TECHNOLOGY DEVELOPMENT CENTER NEWS
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Remarks: Logo used in the news title is not an official IVS logo.

Overview of the 16th TDC Meeting

Mamoru Sekido (*sekido@crl.go.jp*)

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

The 16th meeting of the Technology Development Center was held on February 7, 2000 at the Communications Research Laboratory.

Attendance

CRL members

Takao Morikawa, Taizoh Yoshino, Michito Imae, Noriyuki Kurihara, Hiroo Kunimori, Jun Amagai, Hitoshi Kiuchi, Kouichi Sebata, Akihiro Kaneko, Yuko Hanado, Michiyasu Igarashi, Kuniyasu Imamura, Noboru Kotake, Mizuhiko Hosokawa, Fujinobu Takahashi, Tadashi Shiomi, Hiroshi Kumagai (KSRC: Kashima Space Research Center), Yasuhiro Koyama (KSRC), Mamoru Sekido (KSRC), Tomonari Suzuyama (KSRC), and Tetsuro Kondo (KSRC)

Special members

Noriyuki Kawaguchi (National Astronomical Observatory), Kosuke Heki (National Astronomical Observatory), Hideyuki Kobayashi (National Astronomical Observatory), Misao Ishihara (Geographical Survey Institute), Takahiro Iwata (NASDA), and Hisao Uose (NTT)

The following special members could not attend: Alata Sengoku (Hydrographic Department, Japan Coast Guard) and Kazuo Shibuya (National Institute of Polar Research)

Observer: Hiroshi Okubo and Hiro Osaki (Research Cooperators)

Minutes

1. Opening Greeting

Takao Morikawa, director of IVS TDC at the Communications Research Laboratory (CRL), greeted meeting holding. He made self-introduction of succeeding to chief of TDC from December of 1999. Now VLBI research in CRL is on the turning point just before reformation of CRL from Government Institute to Independent Agency. We hope to have candid opinion for guidance of our future plan, he said.

2. Technical Development Center Activity Reports

2.1 Introduction of IVS Activities (*Tetsuro Kondo*)

Overview of International VLBI Service for Geodesy and Astrometry (IVS) was introduced. In order to build the international organization like International GPS Service (IGS) which was successful in GPS society, the establishment of IVS was discussed by VLBI subcommittee of the CSTG (Commission on International Coordination of Space Techniques for Geodesy and Geodynamics) under IAG (International Association of Geodesy). And the IVS was inaugurated from March 1 of the last year. The aim of the IVS is producing high quality data used for research of geodesy and astrometry. Position of the IVS is as follows. An organization called Advanced Space Technology is under the IAG, and IGS, ILRS, and the IVS exist under it. The IERS is an earth rotation research related organization over both IAG and the IAU, and position of the IVS is equivalent to that of the IERS. Structure of the IVS consists of the analysis, technology development, network, operation, correlator, data, and coordinating center, and each of the technology, network, and analysis coordinators exist. Four organizations of the CRL, Geographical Survey Institute (GSI), National Astronomical Observatory (NAO), and National Institute of Polar Research(NIPR) have participated in the IVS from Japan. The CRL has become one of the TDCs of the IVS from that of the IERS since March 1999. Activities of TDC at CRL such as issue of TDC News, contributions to specification of VLBI Standard Interface (VSI), geodetic test experiments with Giga-bit VLBI system (GIFT Experiment), and real-time VLBI experiment (GALAXY) were introduced as the progress report from the last March.

Q: Do you see a prospect authorization of the VSI at the IVS General Meeting (2/20)?

A: Coordination of VSI specification has been done by Dr. A.Whitney, and it will be discussed in TDC report in the meeting.

Q: What is the position of the development of the VSI in the IVS?

A: Each component of the IVS, such as network, analysis, and technical development set their own themes and they are working for that. The VSI has been set as theme of technology development component.
Q: Is the purpose of IVS TDC narrower comparing with that of former IERS, isn't it?
A: The field of former IERS has divided into IGS, ILRS, and IVS. The IVS is working by relating other organizations, IAU etc.
Q: Although various institutes are nominated as a component of IVS in Japan, has domestic cooperation been done between them?
A: CRL is aware of the responsibility of coordination of domestic IVS components.
C: I want to encourage and expect the activity as a role of a leader domestic IVS components to CRL.

2.2 VLBI Standard Interface (*Yasuhiro Koyama*)

The VLBI Standard Interface (VSI) is the epoch-making trial to unify the interface of various kind of VLBI terminal, whose incompatibility used to be observational restriction in the world VLBI community. And the VSI specification also put real-time VLBI operation into the view. The VSI specification include interface among formatter, recorder, and correlator.

Circumstances Explanation: It was proposed by A.Whitney at the time of GEMSTONE meeting in January 1999 at Tokyo, and work was started. The VSI specification has been discussed through various occasions, a domestic meeting, the IVS Directing board, URSI, and international telephone conference. (A conclusion will be expected soon.)

Overview of the VSI: The specification is for future system but compatibility with traditional VLBI system will be taken into account as much as possible. Current target will be 1024Mbps VLBI system. Compatibility among several kinds of VLBI system, which will be developed at each TDC, should be maintained at observation, correlation, and data copying operations. Data Transfer System (DTS) will be made as transparent as possible from viewpoint of Data Acquisition System (DAS) and Data Processing System (DPS).

Prospect to fix the specification: Endorsement of VSI specification by IVS is expected soon. We hope to realize the specification in Giga-bit VLBI system in the CRL and in VERA project in the NAO. I believe Japanese group will be at the nearest position to realization of the VSI. Works of standardization of a command, a protocol, and a data format, a connector, etc. are remain.

Q: Unless high-tech is more incorporated in the standardization, it is not connected with a breakthrough, is it?
A: Japanese group is in a direction to standardize the present equipment for wider VLBI network performance. Of course we are going to use optical communication technology in the VSI for real-time VLBI.
Q: It is very difficult to make a transparent system. Don't you think that you had better to devide the way of Internet VLBI and VSI?
A: Yes, we are going to make equipment for Internet VLBI for various tests. Then we will make it correspond to VSI one by one.
C: When VSI is realized, its benefit is very large, for example correlation processing become possible by any correlation system, which is compliant to VSI. We are now planning 2 Giga-bit system and I want to apply the VSI specification to our system. It is very important!
Q: Is standardization of a real-time system examined from now on?
C: Yes. We hope to consider with including distributed type data processing system.
Q: Although there are various modes (clock rate etc.) in VSI proposal, which should be adapted receiver side or sending side?
A: It is the compromise of adaptation in a part of modes as a result. Only a hard wire is decided by the present specification, but the compatibility in each mode is also a future argument subject.
Q: Don't you think that certain modes should be guaranteed at least?
A: I think that it is established at a future step. First of all, the first decision will be necessary. I think that probably such subject will be discussed in the next directing board.

2.3 Gigabit VLBI System Development Report (*Yasuhiro Koyama*)

Needlessness of Pcal (phase calibration) signal and Bandwidth synthesis is the peculiar feature of a Giga-bit VLBI system. A 3-m small VLBI mobile antenna was moved to Gifu University, and execution of the geodetic VLBI experiment with Giga-bit VLBI system is planned. Several test experiments had already been done or planned. A test geodetic VLBI experiment with the Giga-bit VLBI system was carried out on October 19, 1999 bu using a KSP baseline, and two GIFT (Gifu University Telescope) experiments were carried out in January and February, 2000. Baseline analysis was done for the experiment on October 19. Although 256 Mbps VLBI system technology is also advanced in the world, Geodetic VLBI by 1 Gbps system is top level technology in the world. However there is still 3 times larger variation of baseline analysis residual comparing with that of K4 (KSP). Collocation with GPS and Ionospheric delay correction with GPS are also thought to be a subject of study. Multi channel observation with higher order sampling technique for bandwidth synthesis will be considered in near future.

Q: Although SNR will be almost the same between KSP 10m pair and 34m - 3m pair, is the geodetic VLBI error of 183ps large, isn't it?

A: Software should be improved.

Q: Doesn't the reason of bad accuracy of the analysis result of Giga-bit system owing to lack of Bandwidth synthesis?

A: Cause of the problem is under study. It may be improved by making multi channel system.

Q: Doesn't the inappropriate phase characteristic in the band cause the bad accuracy of the analysis result?

A: It may be. It will be investigated.

Q: Since it is single frequency observation, I think that the ionospheric delay correction will be required. How do you obtain the ionospheric delay between TEC sampling points by GPS on the sky?

A: We obtain the ionospheric delay by interpolating and extrapolating TEC data using a model.

3. Proposals from the Special Members

Misao Ishihara (GSI)

We are perplexed by the financial and political problem that VLBI group of CRL is faced. Since our VLBI technology is based on that of CRL and we could have 32 m antenna at present. If there are no group which have the technology to lead us, it will be troubled. In our case, performing 50 times international VLBI experiments and four times domestic experiment per year is authorized by our institute. Operation of GEONET (GPS network) is also authorized as an routine project for several years. I would like you to make aware that only our gourp in 2nd geodetic Div. and Mr. Matsuzaka in Geography and Crustal Dynamics Research Center are doing VLBI technology related work in Geographical Survey Institute. Since we have been using VLBI system developed by CRL as an end user, we are expecting CRL to lead the VLBI technology development. Especially, theoretical work in geodetic VLBI, development of water vapor delay model, compact VLBI system, Giga-bit VLBI system, and real-time VLBI system are expected from us.

C: It is good if Geographical Survey Institute becomes the big sponsor of geodetic VLBI technology development in Japan. Supporting institute will be required from now on.

Arata Sengoku (HD/JCG) (Kunimori read for him)

Advantage of SLR: The data accumulation of long period of time of SLR and an immobility point is geometrically stable. Demerit of SLR: Expensive (equipment, and staff cost). There are few observing points. Observation is dependent on the weather. Achievement: Measurement of center of the Earth and gravity field. Verification of the theory of relativity by Lunar Laser Ranging (subject for future) etc. Time comparison, orbit determination of GPS and GLONASS satellites. Pursuit of a altimeter satellite. Collocation of space geodetic measurement system. What should be done from now on: To make LLR highly precise and supporting gravity missions. What is expected to CRL: To increase precision of SLR observation technology, real-time, full automation, development of eye safe system, supporting SLR station in Asia, technology of reverse laser ranging, and ranging among satellites.

Q: Is the LLR possible with present KSP system?

A: Improvement of the system (1 order of magnitude powerful laser and larger diameter) is required. Pointing (1 arc second) is also difficult, because guiding system is not present. So it is difficult in the present condition.

Q: What do you think about to use similar technique like VLBI for eye safe system? i.e. using weak continuum signal instead of pulse and improve SNR by the accumulation of signal.

