TECHNICAL DEVELOPMENT CENTER NEWS No.5

International Earth Rotation Service – VLBI Technical Development Center News

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In October 1990, the International Earth Rotation Service (IERS) designated the Communications Research Laboratory (CRL) and Haystack Observatory, USA, as the Technical Development Centers (TDC). These centers are 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.

The Fifth TDC Meeting

The Fifth meeting of the TDC was held on December 17, 1993 at the conference room of the CRL headquarters.

Agenda

1. *Opening by Fujinobu Takahashi, director of the Standards and Measurements Division, CRL*
2. *Introduction of new committee members*
3. *Report of the iRiS'93 international workshop*
4. *Technical reports*
   - *4.1 Keystone project*
   - *4.2 Other technical development activities*
5. *Report on the working group on VLBI system compatibility*
6. *Discussion*

Attendees

CRL members
Takahashi, Fujinobu
Yoshino, Taizoh
Imae, Michito (Kashima Space Res. Cent.)
Heki, Kosuke (Kashima Space Res. Cent.)
Kunimori, Hiroo
Hama, Shin'ichi
Kiuchi, Hitoshi (Kashima Space Res. Cent.)
Sekido, Mamoru (Kashima Space Res. Cent.)

Special Members

Yokoyama, Koichi (National Astronomical Observatory, Mizusawa)
Shibuya, Kazuo (National Institute of Polar Research)
Okada, Yoshimitsu (National Research Institute for Earth Science and Disaster Prevention)
Kanazawa, Teruo (Hydrographic Department, Maritime Safety Agency)

Other members, Nobuyuki Kawano (NAO, Mizusawa), Noriyuki Kawaguchi (NAO, Nobeyama), Makoto Murakami (Geographical Survey Institute), Hisashi Hirabayashi (Institute of Space and Astronautical Science), Teruyuki Kato (Earthquake Research Institute, University of Tokyo) could not attend the meeting.

Minute of the Fifth TDC Meeting, Technical Reports

1. Keystone Project

Overview

Four tectonic plates (North America, Eurasia, Pacific, Philippine Sea) meet at the Kanto district, causing complicated seismic activity there. In addition to the Tokai Earthquake (M∼8), supposed at the Suruga Trough and the Odawara Earthquake (M∼7), supposed at the western part of the Kanagawa Prefecture, it has been pointed out that the Tokyo metropolitan area may suffer from a medium sized earthquake directly underneath in a near future. Crustal strains have been increasing since they were reset to zero in 1923 by the great Kanto earthquake and the earthquake potential is now large enough to cause an earthquake up to M∼7 directly under the Tokyo metropolitan area.

The project to monitor regional crustal deformations in the Tokyo metropolitan area by using space geodetic techniques has been started in 1993 by CRL. It is planned that four stations surrounding Tokyo are equipped with both Very Long Baseline Interferometry (VLBI) and Satellite Laser Ranging (SLR) facilities and daily routine geodetic VLBI/SLR observations are performed in this network to detect pre-cursory crustal movement that may occur pre-seismically. These points also provide positional references for the nation-wide network of the Global Positioning System being constructed by the Geographical Survey Institute (GSI), Japan. *(Taizoh Yoshino)*

VLBI systems

A new VLBI system is designed for the Keystone Project, in which we emphasized (1) fully automatic observations/data processing, (2) high reliability and stability, and (3) high geodetic accuracy. Each VLBI station is composed of an 11 meter parabolic antenna, with a slewing speed as fast as 3 degrees per second, S/X band receivers, an H-Maser frequency standard and a new K4 VLBI data acquisition system. The data recording is performed with the highest possible rate (256 Mbps) of the DIR-1OOO, the K4 data recorder and a wider receiving bandwidth (7.7∼8.6 GHz) is used for the X band, in order to enable highly accurate determination of the group delays. Full automatic operation can be achieved by using the DMS-24 automatic tape changer and a computer network connecting the controlling computers at individual VLBI sites. Daily geodetic VLBI experiments are to be done by remotely controlling the four VLBI stations from the central station at the Koganei headquarters to detect short-term earthquake precursors. We also plan to build a new correlator dedicated to the Keystone Project that can process more than six baselines simultaneously. *(Michito Imae)*

SLR systems

An SLR system is to be installed at each of the Keystone Project stations in order to reinforce the vertical station position accuracies. 24 hour SLR operation is possible for geodetic satellites as high as 500∼22000km with the ranging accuracies < 1 cm. A new capability of this SLR system is to synchronize the ranging from the individual stations to within 100 nanosecond. This enables precise time transfer and reduction of the systematic errors in estimating the site positions.

