circles and squares) and that estimated from GPS analyses (solid lines) at Sapporo, Akita, Wajima, and Yonago (after Ohtani et al., 1996)

    a. Research and development of tropospheric path delay correction using numerical prediction data
    b. Revision of GPS analyzing software
3. Development and maintenance of GPS water vapor information database
    a. Development of rapid GPS analyzing technique
    b. Development GPS water vapor information database
    c. Evaluation of the database by meteorological, geodetic, and hydrological users

We are now planning to evaluate the tropospheric path delay correction based on numerical prediction data at KSP (The Key Stone Project) sites of Communications Research Laboratory (CRL). KSP network is carried out to monitor the crustal movements around Tokyo metropolitan area, Japan. The network will be equipped with three space geodetic facilities, i.e. VLBI, SLR, and GPS, routinely operated by the end of 1996. Precise correction of tropospheric path delay is indispensable to detect seismic precursors and coseismic movements by using KSP network.

VLBI geodesy can avoid uncertainties of satellite orbit determinations and can independently estimate the tropospheric path delay at each site by long distance measurements. Thus, it is expected that the residual delay estimated by VLBI will be more precise using the correction based on numerical prediction data. The estimated delay is available in the analysis of GPS data as a priori delay. As a result, we can reduce an unknown parameter in the GPS analysis. In addition, realtime VLBI analysis is now under development. Consequently, more precise monitoring of crustal movements by VLBI and GPS will be carried out with sub-daily temporal resolution.

We are now executing a feasibility study for estimating the delay by KSP network and are preparing for observations comparing with water vapor radiometer (WVR). Figure 2 shows time series of the zenith delay estimated by VLBI and GPS analyses at Koganei and Kashima during 8 - 14 July, 1996 (JST). Both plots by VLBI and GPS increase during 9 - 11 July (JST) and extremely decrease during 11 - 12 July (JST) in a similar manner. According to the infrared images by a geostationary meteorological satellite of JMA (GMS5), a typhoon moved northward in the Western Pacific during the concerned period (see Figure 3). It seems that the variations of the zenith delay are attributed to the water vapor variation caused by the typhoon movement though it is a roughly qualitative comparison. For more detailed interpretation another investigations are required; comparisons with numerical prediction data and radiosonde data sets, recalculations of parameter estimations in VLBI and GPS analyses, and so on. The results of these investigations will be reported in another paper.

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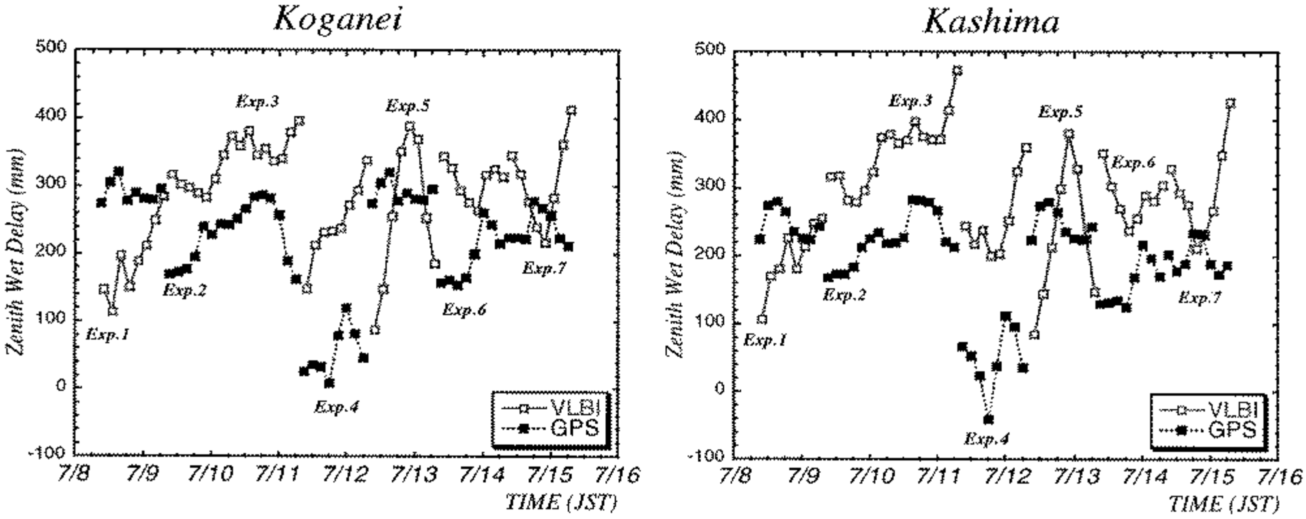