A: Such a method is also considered although there are some methods in eye safe system.

Noriyuki Kawaguchi (NAO)

I would like CRL to develop the observation technology of Giga-bit VLBI system. 10G - 20Gbps system is also desired from astronomical observation. I also expect high-speed data transmission. I want to expect higher speed and more stabilized data transmission technology at a lower price not only with ATM. Moreover, it is kind if CRL provide

us more reliable and user-friendly correlation processing technology. In the future, space craft observation technology, the data transmission technology in the space by optical communication, and correlation processing technology are expected. I also hope development of the high-precision position determination technology of space craft by GPS. Probably, high-precision radiometer technology will be also big contribution for geodetic measurement. Now phase stability measurement of VERA (VLBI Exploration of Radio Astrometry) project is cooperated. I hope contribution of low phase noise oscillator, receiver, low price atomic standard (cost down will change the VLBI circumstance drastically), and Earth orientation observation (we assumes Earth Orientation Parameter as known).
C: When the technology of CRL is required in the project of NAO, such as VSOP2, I want it to examine whether collaboration by cooperation is possible or not.
Q: Does the earth orientation parameters required in VERA project?
A: The accuracy is more important than real-time.
C: There is a merit that real time can perform data processing quickly, and it is connected with the improvement in accuracy.
Q: What accuracy is required as VERA?
A: It is under examination now. The present accuracy is the minimum necessity. Furthermore, it is better as accuracy raises.

4. The project proposed from CRL

4.1 Application of the Space Geodetic Measurement Technology in the Space (*Taizoh Yoshino*)

I want to consider position determination in the space. The demand of position determination, such as a satellite, is increasing in connection with development of space observation technology (Gravity-related satellite missions etc.). Although, conventional space geodetic measurement technology was aimed up to the space near the Earth, now position measurement by using radio or optical link are considered. Lunar laser ranging in SELENE-2 mission by using active optical transponder is considered as an idea.
Q: How long will it take to develop an active optical transponder?
A: It is not yet clarified.
Q: Is it possible to transmit atomic standard signal from the satellite to user satellite?
A: Since it is still under examination, the concrete satellite has not been planned.
Q: If the position of VSOP satellite is decided with sufficient accuracy, astrometric observation become possible. Can position measurement of a satellite be achieved in mm or cm accuracy?
A: By designing exactly by defining the purpose, I think that it will probably be possible in cm accuracy.
A: Since a satellite orbit can be determined by dynamics, if observation by the laser ranging and by VLBI can be performed, its position can be determined with sufficient accuracy even if the satellite is complex shape like VSOP satellite.
C: The NASA has a plan of space optical interferometer with several meter baseline length for astrometry, in which the baseline length is to be measured within order of micro meter. High accuracy determination of satellite orbit is great benefit for astrometric observation.
Q: What is the purpose of the astrometry?
A: By measuring accurate position and the distance of maser sources, 3 dimensional dynamic motions become clear, and it will lead to determine the gravity field of the galaxy.

4.2 Advanced Precise Positioning System: APPS (*Yasuhiro Koyama*)

A position is decided with high accuracy with GPS by analysis of specialist. APPS is a system which enables anyone to get high precision positioning information. In the APPS system, a user will obtain GPS observation data with a geodetic GPS receiver and send them to an APPS analysis server. The data are then processed automatically and analyzed results are sent back to the user. In this way, the user can obtain reliable and accurate coordinates of the GPS receiver. Expected effects would be standardization of position information, accumulation of data on water vapor and ionospheric distribution. Technical developments for fine phase characteristic GPS antenna, automatic GPS data analysis technique, earth orientation parameters, water vapor model, and improvements of ionosphere modeland a numerical weather model will be required.
Q: Although it will be good for a user, there are few development elements, aren't they?
Q: What amount of user can you assume?
C: Probably, it will be used by researchers in universities.
C: It will differ by setting filed of service for Japan or for the world. Although RTK (Real

Time Kinematic)-GPS achieves 1 cm accuracy under good satellite arrangement condition, number of user is small comparing with single positioning. If the accuracy is about 1-10m order, I think there are many users.
A: The system is not limited to Japan. Although there might be few development elements, CRL performs the development of the first framework and a commercial company will realize the entire system. CRL is also responsible for the highly precise earth orientation information service.
C: Will it be performed by IERS and IVS?
C: It will be difficult to evaluate the demand before you present service price and doing market research.
C: Since the geodetic survey performed now becomes unnecessary, I think that remarkable demand can be expected.
C: Probably, it will become a point how the receiver element can be minimized.
C: How about compounding with communication positioning?

4.3 Real-time Earth Orientation Determination System (*Tetsuro Kondo*)

In research of the space and time standard development project being planned at CRL, VLBI will determine the Earth orientation in real-time. As an actual proof experiment plan, Kashima-Okinawa baseline (1600 km) will be promising from viewpoint of network. Various kinds of scientific results are also expectable. Technology of realizing that is Giga-bit VLBI and real- time VLBI. Two kinds of real-time system is considered as VLBI. One is VLBI over the ATM, and the other is using the internet protocol (IP). IP-VLBI targets for multichannel, 16Mbps data rate, and software correlation with distributed processing. High-speed data transmission system used in KSP is characterized by 256 Mbps data rate and special correlation processor. Internet VLBI may extend a base of VLBI community. Research will also be activated if a number of young researchers increases in this field. Multicasting of the signal received by 34m and feed back of observed data from distinct observatory to a central station will be an attractive idea.
Q: Does communication cost (cost per bit) fall down by using IP?
C: Although the ATM is cheaper as cost performance at present, it can be expected that the way of IP system becomes cheap for a scale merit.
C: We can't generally say that ATM suits astronomy and IP suits geodesy, can we?
Q: Although there are various geodetic measurement system such as GPS and VLBI, VLBI is most inappropriate for real-time, isn't it? Why do you persist in VLBI?
C: Although GPS requires time for orbital determination, VLBI does not have it. This point should be claimed more.

4.4 Proposal of Space Positioning Technology Development Center (*Tetsuro Kondo*)

Communications Research Laboratory possesses many kind of technology neccessary for space positioning technique and its development is expected from outside. We have began to propose Space Positioning Technology Development Center (SPDC) dedicated to stable technological development. Frank discussions are welcome. The purpose of the SPDC is as follows. There are various kinds of demand of positioning depending on the accuracy from Earth surface to space around the Moon. These kind of positioning system will be considered in the SPDC. Overviews of the project, demand depending on its accuracy, organization plan were introduced.
C: It should be necessary to make clear whether the benefit pay for the huge cost for that. Just searching for improvement of the accuracy will be difficult to be understood by people certainly and even by researchers (it will be thought maniac.). Since higher accuracy and lower cost are not compatible, demand survey for accuracy will be necessary.
C: This comment is important. If the target is not clearly defined, it is difficult to be permitted in CRL. Target and role, which CRL has to do, should be made clear.
C: I have the same opinion. It is related with a subject whether government has to do. If there are demands and it makes money, somebody will do. Problem in the scientific field is that if pure science is made only at universities, we cannot have a big project. Not only pursuing high accuracy and scientific purposes, viewpoint of searching for seed of future commercial technology is necessary.
A: Although, time and space standardizing project is aimed for high accuracy, explanation that VLBI is necessary for high accuracy became difficult in CRL.
C: The important field that is not included here in earth science is the survey of bottom of the sea. Unless geodetic measurement of sea bed is not included, scientific demand is not satisfied.
Q: Even though the basis is the same, the approach should be quite different in developing a system between higher accuracy system and lower cost system. How do you think about this?

A: I am not sure about that. Radio wave propagation medium has to be taken into account in the case of low cost approach also. The algorithm is similar in both cases. The concept of the proposal is center for research and development with stimulating each other. What kind of approach is the best will be also a subject to be discussed in the center. Budgetary compensations will be possible by combination of variety of elements.
C: From my experience of space science, orbit determination technology in Japan is very behind in the world. If CRL can do that, it is desirable. If determination of satellite attitude is achieved, itself has very big impact.
C: Research is either needs oriented or seeds oriented. Since this is seeds oriented, you should have a self-confidence.
A: Currently, seeds do not produce needs.
C: It is necessary to search for what kind of needs is possible from the seeds.
C: Extending to a variety of fileds such as infra-red will be necessary.

5. Greeting of Closing

Hiroshi Kumagai, the vice-director of the IVS T-DC at CRL, greeted the closing. He thanks to a serious argument over the long time. Furthermore, he mentioned that considering that will be also important, what should be done, what is superior to the other, or what is pleasant.

The social gathering was held after the meeting and discussions continued further.

VLBI Standard Interface (VSI) Meeting Report

Junichi Nakajima(*nakaji@crl.go.jp*)**, Yasuhiro Koyama, and Tetsuro Kondo**
Kashima Space Research Center
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314-0012, Japan

VSI-H is Just About Ready!

In the VLBI community, data transfer between the different system had been a difficult problem for a long time. Derived from diffrent VLBI media (an open reel tape, multiple VHS cassettes, and a single high density cassete), several recording systems are existing. VLBI data conversion from one to another medium often needs special interface hardware. Noriyuki Kawaguchi and his colleagues made great efforts to realize data compatibility between VLBA, S2 and K4-VSOP recorders.

Discussions of VSI (VLBI Standard Inteface) started in 1999 to achieve global compatibility among different VLBI observation systems. The issue is separated into VSI-H (hardware) and VSI-S (software). The VSI-H specification has been intensively discussed by the international VSI Technology Coordination Group (TCG) members led by Alan Whitney.

The initial VSI concept was presented by Alan Whitney in February,1999. Then he called an establishment of the VSI-TCG to VLBI communities to establish standardization in VLBI data interface. Members from CRL and National Astronomical Observatory of Japan group joined the VSI-TCG and poroposed detailed design concepts in June, 1999. Following these documents, intensive discussions were raised among international VSI-TCG members.

In 1999, Japanese group had domestic VSI meetings on 7th April, 14th May, 2nd June, 28th July, 3rd September, 5th November and 7th December. In addition to these meetings, we had three international telephone conference on 20th December 1999, 7th January 2000 and 11th May. An international meeting was also held at MIT Haystck Observatory on 8th and 9th of February, 2000. The members who attended the meeting were Alan Whitney (Haystack), Will Aldrich (Haystck), Wayne Cannon (York Univ.), George Peck (NRAO), Jon Romney (NRAO), Rick Wietfrldt (JPL), Sergei Pogrebenko (JIVE), Dick Ferris (ATNF), Noriyuki Kawaguchi (NAO), Hitoshi Kiuchi (CRL), Yasuhiro Koyama (CRL) and Junichi Nakajima (CRL). The draft for the VSI-H specifications has been revised several times and now it is under the finalaization process.