A new SLR data analysis software, CONCERTO, is under development in CRL and its parameter adjustment part is now being written. We confirmed the precision of the orbits generated by CONCERTO by comparing them with those produced by UTOPIA. The four SLR stations of the Keystone Project will have a large common view and a variety of data analysis schemes including the geometric method are possible. We plan to solve for the site positions as common parameters over a few successive passes and we expect their accuracies of <1 cm with 3∼4 passes. *(Hiroo Kunimori)*

Q&A

Q: Is the currently available 3 meter mobile VLBI antenna at Koganei to be used for this project?

A: No, we build a new 11 meter antenna dedicated for the Keystone Project at each station. Please do not confuse the Keystone Project with the MDX (Metropolitan Diamond Cross) VLBI network.

Q: How many hours do you plan to observe daily in the Keystone Project?

A: We have a provisional plan of ∼4 hours a day. It will yield a few recorded K4 tapes.

Q: How far is it possible to automate the SLR observations?

A: It still needs some help by an operator to catch the satellite. This technique is advancing rapidly, though. "24 hour observation" means that the stations are ready to observe whenever a satellite passes over the stations.

Q: In order to reinforce vertical site position accu-

racies, one SLR station will do. Why do you plan to have SLR at each station?

A: VLBI is still poor in estimating "relative" vertical component which is highly correlated with clock offset and atmospheric delay. SLR coordinates give the absolute position with respect to the geocenter as observed ranges are not biased by system delay and target shape. SLR is also free from ionospheric delays and turbulence by water vapor components. That is why we need SLR at each station.

Q: How about the collocation plan between VLBI and SLR in the project?

A: Local tie would be relatively easy because they are installed closely. Subcentimeter precision is still difficult, though.

2. Other technical development activities

Present status of the Kashima 34m antenna

A great amount of works have been done for the Kashima 34m antenna since the end of 1992. The works include re-painting and anti-corrosion treatments of the whole body, replacement of the azimuth rails, reinforcing the backup structure of the main reflector, and the improvement of the receiver/feeder systems. We put a cover over the azimuth rail to make its future corrosion slower. We removed 300/600 MHz band receivers installed beside the subreflector and replaced the IF signal coaxial cables with highly reliable optical fibers. In September 1993, a typhoon hit the antenna and damaged the subreflector controller. Now it has been fixed. We started the development of the mm-wave receiver (40/lOO GHz) to be installed into the 34m antenna as a joint project with the National Astronomical Observatory, Japan. *(Noriyuki Kurihara)*

Development of the new K4 backend

The new K4 system is designed to enable high accuracies in all possible observing modes in VLBI by employing wider bandwidths and multiple-bit sampling capabilities. Present targets include 1∼2 bit sampling, maximum sampling rate of 64 MHz, flatness of the phase throughout the band, and so on. We are currently developing a fast A/D converter and a wide-band image rejection mixer. In the new K4 data recorder, we use a new data recording format where the time labels are not inserted in the data tracks but are written onto an independent control track. This enables quicker data recorder synchronization in correlation processing. *(Hitoshi Kiuchi)*

Development of the new K4 correlator

A new XF-type correlator, specially designed for K4 data recorders, is currently under development. 16 units are to be installed in a single compact box (32kg, 45cm×31cm×46cm) together with the control part. This new correlator can handle up to 32 Msps/channel × 8 channels by using high-speed programmable IC's. It can also handle multi-bit-sampled data in each unit and the gating function is implemented in order to correlate pulsar signals efficiently. This correlator is controlled by using the VME system. *(Shin'ichi Hama)*

R&D experiment No. 1 - Kashima-Usuda Pulsar VLBI

A pulsar VLBI experiment is performed between the Kashima 26m antenna and the Usuda 64m antenna on Aug.7, 1992 and good fringes were found for the pulsar PSR0329+54. We investigated the relationship between the correlation amplitudes and the widths of the signal gate in the K3 cross correlator by using its gating function, and confirmed that the amplitude reaches its maximum when the gate is as wide as the pulse. With the new K4 correlator, which has a higher pulsar gating function, we will be able to correlate millisecond pulsar signals as well as relatively slow pulsars such as the one observed here. *(Mamoru Sekido)*

R&D experiment No. 2 - 22 GHz VLBI experiment

Conventional phase calibration signal generating system can not generate sufficiently stable and strong phase calibration signals for frequencies higher than 10 GHz. We started to develop a new phase calibration signal generating system in order to enable geodetic VLBI in higher frequencies. In the new phase calibration unit, phase calibration signals are created at a lower frequency and then up-converted by mixing them with a higher frequency signal. We tested its performance and confirmed the signal strength and the long-term phase stability. This new system is to be used in the coming 22 GHz VLBI experiment between Kashima and Australia in 1994 March. *(Hitoshi Kiuchi)*

Q&A

Q: Why is the new system not called "the K5"?