Figure 2. Time series of zenith tropospheric delay estimated by VLBI and GPS analyses at Koganei - Kashima baseline (about 109 km) during 8 - 14 July, 1996. Since a priori delay is not used in this analyses for both VLBI and GPS, the absolute values are not confident. However, similar characteristics are shown for both plots by VLBI and GPS; increasing in Exp.2 (July 9) and Exp. 3 (July 10), and decreasing in Exp. 4 (July 11).

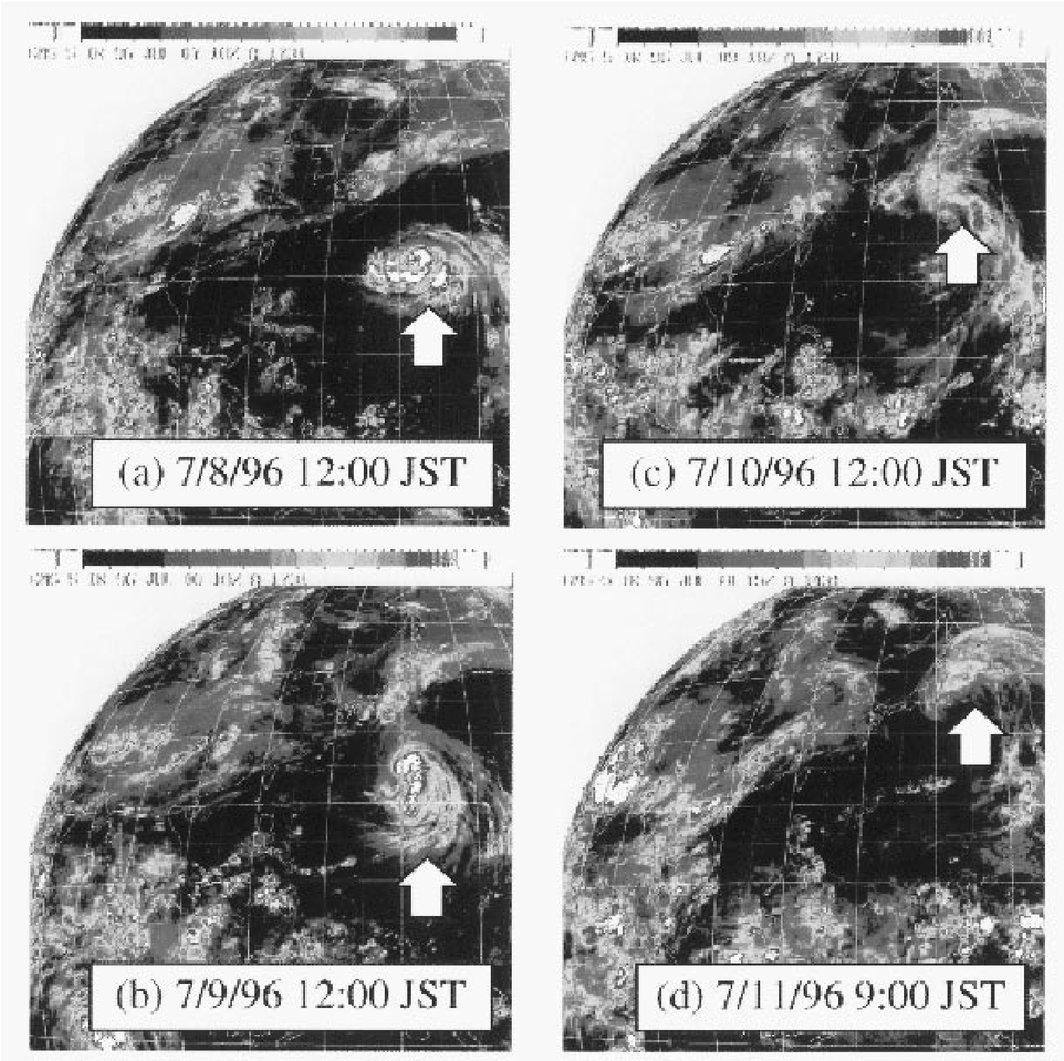

Figure 3. Infrared images by GMS5 of JMA. Arrows as shown in these figures indicate typhoon. It is inferred that the variation of water vapor related to the typhoon causes the temporal variations of zenith delay as shown in Figure 2.

Radar Observations of Near Earth Asteroids

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1. Introduction

Planetary radar technique has revealed its unique capability to investigate geometry and surface properties of various solar system bodies (Ostro, 1993). The radar technique has advantages over optical techniques in its high spatial resolution and ability to construct three dimensional images. Recently, deep space spacecraft can make more detailed investigations, but the planetary radar is still playing an important role since observation opportunities are far more frequent than space missions.

The asteroid 6489 Golevka (= 1991 JX) approached Earth to the geocentric distance of 0.034 AU on June 9, 1995. The asteroid is an Apollo object and has an earth-crossing orbit with perihelion and aphelion distances of 1.0098 and 4.0328 AU, respectively (Fig. 1).