In the current soecifications, the VSI-H uses advanced LVDS (Low Voltage Differential) and attribution lines which define precise data epoch. It is expected that new instruments based on the VSI-H specifications will establish a connection with a minimum effort between diferent VLBI observation systems.

More information is available from the Web sites at the following URLs.

http://www.crl.go.jp/ka/radioastro/tdc/ivs/vsi/
http://dopey.haystack.edu/vsi/

Finally, we would like to thank Alan Whitney and international members of the VSI Technology Coordination Group for continuous efforts to realize the VSI.

The Facility of Tsukuba 32-m VLBI Station

Kazuhiro Takashima[1] (*takasima@gsi-mc.go.jp*), **Yoshihiro Fukuzaki**[1], **Keizou Nemoto**[1], **Kousei Shiba**[1], **Shinobu Kurihara**[1], **Michiko Onogaki**[1], **Kouhei Miyagawa**[1], **Kyoko Kobayashi**[1], **and Shigeru Matsuzaka**[2]

[1] *Geodetic Department, Geographical Survey Institute, Ministry of Construction Kitasato 1, Tsukuba, Ibaraki 305-0811, Japan*
[2] *Geography and Crustal Dynamics Research Center, Geographical Survey Institute Ministry of Construction Kitasato 1, Tsukuba, Ibaraki 305-0811, Japan*

Introduction

This report summarizes the specification of Tsukuba 32m VLBI station at the Geographical Survey Institute (GSI). We present our history of VLBI activities and the status. First of all, GSI developed three mobile VLBI systems and had repeated observations with CRL. In 1998, GSI constructed a domestic VLBI network with five permanent stations. A main station of the network is Tsukuba 32-m VLBI station (Fig. 1). It also becomes a key station in the international VLBI networks, especially in Asia.

Antenna

Tsukuba station has a 32m cassegrain parabolic antenna, which is made by NEC Co. All of components are painted white color to protect the deformation by the imbalance of temperature from sunshade. The main reflector is covered with thermal insulator panels, then its temperature is kept between ±3 degrees by using a ventilation system in the back structures. The antenna structures have covers to avoid direct sunlight. The table 1 shows the specification of the antenna, such as the slewing speedand limit angles.

Figure 1. Tsukuba 32m VLBI antenna.

Table 1. The specification of antenna

Year of Construction	1998
Radio Telescope	cassegrain
Mount	Az-El
Diameter of Main ref.	32 m
Surface Contour of ref.	±0.5 mm
Azimuth Velocity	3°/s
Elevation Velocity	3°/s
Azimuth Limit	10 - 710
Elevation Limit	5 - 88

Table 2. Station Configuration

8 letter	TSUKUB32
2 letter	Ts
DOMES	21730S007
CDP	7345
Approx. Pos	
X (m)	-3957408.8
Y (m)	3310229.3
Z (m)	3737494.8
Lat (deg.)	36.1031
Lon (deg.)	140.0887
Hight (m)	44.7
X-Band Tsys	50 K
S-Band Tsys	75 K
X-Band SEFD	300 Jy
S-Band SEFD	360 Jy

Azimuth angle of the antenna is controlled by a wheel and track system. The original azimuth rails, which weigh 73 kg per meter and are 10 cm wide, was cracked because the stress between wheel and rail was larger than our assumption. In April 1999, the rails have been replaced with larger ones (Fig.2). For the moment, the significant problem of the rail has not happened again. On the top of antenna, which is above subreflector, a GPS antenna (Fig.3) is attached for the purpose of tie survey and collocation.

Front-end

Table 3 shows front-end frequencies of Tsukuba 32m antenna. A cooled HEMT receiver which was made by Nitsuki Co. was installed in X-band. First local PLOs, which were made by CTI LTD., were installed. However, the phase of the PLOs were unstable worse than a thousand degree per day due

Figure 2. The replaced rail (Left: before, Right: current).

to change the temperature variation in the front-end room. We installed a cover rack for PLOs, and the PLOs are now always cooled by Peltier cooling system to minimize effects by the temperature variations of the outside air. Three intermediate frequencies (IF) at X-band were installed there.

Back-end

From front-end to back-end, signals are transmitted by optical fibers to avoid the power loss. But we have troubles with the optical fibers since they often fails to operate recently. We are now investigating the cause of the troubles. Mark IV and K-4 systems have been installed there. We can record with both systems simultaneously.

Others

Two control systems have been installed in the station. One is the Field System version 9 (FS9) developed by NASA GSFC. It is used for international experiments with the Mark IV system. Another is the workstation GAOS (WS-GAOS) developed by CRL and GSI. It is used for domestic experiments with the K-4 system. Recently, we can also use the FS9 for domestic experiments because it now supports K-4 systems by a cooperation with CRL Kashima and NASA GSFC.

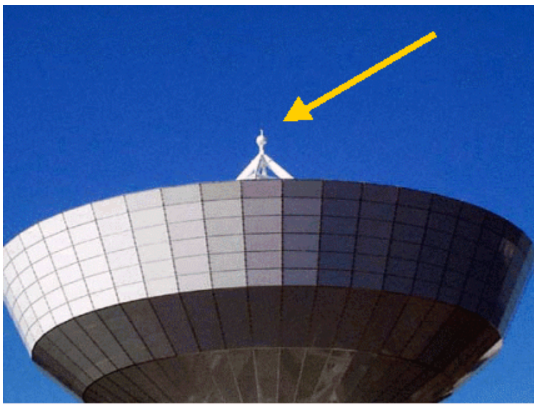

Figure 3. GPS antenna on the top of antenna.

Figure 4. Back-end equipment.

Table 3. The front-end frequencies at Tsukuba station

	S band	X1 band	X2 band	X3 band
Input (MHz)	2100-2500 2120-2360 (BPF)	7780-8280	8180-8680	8580-8980
PLO1 (MHz)	1600	7280	7680	8080
PLO2 (MHz)	2000	7680	8080	8480

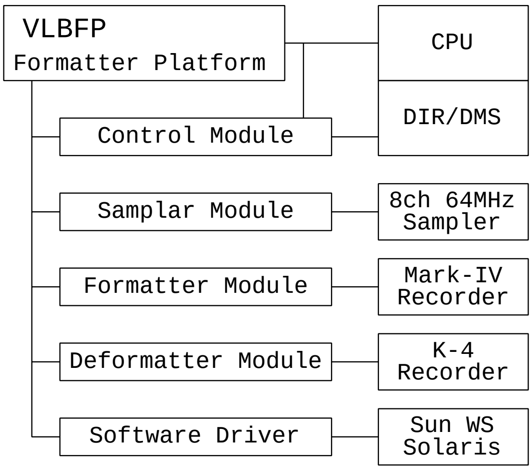

Figure 5. The diagram of copy machine (from K-4 to Mark-IV).

Since 1999, a copy system, which can copy data from K-4 tapes to Mark-IV tapes, has been installed to translate the data recorded at the stations only with the K-4 system.

Geodetic VLBI Observations Using the Giga-bit VLBI System†

Yasuhiro Koyama[1] (*koyama@crl.go.jp*), **Tetsuro Kondo**[1], **Junichi Nakajima**[1], **Mamoru Sekido**[1], **Ryuichi Ichikawa**[1], **Eiji Kawai**[1], **Hiroshi Okubo**[1], **Hiro Osaki**[1], **Hiroshi Takaba**[2], **Minoru Yoshida**[2], and **Ken-ichi Wakamatsu**[2]

[1] *Kashima Space Research Center*
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314-0012, Japan
[2] *Gifu University*
1-1 Yanagido, Gifu 501-1193, Japan

Abstract: A series of the geodetic VLBI experiments have been performed with the giga-bit VLBI system using a baseline between Kashima and Koganei stations in the Key Stone Project VLBI Network, and a baseline between 34-m antenna station at Kashima and a mobile VLBI station at Gifu University. The baseline vector was successfully estimated from the first test experiment on October 19, 1999. The results are still preliminary, but the challenge became the first success of the geodetic VLBI experiment at the recording speed of 1024 Mbps. Details of the giga-bit VLBI system and the geodetic VLBI experiments using the system are reported in this paper.

1. Introduction

Communications Research Laboratory has been developing the giga-bit VLBI system which has a capability to perform VLBI observations with a continuous bandwidth of 512 MHz from the baseband. The primary purpose of developing the system is to observe weak radio sources by the means of VLBI since the wide bandwidth of the giga-bit VLBI system can improve the observation sensitivity. Since the bandwidth of the giga-bit VLBI system is four times wider than the currently used other operational systems, an improvement of the signal-to-noise ratio is a factor of two. This unique characteristic is considered to be most effectively utilized in the radio astronomical applications. Several observation sessions were already performed and are planned with the baseline between 34-m antenna station at Kashima and either 45-m antenna station at Nobeyama or 64-m antenna station at Usuda. Geodetic VLBI experiments are usually performed with multiple channels and these channels are allocated to X-band and S-band frequency bands. It is because the precise time delay is obtained by using the bandwidth synthesis technique and the ionospheric propagation delay have to be corrected by performing observations in two frequency bands. The single-channel architecture of the giga-bit VLBI system prevents to apply both the bandwidth synthesis technique and the ionospheric delay correction. However, on the other hand, the giga-bit VLBI system has a potential to improve the observation sensitivity so that small aperture antennas can be used for geodetic VLBI observations. In addition, the system does not require base-band converter units and phase-calibration tone signals, and has a possibility to simplify the geodetic VLBI observation system. By considering these advantages, we determined to try to apply the giga-bit VLBI system for the geodetic VLBI observation.

† This manuscript has been submitted to the proceedings of the 1st General Meeting of the IVS.