The asteroid was a very good target of international bi-static radar experiment since it had a high value of declination when it approached earth. Taking this opportunity, an international asteroid radar experiment was organized as a collaboration between Japan, Russia, and the United States. In the bi-static radar experiment, a high power radio signal was transmitted from 70m antenna at Goldstone, and the radar echo reflected at the surface of the asteroid was received by the 34m antenna at Kashima along with other antennae at Evpatoria in Ukraine, and at Goldstone. The radar echo was successfully detected and the asteroid became the first solar system object observed by means of radar from Japan. The name of the asteroid was proposed to the Minor Planet Center of the International Astronomical Union after the radar experiment to honor the success by taking two or three letters of three ground stations (GOLdstone-EVpatoria-KAshima = GOLEVKA) and it was officially approved in January, 1996 (Minor Planet Circular 26245, 1996).

In this report, the results of the Golevka radar observations and the future prospects of asteroid radar experiments will be discussed. The full detail of the Golevka experiment can be found in the papers by Koyama et al. (1996) and by Zaitsev et al. (1996).

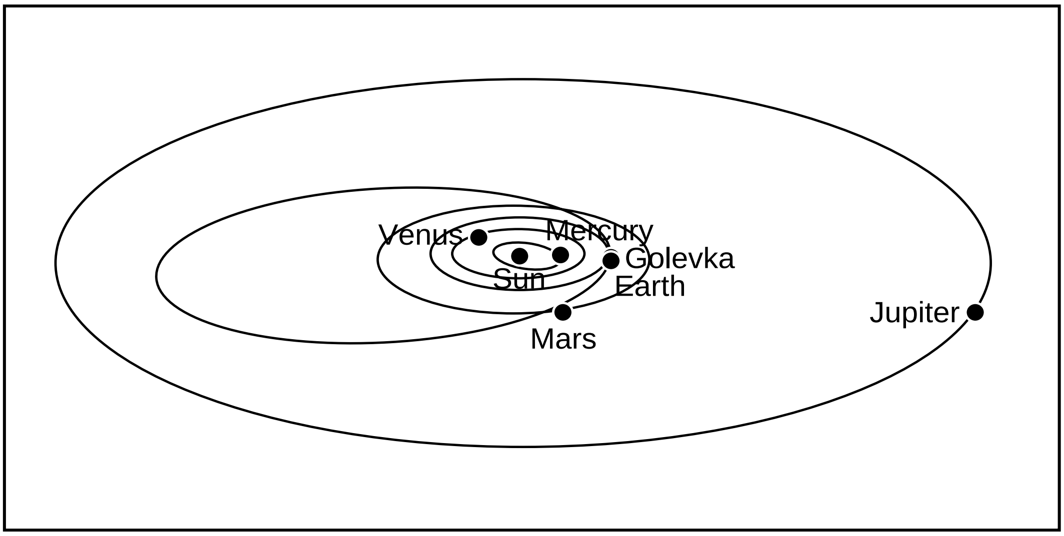

Figure 1. Orbits of the asteroid 6489 Golevka and planets and their positions on June 9, 1995.