2. The Giga-bit VLBI System

The giga-bit VLBI system consists of 6 components, i.e. sampler units, data recorder units, a correlator unit and three kinds of interface units. The entire view of the giga-bit VLBI system is shown in the Figure 1. The sampler unit has been developed based on a commercially available digital oscilloscope products (Tektronix TDS784/TDS580). The oscilloscope unit has a high speed analog-digital sampler chip which operates at the speed of 1024 Mbps (bit-per-second) with a quantization level of 4 bits for each sample. One of the 4 quantization bits is extracted from the digital oscilloscope and is connected to the sampler interface unit. The sampler interface unit demultiplex the 1024 Mbps of serial data stream to 32 parallel lines. The parallel data are then formated by a time control unit (DRA1000) and the data are recorded by the data recorder unit (Toshiba GBR1000). The time control unit uses the track set ID counts in the data recorder unit to control the precise timing so that recorded data can be precisely reproduced with the recorded time. The data recorder unit records digital data in the D6 standard format. The recording speed of the data recorder unit was increased so that it can record the input data stream at 1024 Mbps. The correlator interface unit (DRA2000) is used in the data correlation processing and it absorbs the large time delay which can not be absorbed in the correlator unit (Giga-bit Correlator : GICO). The correlator interface unit also multiplexes and demultiplexes 32 parallel data into 64 parallel data since the correlator unit requires the 64 parallel data lines for the input data. In the correlation processing, two DRA1000 units are

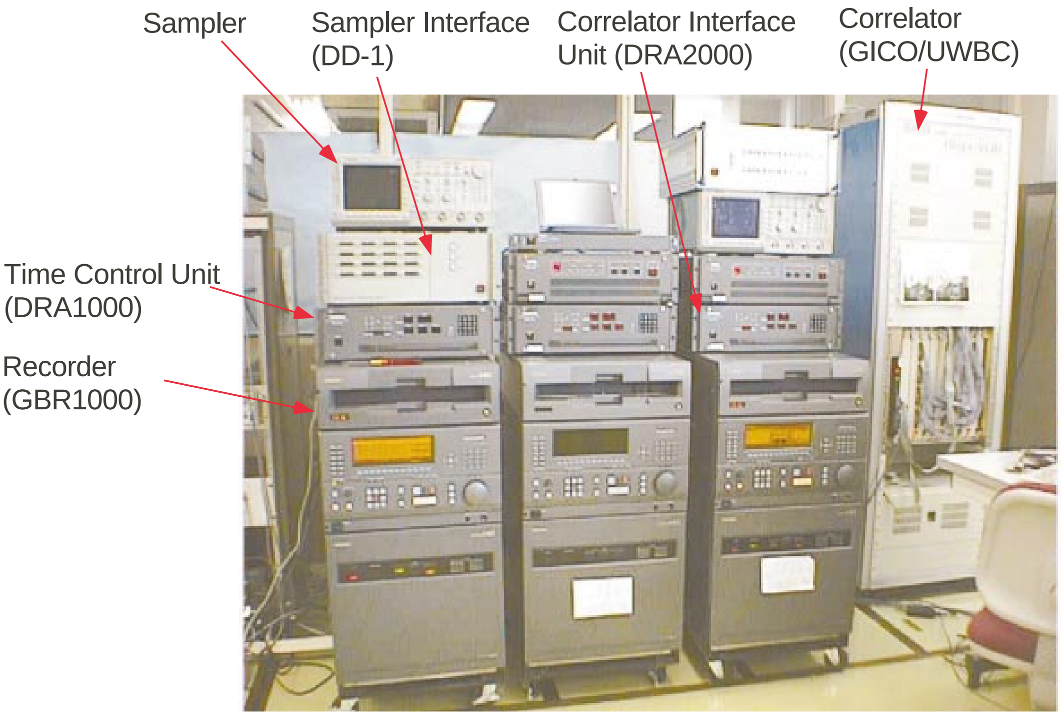

Figure 1. Entire view of the giga-bit VLBI system.

connected to a common 1 PPS signal and each unit synchronizes the reproduced data by controlling the GBR1000 data recorder. The correlator system was first developed at Nobeyama Radio Observatory for the Nobeyama Millimeter Array. It has a capability to correlate data stream of 1 GHz of 2 bits data and only half of the processing speed is used for the giga-bit VLBI system.

In the observations, the GBR1000 data recorder is controlled by a notebook PC using a PCMCIA GP-IB interface card. The observation program has been originally developed to control K-4 VLBI system and a 3-m mobile antenna system using a basic command interpreter. In the data correlation processing, the GICO and GBR1000 units are controlled by a Unix workstation over the GP-IB interface. The correlated data are saved in a file on the workstation and the time delay and its rate of change are calculated. For the geodetic VLBI data analysis, a set of programs have been developed to create Mark-III database files from the output file generated by the correlator control program.

3. Experiments

The first geodetic VLBI experiment by using the giga-bit VLBI system was performed for about 6 hours on October 19, 1999 with the KSP VLBI stations at Kashima and Koganei. Several softwares have been developed to process the correlator outputs using the actual data obtained in the test experiment. Following the test experiment, two full-day geodetic VLBI experiments were performed with a baseline between a mobile VLBI station at Gifu University and the 34-m antenna station at Kashima on January 18 and on February 29, 2000. The mobile VLBI system with a 3-m VLBI antenna was transported to the campus of the Gifu University in November, 1999 for the experiments. Figure 2 shows the 3-m transportable antenna and the observation shelter of the mobile VLBI system installed at Gifu University. Figure 3 shows the geographic locations of the observation stations.

The mobile VLBI system was developed in 1987, and has been used in geodetic VLBI experiments at Kashima, Koganei, Wakkanai, Okinawa, and Minamidaito island. Minamidaito island is located on the Philippine Sea Plate and the motion of the plate with respect to the North American Plate was detected by the means of geodetic VLBI technique for the first time by using the mobile VLBI system [*Amagai et al.*, 1990; *Kondo et al.*, 1992]. The 3-m antenna system does not have a receiver for S-band, but instead, it has two X-band receivers to expand the frequency bandwidth within the frequency band. Although the small aperture of the antenna degrades the sensitivity of the obser-

Figure 2. 3-m mobile antenna and VLBI observation shelter system at the campus of Gifu University.

vations, the wide frequency bandwidth of the receiver helps to improve the precision of time delay measurements. The maximum slewing speed of the antenna is 3 degrees per second for both elevation and azimuth angles, and the fast slewing capability increases the number of observations within certain length of time, which also contribute to improve the results.

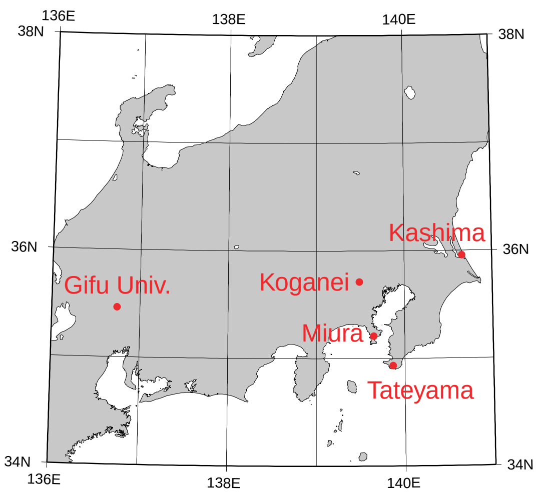

Figure 3. Geographical locations of the observation sites in the Key Stone Project VLBI Network and the new site in the campus of Gifu University.

The giga-bit VLBI system improves the observation sensitivity by a factor of two compared with the conventional VLBI recording system with the recording speed of 256 Mbps. The high sensitivity of the giga-bit VLBI system is considered to be most effectively demonstrated in the VLBI experiments with a small aperture antenna like the 3-m antenna system. In this scope, it was decided to conduct two geodetic VLBI experiments by using the 3-m antenna and the giga-bit VLBI system. Since the giga-bit VLBI system allows to sample baseband signal up to the frequency of 512 MHz, phase calibration signals and baseband converter units are not required and the VLBI observation system can be greatly simplified.

During the first test experiment and two full day experiments, the K-4 VLBI system was also used for the observations in addition to the giga-bit VLBI system for the comparison between the results from two independent systems. The observation tapes recorded during the two full day experiments have not been processed yet, but the observation tapes from the first test experiments have been processed and the preliminary results are compared in the Table 1.

Although the estimated baseline lengths are in good agreement, both the estimated error of the baseline lengths and the root-mean-squared of the

Table 1. Comparison with analysis results from the KSP system.

	K-4 system	giga-bit VLBI system
Baseline Length	109099666.04±3.69 mm	109099667.87±13.14 mm
RMS Delay Residual	48 psec.	183 psec.

residual time delays obtained from the observations with the giga-bit VLBI system were worse than the results obtained with the K-4 VLBI system. This fact suggests that there remains some problem either in the data processing software or the hardware system. In either case, we are planning to continue our efforts to eliminates these problems.

4. Conclusions and Future Plans

The giga-bit VLBI system was used for three geodetic VLBI experiments and we succeeded to estimate the baseline vector for the first time with the unprecedented speed of data recording at 1024 Mbps. Although the results are still preliminary, the high sensitivity of the system will give us many potential possibilities for the innovation in the technical developments in the field of geodetic and astronomical VLBI observations.

The observation tapes recorded in the two full-day experiments will be correlated as soon as the GBR1000 and related systems returns to the Kashima Space Research Center from Nobeyama Radio Observatory after an astronomical VLBI experiment which was sjust finished on March 12, 2000. The improvements of the data processing softwares and the hardware systems will be continued by using the actual data taken in these experiments.

We are also planning to develop a new data transmission system for the real-time VLBI observations based on the Internet Protocol. The 3-m antenna mobile VLBI station at Gifu University and the 34-m antenna station at Kashima will be used for the technical developments and test observations using the high speed network connection which will become available in the near future between Gifu University and the Communications Research Laboratory. We are looking forward to expand the real-time VLBI network to the international baselines by using the Internet Protocol and are hoping to make another innovation in the technical developments for the geodetic and astronomical VLBI observations.

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Optical Linked VLBI in Japan†

Junichi Nakajima[1] (*nakaji@crl.go.jp*),
Yasuhiro Koyama[1], **Tetsuro Kondo**[1], **Mamoru Sekido**[1], **Yukio Takahashi**[2], **Eiji Kawai**[1], **Hiroshi Okubo**[1], **Hitoshi Kiuchi**[2], **Noriyuki Kawaguchi**[3], **Moritaka Kimura**[3], **Kenta Fujisawa**[3], **and Hideyuki Kobayashi**[3]

[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
[3] *National Astronomical Observatory*
2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

1. Introduction

Optical linked VLBI is the key technology to change historical VLBI style in this decade. Not only achieve high sensitivity by the fast data transfer beyond magnetic tapes, but other features are also attractive for the VLBI operation. The optical linked data transfer without the media transport and its real-time correlation capability enables the quick look of observations. This means our global VLBI network will serve as a connected interferometer. Dynamic scheduling and real-time fringe check eliminate independent fringe test before observation and after standby. These feature of optical linked VLBI minimize observation failure usually known long after observation and maximize telescope resources. Currently operated optical VLBI network KSP(Key Stone Project), GALAXY (Giga-bit Astronomical Large Array Xross-connect) and other experimental based optical VLBI in Japan are briefly summarized in this report.

2. Currently Operated Optical Linked VLBI in Japan

2.1 Key-stone network

One of the long operated optical linked VLBI for geodetic data production is the KSP-VLBI around Tokyo metropolitan area. The 256Mbps VLBI data is transmitted via ATM (Transfer Protocol). The retrieved data from four telescopes are adjusted their data epoch at buffers in front of the Koganei correlator. The highly reliable KSP VLBI is operated every other day and additional R&D observations are scheduled between the geodetic regular schedule [*Kiuchi et al.*, 1999].

2.2 GALAXY

In 1998 geodetic KSP-network and astronomical VSOP/OLIVE network are mutually connected. The GALAXY is appeared under three different institutes. The network is consist from Usuda 64 m (ISAS), Nobeyama 45 m (NRO), Kashima 34 m (CRL) and four 11m in Kashima, Koganei, Miura, Tateyama[et al., 1999]. Correlation capability is four station maximum at Koganei correlator and there is additional limitation in telescope combinations. Possible observation frequency are listed in Table 1. The GALAXY network performed dynamical change of schedule when they found the HR1099 flare up stars variability during the observations. Mitaka VSOP-FX correlator is planned to share the processing.

3. Optical Linked VLBI with Experimental Result

3.1 Giga-bit ftp-VLBI

CRL has been developing the Giga-bit VLBI system which has a capability to perform 1024 Mbps VLBI observations. In this system, we realized ftp based data transfer which enables us the fringe check during observation sessions. Using large memory 1024 Mbit(=128 MByte) the unit freeze the stream data of assigned epoch. Beside the continuous tape recording, a connected PC start ftp transfer from a station to the other. After the ftp, immediately software correlation started and show the result. The software correlator has an advantage in their flexibility to extended lag windows. Although the delay resolution is less than 1-ns at 1024 Mbps/1 bit/1 ch system, we are able to know the precise clock offset before tape correlation. Except small telescope combinations, One second of the Giga-bit observations is enough to detect fringes from strong sources. Amount of ftp data is reduced when large telescopes are used. Figure 2 shows the ftp-VLBI 3C279 fringe between Nobeyama 45 m and Kashima 34 m from 12.8 MByte (0.1 sec) data. The processed lag window is expanded to about 50000 in this case. Start from ftp, it takes about 10 to 15 minutes to see the fringes when the observation is normal.

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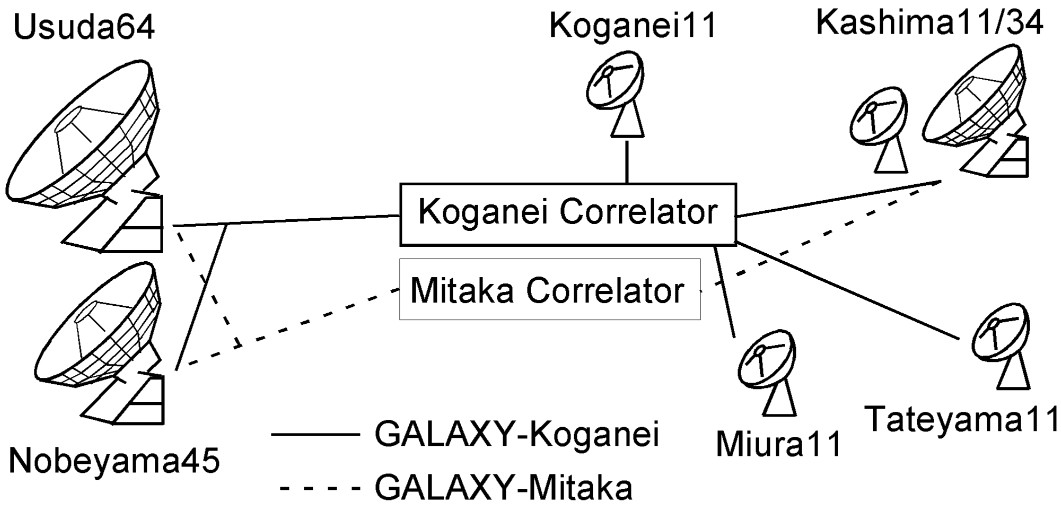

Figure 1. Optical Connection of KSP and GALAXY domestic optical VLBI.

Table 1. Two currently operated optical VLBI network in Japan.

	KSP real time VLBI	GALAXY real time VLBI
Telescopes	4 x 11m(KSP)	Usuda 64m, Nobeyama 45m, Kashima 34m, 4 x 11m (KSP)
Receiver Frequency	2/8 GHz	1.6/2/5/8/22GHz
Correlator (Terminal)	Koganei (K4)	Koganei (K4), Mitaka (VSOP-FX)
Baseline Maximum Length	134 Km	208 Km
Scheduling	Automatic, Static Schedule	Operator control, Dynamic schedule

3.2 Giga-bit SDI-based optical system

There are several approach to establish over Giga-bit VLBI data transmission. One method is the high speed ATM and IP enhancement. The standardized transfer protocol promise commercial based extension in future. One the other hand, the interface employed in high speed consumer instruments are focused for local usage. In this case, the technology is concentrated into key devices and much cheaper than the ATM under its strict definition. SDI (Serial Data Interface) used in HDTV (High Definition TV) instrument connection support optical data transmission up to 1.5 Gbps and 20 km distance without optical repeater. We have developed the interface 1024 Mbps VLBI data and attribution data transfer Figure.3 [et al., 1999]. Large digital delay is occurring at parallel to serial data transfer. To compensate this delay the concept of VSI (VLBI standard Interface, works important role. In the idea, 1 PPS tick label the data at DAS (Data Acquisition System). This will eliminate all digital delays introduced at latter digital/analog component and only the clock offset between the telescopes are remained in processing. There is no need to use cable counter when the DAS located near the receiver and the digital optical transmission is installed. We confirmed fringes and 1024 Mbps transmission performance by experimentally installing the unit in the correlation system as in Figure 4. Short distance interferometry experiment between Kashima 34 m and Kashima 26 m are planned.

3.3 Other optical-based VLBI experiment in Progress

The other optical based VLBI projects are follows. 155 Mbps STM-1 ATM transmitter is completed to provide real-time VLBI. The unit will support VLBI via an international optical link or a satellite link (Kiuchi, personal communication). Recently, National Astronomical Observatory carried out 2048 Mbps VLBI data transmission test which will fully utilize 2.5 Mbps ATM performance. They succeeded send-back more than hundreds Km(Kawaguchi, personal communication). The GALAXY network is expected to enhance the performance up to 1024 Mbps in future. NTT (Nippon Telegraph and Telephone Co. Ltd.) is developing high speed “IP over ATM” interface which will adapt the KSP system for future expansion.

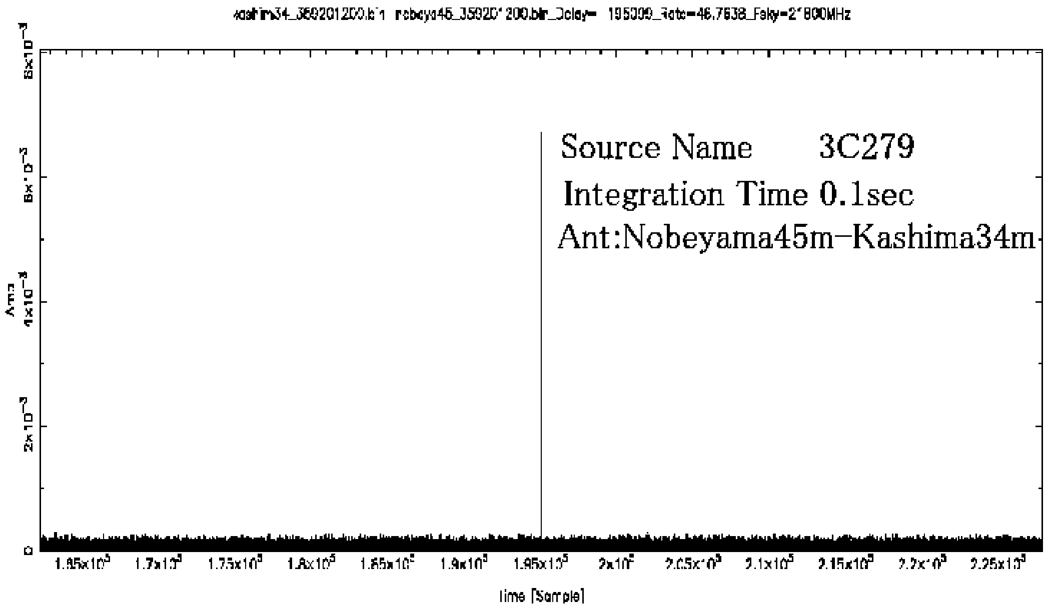

Figure 2. Gigabit ftp-VLBI fringe between Kashima 34m and Nobeyama 45m.

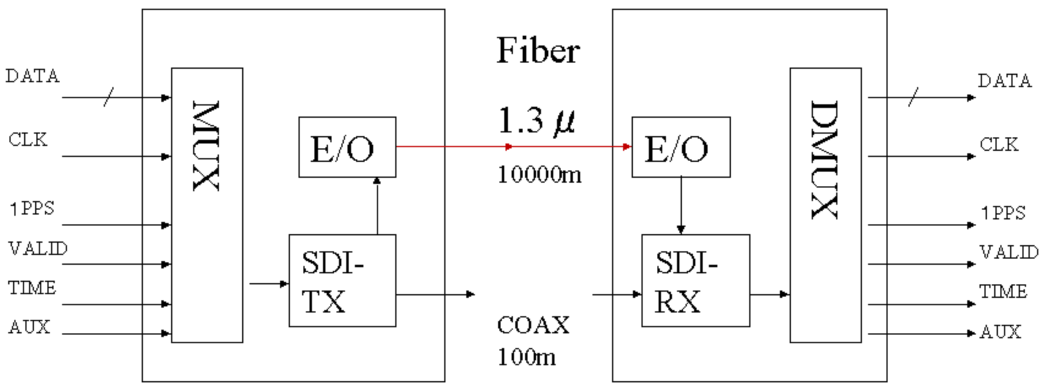

Figure 3. SDI Gigabit optical transmission system.

CRL is also developing IP-based VLBI system less than 1Mbps. The variable rate IP-VLBI is realized by PC computer based technology. Experimenting with a simple frequency standard, The system will provide possibility of preliminary VLBI experiment at many dishes never used for VLBI. This will give a experience and opportunity to join the VLBI network to new groups. In future, when we afford to use broadband optical link between remote place this will bring us standard bandwidth VLBI observations. All real-time VLBI progress brought about direct result never obtained by tape based VLBI. But it should be noted that the fringe finding method and observation procedure is difficult than tape based VLBI. Since most of the current VLBI system designed under tape based concept, future system should be improved to adapt automatic optical linked VLBI operation.

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Figure 4. Giga-bit optical transmitter SPO1152TX/RX test in VLBI correlation.

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Photo. Kashima 34 m antenna and the Kitaura Lake.