2. Radar Experiment of the 6489 Golevka

In the bi-static radar experiment, high power radio signal was transmitted at 470 kW towards the asteroid 6489 Golevka from a 70m antenna at Goldstone, which is one of the worldwide deep space telecommunication facilities operated by Jet Propulsion Laboratory (JPL). The signals reflected from the surface of the asteroid were then received by the 34m antenna at Kashima (Fig. 2). Since our objective was to detect the radar echo from an asteroid for the first time in Japan and to ensure the feasibility of conducting international asteroid radar experiments, a CW wave form was transmitted in Left-Hand-Circular-Polarization without any modulation which makes time delay measurements possible.

At Kashima, the received signal was down-converted to about 10 kHz and sampled at 48 kHz sampling rate after a low-pass-filter. The low-pass-filter is built-in in a DAT digital data recorder unit, which has a cut frequency at 20 kHz. The digitized data were recorded on a DAT tape. Both Right-Hand- Circular-Polarization and Left-Hand-Circular-Polarization data were recorded. A DAT tape can record two data channels for two hours. The configuration of the observing system is shown in Fig. 3.

Observations were made for two hours on June 15, 1995, about a week after the closest approach of the asteroid to the Earth. The geocentric distance to the asteroid at the time of observations was about 0.048 AU. After the observations, the data recorded on a DAT tape were transferred to a UNIX workstation through a GP-IB interface. Power spectrum $\mathcal{P}(\Delta f)$ of the signal was calculated from 5 seconds of data duration at frequency resolution of 0.2 Hz, and then integrated for the period that the power of received radar echo was stable, which is a span of 54 minutes, by compensating the Doppler-shift (Fig. 4). The radar echo is apparent in the RHCP power spectrum. The echo signal spectrum has a broad frequency width in spite the transmitted signal was a pure CW signal because of the rotation of the asteroid.

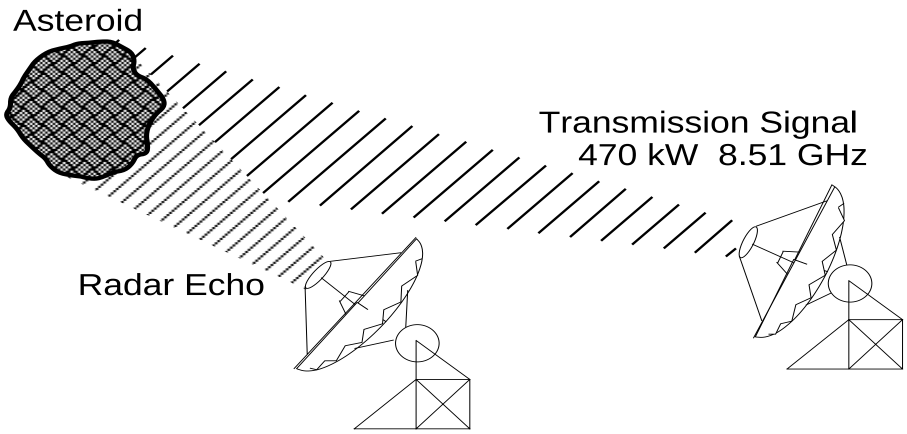

Figure 2. Principle of bi-static radar observations towards Near Earth Asteroids.