Portable Cryogenic Low Noise Amplifier Evaluation at Kashima 34-m Antenna

Hiroshi Okubo (*okubo_staff@crl.go.jp*), **Junichi Nakajima, and Eiji Kawai**

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

Abstract: In Kashima 34-m radio telescope, we replaced an ambient 5 GHz LNA to a newly developed portable cryogenically cooled low noise amplifier made by MITEQ. Radio telescopes purpose is detection of the weak noise signal from the space as clear as possible. But signal from external objects are much lower than noise originated by receiver itself. Good signal to noise ratio (SNR) is the most important both in single dish observation and interferometric (VLBI) observation. To realize good SNR receiving system, Helium gas Cooled LNA system are used for radio astronomy observatory in general. Those cryogenic systems have performed excellent result especially in cm and mm wavelength observation. But physical and economical reason, installing those cryogenics system is not possible in all telescopes. We report installation process and first result of portable cryogenic cooled low noise amplifier.

1. Kashima 34-m antenna demand for LNA

One of characteristics of Kashima 34-m antenna is multi band receiving system. Each band receiver is installed on one of 4 trolleys. If one choose receiving band, the trolley moves to the focal plane of the parabola. But the space in each trolley is limited for installing new receiver system. Kashima 34-m antenna had equipped 5 GHz receiver system with an ambient LNA, which is made by domestic company Nihon-tsuushinki. This system has been mainly used for VSOP (VLBI Space Observatory Project) observations. This ambient LNA receiver system is measured T_{sys} (system noise temperature) approximately 127 K.

Seek for better 5 GHz receiver performance with reasonable cost and labor, we choose portable cryogenically cooled LNA made by MITEQ. The uniqueness of cooled LNA unit (hereafter, CLNA) is closed cycle cryogenics and amplifier system integrated into compact size (309.4×189.7×258.6 (mm)). The power supply is +24V DC 6A, and there is no need of external gas supplying which simplify receiver installation.

Figure 1 shows dimension of the CLNA with a swivel bracket. There is master switch and amplifier switch in front panel that turned on powers cryogenics system and amplifier. RF input and output SMA connector are in the front panel. There is temperature controller in the front panel. Both the desired temperature and actual temperature are displayed. Monitoring the temperature via RS422 port is also possible.

Table 1. CLNA Test Data (MITEQ Inc).

Frequency (GHz)	4.7	4.8	4.9	5.0
Gain (dB)	41.5	41.4	41.2	41.1
VSWR IN	1.42	1.43	1.58	1.43
VSWR OUT	1.68	1.67	1.65	1.63
Noise Figure (dB)	0.35	0.35	0.34	0.34

Operation temperature : 123 K
Serial Number : 605409

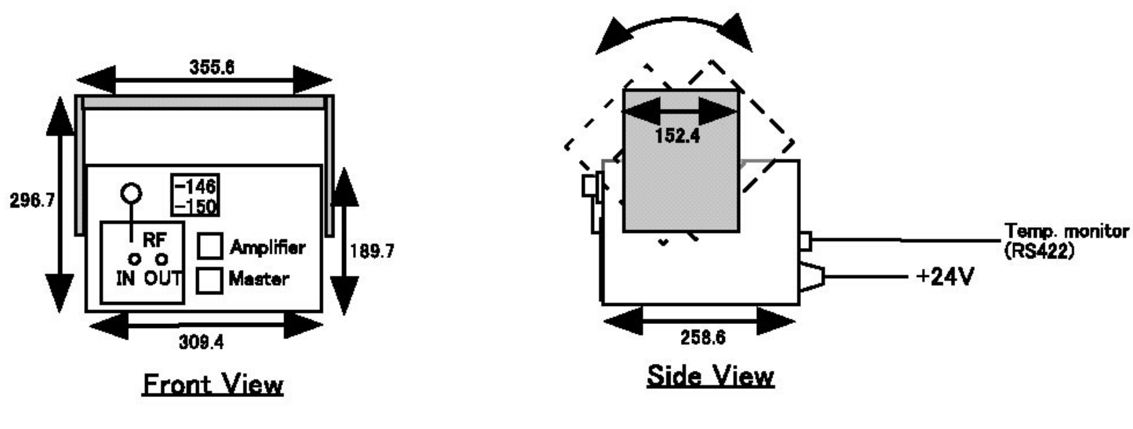


Figure 1. Dimension of CLNA with swivel bracket.

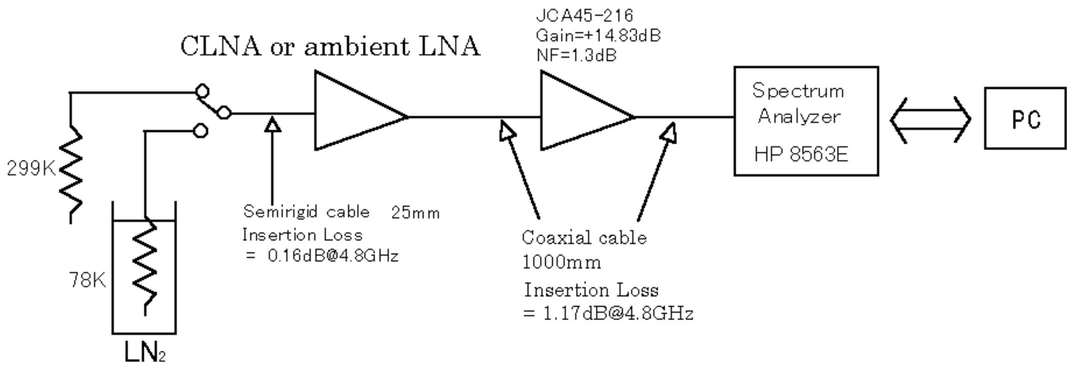


Figure 2. CRL Measurement Configuration.

2. Measurement

In receiver system, transmission loss before 1st amplification and Noise Figure (NF) of 1st amplifier affects system noise performance dominantly [*Kraus*, 1986]. Table 1 shows performance of CLNA measured by MITEQ, this measurement use NBS standard noise source. To verify noise performance of the CLNA without calibration error, CRL use ambient (290 K) / liquid nitrogen cooled (78 K) load for Y factor method.

Figure 2 shows configuration of CRL noise figure measurement. The terminator is connected to the CLNA input using 25 mm semi-rigid cable which insertion loss measured 0.16 dB. The CLNA output is amplified at a post amplifier (Gain=14.73 dB, NF=1.3 dB) then measured by a spectrum analyzer HP8563E, each components are connected with 1000mm low loss coaxial cable (insertion loss = 1.17 dB at 5 GHz). Data acquisition PC is connected to the spectrum analyzer, each measurement data was stored in PC and calculated.

The CLNA and ambient LNA measurement was carried out for comparison. The CLNA temperature controller was set 123 K and operated continuously before measurement. During the measurement, room temperature was 299 K. Measured powre level generated from the ambient terminator is defined as Hot (P_h) 299 K. Then the terminator was immersed in liquid nitrogen, temperature of the terminator is considered approximately 78 K and this measured noise power level is defined as Cold (P_c). The NF is calculated from both levels in each frequency from 4500 MHz to 5000 MHz. Y factor is ratio of measured HOT and COLD signal level and is expressed as follows.

$$Y = \left(\frac{P_h}{P_c}\right) \tag{1}$$

Modified Hot and Cold temperature is calculated from following equations.

$$T_{h1} = \frac{T_h}{10^{\frac{L_{attn}(dB)}{10}}} + T_d\left(1 - \frac{1}{10^{\frac{L_{attn}(dB)}{10}}}\right) \tag{2}$$

$$T_{c1} = \frac{T_c}{10^{\frac{L_{attn}(dB)}{10}}} + T_d\left(1 - \frac{1}{10^{\frac{L_{attn}(dB)}{10}}}\right) \tag{3}$$

where

T_h = physical temperature of HOT terminator

T_c = physical temperature of COLD terminator

L_{attn} = attenuation of the 25 mm semi-rigid cable (dB)

T_d = physical temperature of the 25 mm semi-rigid cable

Receiver noise temperature T_{RX} (K) is calculated from a following equation.

$$T_{RX} = \frac{T_{h1} - T_{c1} \cdot Y}{Y - 1} \tag{4}$$

The NF is given by a following equation in log scaling (dB).

$$NF = 10 \log\left(\frac{T_{RX}}{290} + 1\right) \tag{5}$$

Figure 3 shows the measured NF of the CLNA and the ambient LNA near 5 GHz band. The power gain of CLNA in 4.8 GHz band is measured 40 dB. The NF of post amplifier and cable loss after CLNA RF output is ignorable in the CLNA measurement. From our measurement, the noise temperature of the CLNA and former ambient LNA were 27 K and 100 K. These are converted to NF 0.4 and 1.3

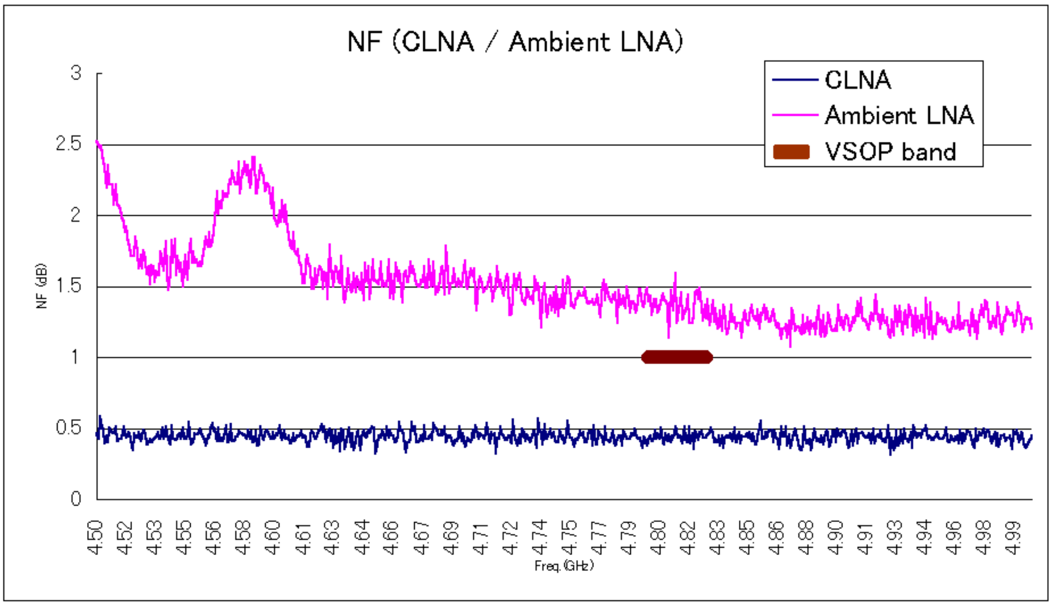


Figure 3. NF measurement (CRL).