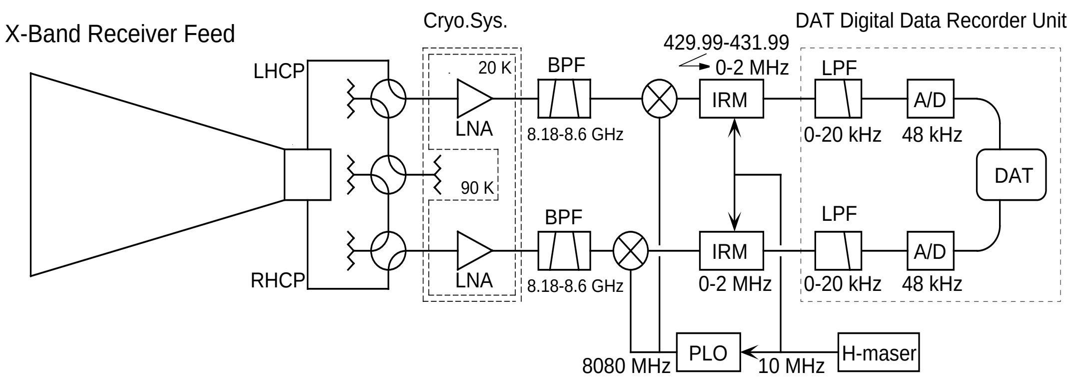

Figure 3. Block diagram of the observation system set-up used at Kashima.

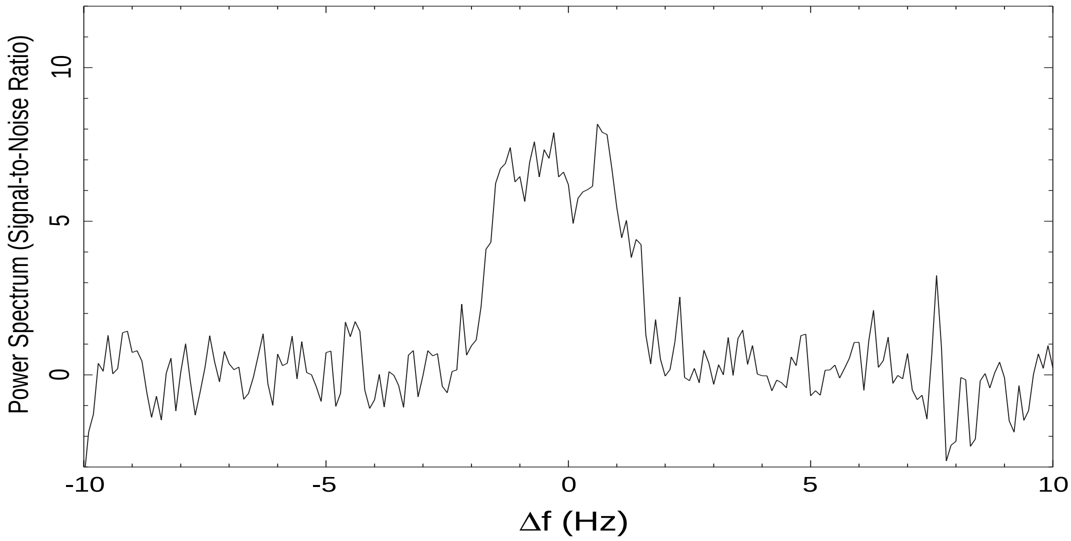

Figure 4. Power spectrum $\mathcal{P}(\Delta f)$ of the received signal integrated for 54 minutes with frequency resolution of 0.2 Hz.

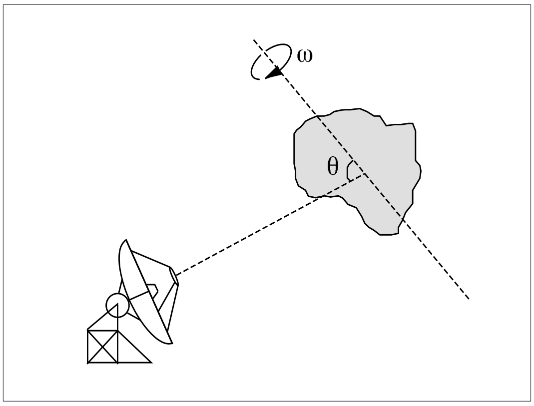

Figure 5. Geometric relation between the rotation axis of the asteroid and the observation site.

The maximum dimension of the asteroid perpendicular to its apparent rotation axis D and its apparent rotation angular velocity ω can be related to Doppler frequency width W as,

$$W = \frac{D\omega\sin\theta}{c} f_0. \tag{1}$$

where f_0 is the frequency of the central frequency of the received echo signal, c is the velocity of light, and θ is the angle between the apparent rotation axis and the direction towards the receiving station seen from the asteroid (Fig. 5).

From Fig. 4, by taking the threshold of signal existence to be $\mathcal{P}(\Delta f) = 2.96$ from a confidence limit of 99%, the lower edge of the radar echo signal is between -1.8 Hz and -1.7 Hz, whereas upper edge is between 1.5 Hz and 1.6 Hz. Thus the frequency width of the radar echo can be estimated as $W = 3.3 \pm 0.2$ Hz. If we employ 6.02 hours as the rotation period of the asteroid (Mottola *et al.*, 1995, Hudson and Ostro, 1995), $D\sin\theta = 0.40 \pm 0.02$ km. This value places a lower bound of about 0.4 km on the asteroid's maximum pole-on breadth.

The total power of a radar echo signal is proportional to an effective cross section, $\rho_{\rm r}A$, of a target asteroid where $\rho_{\rm r}$ is a radar albedo and A is a cross section of the asteroid. The relation can be expressed as

$$P_{\rm rec} = \frac{P_{\rm tx} G_{\rm tx} G_{\rm rec} \rho_{\rm r} A \lambda^2}{4\pi R_{\rm tx}^2 \cdot 4\pi R_{\rm rec}^2 \cdot 4\pi}. \tag{2}$$

Here, λ is the wavelength of the radar signal, $P_{\rm tx}$ is the transmitting signal power, $G_{\rm tx}$ is the gain of the transmitting antenna, $R_{\rm tx}$ is the distance of the asteroid from the transmitting station, $P_{\rm rec}$ is the received signal power, $G_{\rm rec}$ is the gain of the receiving antenna, and $R_{\rm rec}$ is the distance of the asteroid from the receiving station. On the other hand, the standard deviation for power spectrum of noise, N, can be evaluated by equation,

$$N = k_{\rm B} T_{\rm sys} \sqrt{\frac{B}{t}}, \tag{3}$$

where $k_{\rm B}$ is Boltzmann's constant, $T_{\rm sys}$ is the system noise temperature of the receiving station, B is the frequency resolution of the power spectrum, and t is the integration time. The normalized total power spectrum of the received data obtained by integrating $\mathcal{P}(\Delta f)$ can then be evaluated as

$$\int \mathcal{P}(f) df = \frac{P_{\rm rec}}{N}, \tag{4}$$

where the integration should be done for the frequency range where radar echo signal is present.

The total power of the radar echo signal was evaluated as $20.5 \times N$. This value gives $\rho_{\rm r} A = 0.11({\rm km}^2)$. This radar cross section shows good agreement with Arecibo 1991 results and monostatic Goldstone 1995 results. The effective diameter of Golevka has been estimated to be no greater than 600 m from a preliminary inversion of Goldstone delay-Doppler images (Mottola et al., 1995; Hudson and Ostro, 1995). Thus the estimated effective diameter implies a radar albedo of at least 0.39, or several times larger than the typical values reported to date for small asteroids (Ostro et al., 1991; Ostro et al., 1996).

From this result, it is expected that this object's surface is unlikely to be porous, that is, it probably lacks a regolith.

3. Future Asteroid Radar Observations

The success of the first asteroid radar experiment from Japan is quite encouraging. In the near future, radar observations to 1982TA and 1994PC1 are being considered. In these experiments, the phase-modulated signal will be transmitted to the asteroids to make the ranging observations possible. Also, the technical feasibility of radar interferometric observations will be investigated by using two large antennas at Kashima and at Usuda.