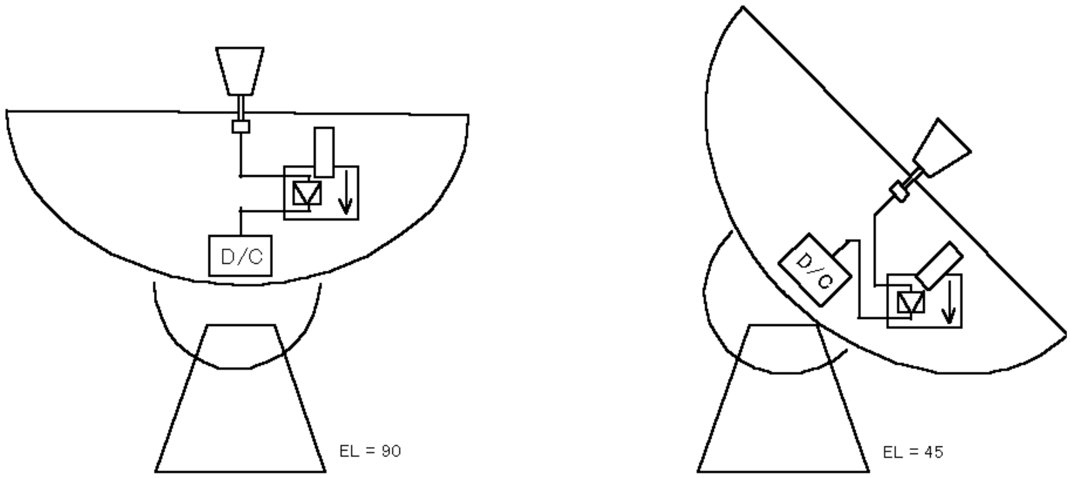


Figure 4. CLNA on Kashima 34-m antenna (Swivel bracket).

dB respectively. The CLNA shows improvement of noise performance. The MITEQ data provided in Table 1 and the result of CRL absolute well agreed.

In spite of same temperature setting, displayed case temperature controlled by closed cryogenics is slightly different between MITEQ and CRL measurement. According to MITEQ Inc. it takes approximately 2 hours to refrigerate the LNA to reach 123 K. In CRL measurement, the LNA temperature displayed 126 K minimum and it was not reached 123 K during operation. MITEQ Inc. informed us this is due to high room temperature under operation. However, difference 3 K was not critical in NF measurement result.

There was slight temperature variation in tilted CLNA. When the CLNA tilted a few degree toward "face-down" direction, temperature display decrease 2 to 4 K from 126 K. According to MITEQ Inc. it is due to attachment of sensor, cooled LNA temperature is not affected.

3. Installation

The compact feature of CLNA is suitable for Kashima 34-m antenna which has limited space for

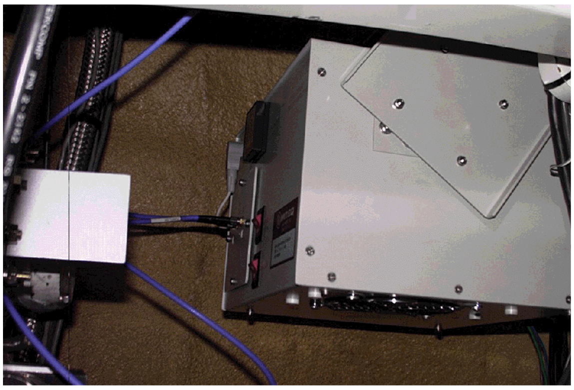


Figure 5. CLNA installed on Kashima 34-m antenna.

new receiver. But tilting is major problem of installing the CLNA. According to MITEQ Inc. tilted CLNA caused refrigerant pump up difficulty.

The antenna feed room is tilt depend on elevation angle (zenith to horizon). The swivel bracket has designed to keep the CLNA level regardless of elevation angle. The swivel bracket is consisting of ball bearing "swivel" with aluminum flame, which is attached with tilted connecting stay. The stay is fixed to the antenna to keep room for the CLNA moving freely in any elevation angle.

Figure 5 shows photograph of the installed CLNA on Kashima 34-m antenna. A power supply which maximum current is 10 A is closely located. Considering to keep the CLNA moving freely in any elevation angle, between waveguide-coaxial adapter and CLNA RF input is connected by flexible coaxial cable (1000 mm), measured insertion loss is 1.17 dB. The CLNA RF output to down converter input is connected same cable.

Table 2. Noise temperature and performance of 5GHz receiver system.

	Ambient LNA	CLNA
T_{LNA} (K)	100	27
T_A (K)	27	80*
T_{sys} (K)	127	107
SEFD - Cas-A (Jy)	626.9 (1999/12/08)	633.7 (2000/04/12)

*include flexible cable connection

Table 2 shows current summery of the CLNA and the ambient LNA installed in Kashima 34-m antenna 5 GHz receiver system.

Measured performance of 5 GHz receiver system using the CLNA is showing little improvement. Antenna system temperature (T_A) is defined following equation [*Kraus*, 1986].

$$T_{sys} = T_A + T_{LNA} \tag{6}$$

The ambient LNA is directly connected to waveguide-coaxial adapter and which T_A is sum of signal loss of feed horn, waveguide, waveguide-coaxial adapter and atmospheric absorption.

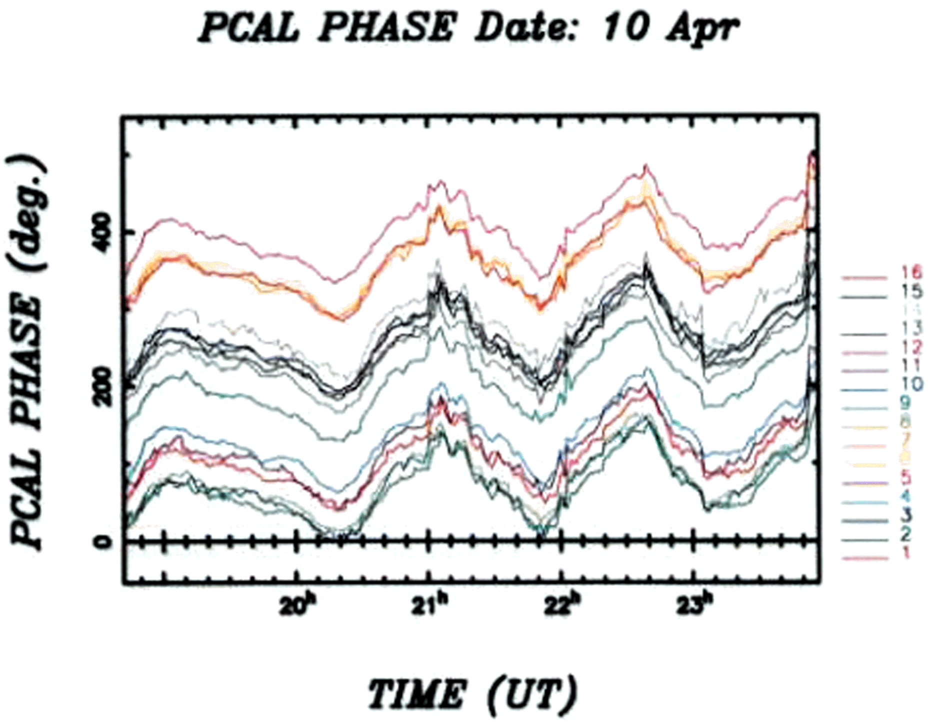


Figure 6. Phase calibration tone signal phase variation.

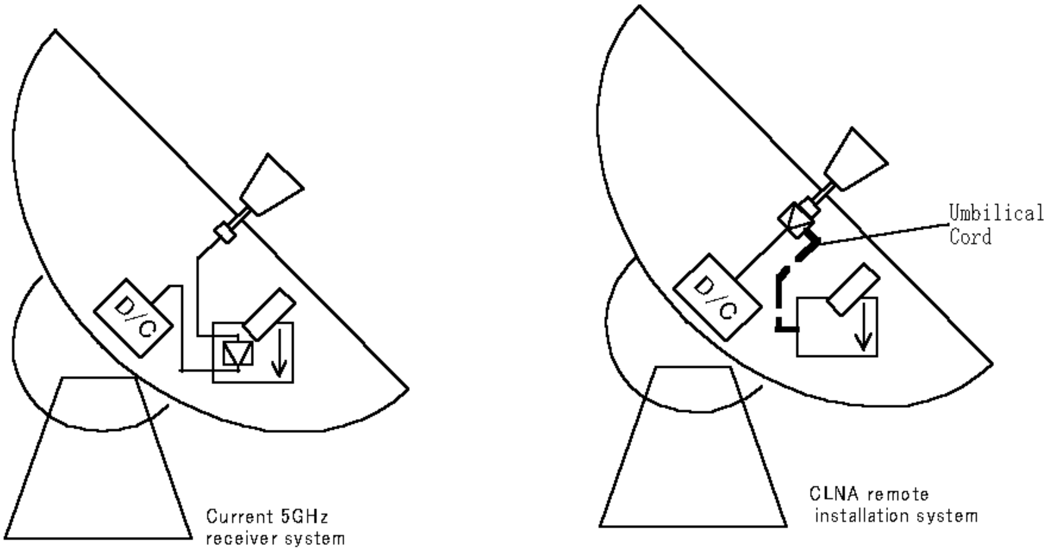


Figure 7. CLNA remote installation system.

As for the CLNA, receiver system increased noise with loss of flexible coaxial cable connecting between waveguide-coaxial adapter to the CLNA input. Contributed noise temperature from the flexible coaxial cable is calculated 53 K. We have tried 300 mm semi-rigid cable (insertion loss = 0.5 dB at 4.8 GHz) for this connection and measured T_{sys} is approximately 82 K.

Figure 7 shows phase variation plot of the CLNA C-Band RX system using phase calibration signal which is injected into system by cross guide coupler. There is slow phase rotation which is considered due to room temperature variation affected by air conditioning system. However, this slow phase rotation is not serious concern for interferometric (VLBI) observation.

5. Conclusion

We are installed the portable cryogenic cooled LNA (CLNA) made by MITEQ to Kashima 34-m antenna 5 GHz receiver system. The CLNA itself shows excellent performance compared with the ambient LNA, measured performance of the C-Band receiver system after installation shows improvement. Furthur improvements are possible in future. One is the flexble waveguide install between the telescope feed and the CLNA. This will reduce loss before the LNA input. Another choice of LNA separation with an unbilical code will also drastically reduce the noise temperature. The compact cooled LNA is attractive as a substitute of an ambient LNA. This is much attractive for small telescopes. Since, the most of small telescopes have to use ambient receivers in their limited receiver space.