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Current Status of Kashima Radio Spectrograph (KaRAS) for Observing the Sun and Jovian Radio Wave Emissions at Low Frequencies (20 - 70 MHz)

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Kashima Radio Spectrograph (KaRAS) was constructed at Kashima Space Research Center for observing decametric radio emissions from the sun and Jupiter. In particular KaRAS is designed to form an interferometer in combination with a similar system at Hiraiso located about 40 km north. The KaRAS consists of a wide band antenna system, two swept-frequency type spectrum analyzers and a video converter system for a future interfereometer use (Fig.1). A wide band antenna is a crossed log-peri antenna mounted on the top of 15-m high tower as an AZ-EL type mount. Its nominal receiving frequency range is 25-70 MHz. Received crossed linear polarized component signals are fed to a hybrid circuit to form a right handed and a left handed circularly polarized component signals. Both right- and left- polarized signals are amplified and then fed to the two spectrum analyzers. Data from spectrum analyzers are acquired by a system control computer (HP Vectra) through the GP-IB interface. The data are transfered to a UNIX workstation (HP9000/730) to produce a spectrogram and to perform further analyses.

Development of observation control software has been completed and daily observations were started in July, 1996. The object is selected automatically. In the daytime, the sun is tracked. At present, Jupiter is observed when it is in the sky during nighttime. Receiving frequency range of spectrum analyzer is also controled automatically according to the target. It is set 20-70 MHz for the sun, and 25-35 MHz for Jupiter. This difference comes about due to the characteristics of each emission. For Jovian decametric radio wave emissions, the intrinsic lower frequency limit is about 38 MHz.

Observations of radio waves at lower frequencies are becoming more difficult in recent years due to the increase of man-made noise such as TV broadcasts and other telecommunication signals. KaRAS observations are also affected by this interference. To improve the signal-to-noise ratio of spectrograms under these difficult conditions, we have developed computer software which eliminates man-made interference as much as possible.

In this process, first we subtract the background from raw spectral data. Background level is calculated as a time average (1 hour) of each sweep spectrum data. Then we adopt the following 3-sigma criterion to eliminate interference signals still remaining on a spectrogram (Fig.2). First, the running average and standard deviation of a given frequency span is calculated for each sweep. Any data points with deviations larger than 3 sigma are replaced by an adjacent data values. This simple algorithm is considered to be working properly for actual data as shown in Fig.3.

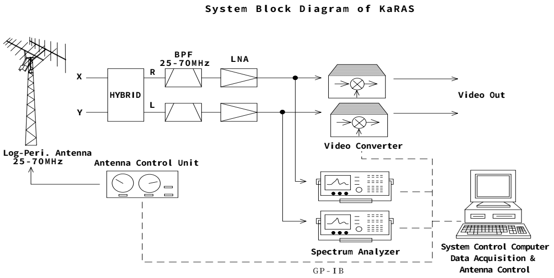

Figure 1. A schematic block diagram of KaRAS system.

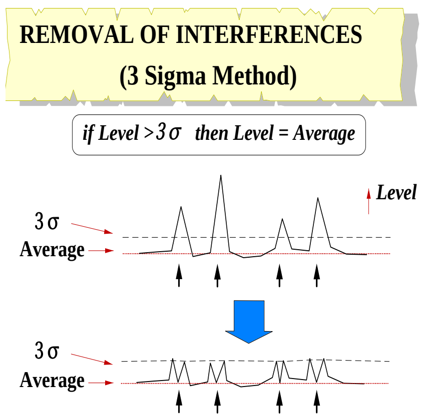

Figure 2. A simple 3-sigma method for removing noise.

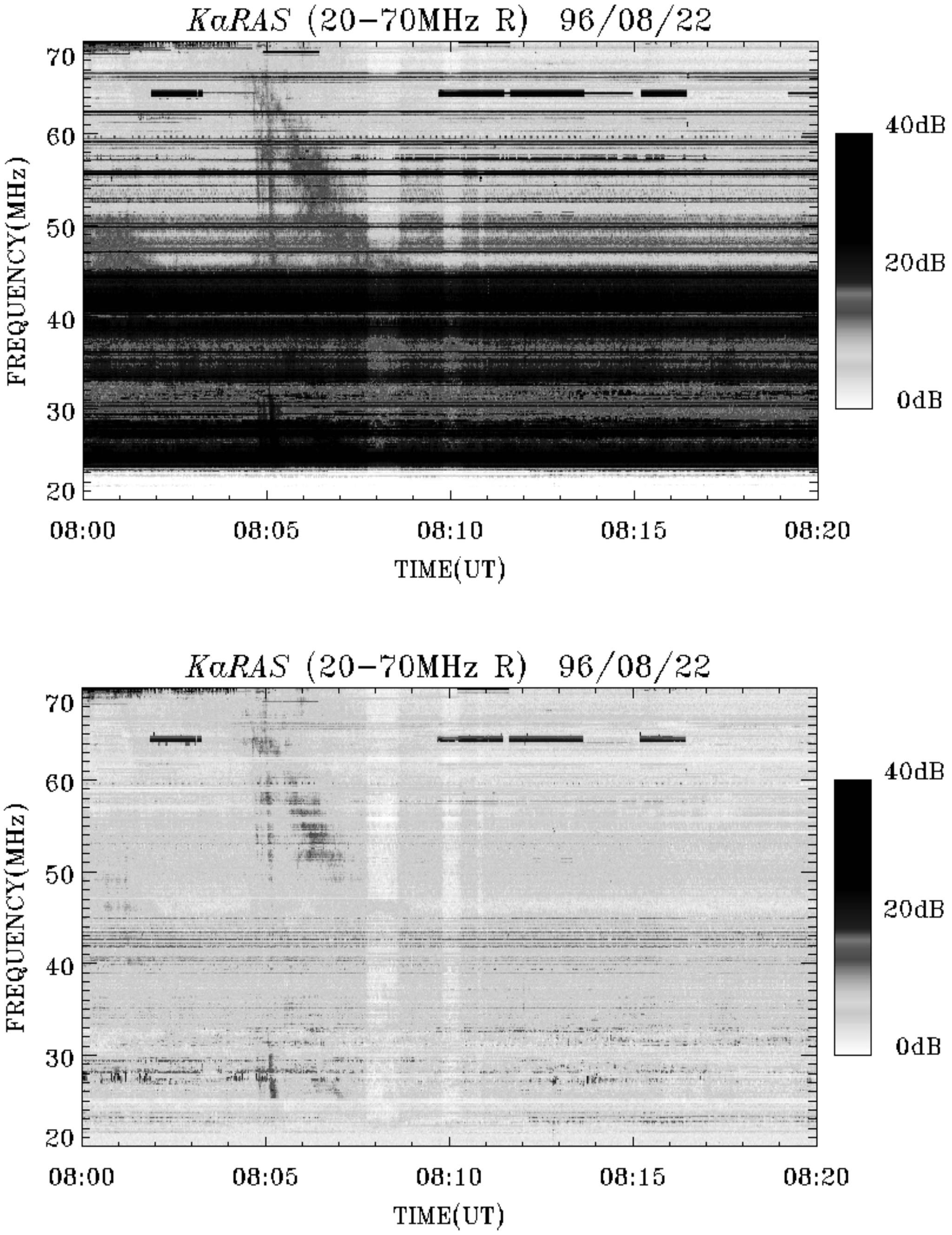

Figure 3. Raw (top) and processed (bottom) spectrograms.

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. The editors wish to thank Dr. O. J. Sovers for his kind help in the correction of the news translated from Japanese to English. Inquires on this issue should be addressed to T. Kondo, Kashima Space Research Center, Communications Research Laboratory, 893-1 Hirai, Kashima, Ibaraki 314, Japan, TEL : +81-299-84-7137, FAX : +81-299-84-7159, e-mail : kondo@crl.go.jp.

Summaries of VLBI and related activities at the Communications Research Laboratory are available from the home page of the Radio Astronomy Applications Section of the Kashima Space Research Center on the World Wide Web (WWW). The URL to view the home page is : **http://apollo.crl.go.jp/**

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