References

Kraus, J. D., "Radio Astronomy 2nd edition," Cygnus-Quasar Books, Ohio, 1986.

S2 Recorder Installed at Kashima 34 m VLBI Station

Mamoru Sekido (*sekido@crl.go.jp*)

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

1. Introduction

Canadian S2 VLBI data recording (RT) and play back (PT) terminal has been installed at Kashima 34 m VLBI station to extend VLBI observational capability (Figure 1). Kashima 34 m VLBI station has K-4 type1, type2, VSOP terminal (VSOP-T), K-3, and VLBA (Mk-IIIa) recording system. And they are used for various kinds of VLBI experiment, such as geodetic VLBI, Space VLBI, domestic astronomical VLBI (J-Net), Pulsar VLBI, and so on. The newly installed S2-RT/PT is currently aimed for pulsar VLBI observation in Kashima (Japan) - Kalyazin (Russia) - Algonquin (Canada) VLBI network (Polar Bear Array; see Figure 2), and geodetic VLBI experiment between Kashima and Shanghai. Data copying in both direction from S2-PT to VSOP-T and from VSOP-T to S2-RT has also became available by using S2-PT/RT in conjunction with VSOP terminal (CTCU:VSC7220).

Figure 1. Left is S2-RT/PT and right is VSOP backend including Video converter, Sampler, and VSC7220.

2. VLBI Experiments with S2-RT

2.1 Pulsar VLBI

VLBI observation of pulsars for astrometry had been performed between Kashima and Kalyazin (Russia) baseline [*Sekido et al.*, 1999] by using K-4 type1 VLBI system since 1995. The observation network was widely extended by using S2-RT. Algonquin (Canada) - Kalyazin - Kashima pulsar VLBI network (Polar Bear Array) was coordinated. During 18-19 May 2000 the first VLBI observation was performed and Noto VLBI station in Italy was joined in the experiment this time.

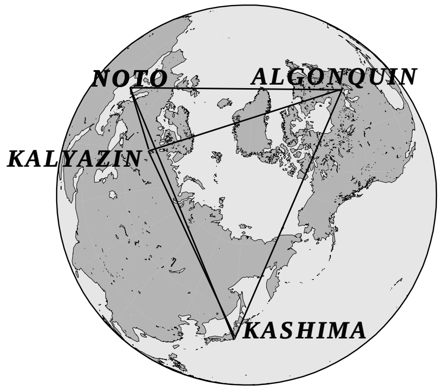


Figure 2. Pulsar VLBI observation stations in May 2000 experiment.

2.2 Geodetic VLBI with Shanghai Station

Shanghai Observatory has mobile VLBI station and S2 VLBI system is used for geodetic VLBI experiment. Fringe test experiment of the mobile station was organized in January 2000 and Kashima 34 m antenna had joined it. Fringe between Kashima and Shanghai was detected successfully by correlation processing at Penticton.

3. Available recording mode

There are two ways to record VLBI data into S2-RT at Kashima station. One is using 16 ch 4 MHz 1 bit sampler provided by Space Geodynamics Laboratory. Data is recorded in 4x16-1 mode in S2-RT. The other is using K-4 type2 sampler and VSOP terminal in combination. In this case, there are several choices of recording mode as listed in Table 1. Actually successful recording was confirmed in 32x4-2 and 16v8-2 (VSOP mode). Other

Table 1. Possible S2 recording mode through VSOP-T

Wires	Clock	Modes	Total Rate
4	32 MHz	32x4-1, 32x4-2	128Mbps
	16 MHz	16x4-1, 16x4-2, 16i4-1	64Mbps
	8 MHz	8x4-1, 8x4-2, 8i4-1	32Mbps
	4 MHz	4x4-1, 4x4-2	32Mbps
8	16 MHz	16x8-1, 16x8-2, 16i8-1, 16p8-2, 16v8-2	128Mbps
	8 MHz	8x8-1, 8x8-2, 8i8-1, 8p8-2	64Mbps
	4 MHz	4x8-1, 4x8-2, 4i8-1, 4p8-2	32Mbps
16	8 MHz	8x16-1, 8x16-2	128Mbps
	4 MHz	4x16-1, 4x16-2	64Mbps

modes will possible but have not tested yet.

4. S2 - VSOP-T Copying capability

Since VSOP terminal (CTCU:VSC7220) has been installed at Kashima, all equipment for data copying between VSOP-T and S2 is available as the same with Mitaka. And data copy in both direction, from S2-PT to VSOP-T and from VSOP-T to S2-RT, was confirmed in 32x4-2 and 16v8-2 modes. Other modes in Table 1 will be possible.

References

Sekido, M., M. Imae, Y. Hanado, Y.P. Ilyasov, V.V. Oreshko, A.E. Rodin, S. Hama, J. Nakajima, E. Kawai, Y. Koyama, T. Kondo, N. Kurihara, and M. Hosokawa, Astrometric VLBI observation of PSR 0329+54, Publ. Astron. Soc. Japan, 51, pp.595-601, 1999.

Photo. Kashima 34 m antenna and the Pacific Ocean.

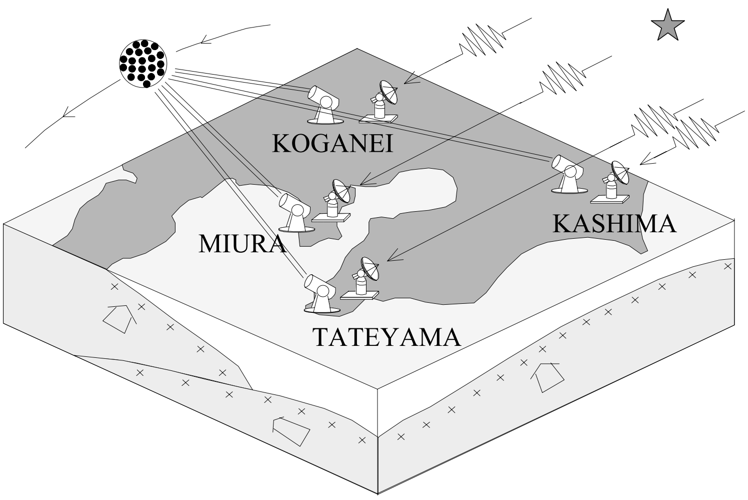
IMPORTANT ANNOUNCEMENT

Decision Concerning the Key Stone Project

The Key Stone Project is a program to apply the most advanced space techniques to study the crustal deformation around Tokyo using VLBI, SLR and GPS. All the facilities worked properly with some advanced functions such as real-time VLBI and an automated, remotely controlled SLR system. All three systems have produced invaluable data. Since the project, however, is time limited, it was decided that **the Keystone project will be terminated at the end of March in 2001**. The planned lifetime of the project has almost passed, although it is one year shorter than originally anticipated. Budget limitations also played a part in this decision. The decision was already announced at a formal committee in Japan.

We have found no alternative institute to continue the function of regular geodetic observations. In March of 2001, all the facilities in Miura and Tateyama will be dismantled because the rented land that they occupy must be returned to the owner. A part of the operation will be finished even before the end of March 2001. The VLBI, SLR and GPS facilities of the Koganei and Kashima stations will remain available to be exploited in future experiments. We encourage utilization of the Key Stone data taken in the past. All these data is freely available.

Taizoh Yoshino
Project Leader
Keystone Project Team
Communications Research Laboratory
E-mail: yosh@crl.go.jp, Tel: +81-42-327-7560, Fax: +81-42-327-6077
URL: http://ksp.crl.go.jp/



- New Book - New Book -

Very Long Baseline Interferometer

by

Fujinobu Takahashi, Tetsuro Kondo, Yukio Takahashi, and Yasuhiro Koyama

The authors are members of the research staff at the Communications Research Laboratory. This book explains VLBI technology comprehensively and is aimed at university students and graduate students of science and engineering. It should be useful for people who want to study space geodetic technology, not only VLBI but also GPS and SLR. Although the book was first published in Japanese in 1997, the description to the Key Stone Project (KSP) which CRL has promoted is more enriched in publication with the English version. The KSP is the project dedicated to measuring crustal deformation around the Tokyo metropolitan area using space geodetic techniques, such as VLBI, and the KSP implemented the world's first practical unmanned regular observations by the real-time VLBI technique. The contents are as follows:

Chapter 1: Introduction
Chapter 2: Basic Concepts: A Quick Tour of VLBI
Chapter 3: Data Processing Techniques
Chapter 4: Data Analysis
Chapter 5: Geodetic VLBI Experiments
Chapter 6: Applications of VLBI Techniques
Chapter 7: In Conclusion

The book will be published in June, 2000 by Ohmsha. More information will be available at *"http://www.crl.go.jp/ka/radioastro/book_ad_e.html"*.

Contacts

IOS Press
Nieuwe Hemweg 6B
1013 BG Amsterdam
The Netherlands
Tel: +31-20-688-3355
Fax: +31-20-620-3419
E-mail: market@iospress.nl
http://www.iospress.nl/

Ohmsha
3-1 Kanda Nishiki-cho,
Chiyoda-ku,Tokyo 101 Japan
Tel: +81-3-3233-0641
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- New Book - New Book -

Astrometry of Fundamental Catalogues – The Evolution from Optical to Radio Reference Frames

by

H. G. Walter and O. J. Sovers

The authors are associated with Astronomisches Recheninstitut, University of Heidelberg, Germany and Remote Sensing Analysis Systems/Jet Propulsion Laboratory, U.S.A., respectively. The book defines the concepts of fundamental reference frames and catalogues, and traces the history of conventional astronomical reference frames from the FK catalogues to Hipparcos and the ICRF. It is intended for researchers and advanced students having some training in astronomy, and should serve as a guide to current astrometric reference systems that find application in astronomy, geodesy and geodynamics. Establishment of the International Celestial Reference System and its optical extension via Hipparcos is treated in detail.

Chapter 1: Fundamental Catalogues
Chapter 2: The Conventional Fundamental Catalogue FK5
Chapter 3: Contributions of Space Astrometry to Fundamental Catalogues
Chapter 4: Astrometry with Radio Interferometers
Chapter 5: Fundamental Catalogues of Extragalactic Radio Sources
Chapter 6: The International Celestial Reference Frame
Chapter 7: Hipparcos Tie with Conventional Celestial Reference Frames
Chapter 8: Future Prospects

This book is part of the Springer Verlag Astronomy and Astrophysics Library, and should be published in late summer 2000. Information will be available at *"http://www.springer.de/phys/books/aal"*.

Contact

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

VLBI Technology Development Center (TDC) at CRL is supposed

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

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

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 : +81-299-84-7159, 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/"**.

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