A: There should be a drastic improvement to do so. For example, bandwidth synthesis technique was first adopted when Mk2 becomes Mk3. The new K4 does not have that kind of essential breakthrough.

Q: Is the new K4 have compatible with the old K4?

A: Yes, it is.

3. Report on IRIS-P and VLBI activities in NAO-Mizusawa

We are going to purchase new K4 data recorders and install them at the Hobart and the Fairbanks stations next year. The Urumqi station, China, is expected to join the IRIS-P network and we plan to install another K4 data recorder there in 1995. We also hope to install a new K4 recorder in 1996 at the Kokee VLBI station, Hawaii, so that it can join the IRIS-P experiments again. We have to start thinking about the contribution to the world VLBI community not only by R&D (Research and Development) but also by D&D (Development and Deployment). The new 10 meter antenna at Mizusawa successfully participated in the IRIS-P experiment in July, 1993 for the first time. We just finished the development of the bandwidth synthesis software for the NAOCO (NAO correlator) and we plan to perform weekly or bi-weekly IRIS-P experiments by using the NAOCO at Mitaka, Tokyo. *(Koichi Yokoyama)*

Report of the IRIS Working Group on Compatibility of VLBI Systems

The first meeting of the IRIS Working Group on Compatibility of VLBI systems was held on September 9, 1993 as an ad hoc meeting of VLBI'93 in Kyoto. The meeting was attended by, *A. Tzioumis* (ATNF, Australia), *W. Cannon* (ISTS, Canada), *R. Wietfeldt* (ISTS, Canada), *B. Petrachenko* (EMR, Canada), *J. Cai* (Xian, China), *Qian Zhihan* (Shanghai, China), *Ye Shuhua* (Shanghai, China), *J. Ulvestadt* (JPL, USA), *A. Niell* (Haystack, USA), *S. Lowe* (JPL, USA),*K. Heki* (CRL, Japan), *M. Imae* (CRL, Japan). *H. Kiuchi* (CRL, Japan), *H. Kobayashi* (ISAS, Japan), *T. Yoshino* (CRL, Japan).

From each institution, current status on VLBI compatibility was reported.

ISTS(Canada) Assuming MarkIII system, interface, to and from S-2 system, is developed.

NAO(Japan) According to the agreement on the VLBI generic interface, we are developing the interfaces between VLBA and K-4, and between S-2 and K-4.

JPL(USA) Compatibility issue was discussed at Pasadena and Russia for space VLBI cooperation.

Haystack(USA) Compatibility between MarkIII and other systems are studied.

CRL(Japan) Hybrid data correlation and tape copying are currently made to process data at Kashima and to send tapes overseas to the foreign data processing station. Except the time tag problem, data conversion is technically possible.

Following items are discussed for the next step.

(1) If we are to continue tape copying, we need a tape copy center. Then we have to pay money for copying.

(2) When we copy data, data rate is usually selected to the slower one. It is hence time-consuming.

(3) If we take the option of direct connection to a correlator, we can avoid the above problems. We can influence the designers of the Mark IV and the EVN correlator so that they will take this into account. However, the number of data recorders to be installed in the processing center would be unacceptable.

With only existing tools, what we can do would be limited. It is agreed to copy tapes as an immediate action for VLBI compatibility. All the participants also agreed on having a unique international VLBI system as a final goal. The participants of the meeting agreed that Noriyuki Kawaguchi (NRO) takes over Taizoh Yoshino (CRL) as the contact person of the IRIS Working Group on Compatibility of VLBI systems at the end of 1993. *(Taizoh Yoshino)*

The New Representative of the VLBI Technical Development Center

The space geodesy group of CRL has experienced a major restructuring in 1994 summer. Now we have two research sections at Koganei CRL headquarters, i.e. Space and Time Measurements Section (chief: Michito Imae), Space Geodesy Section (chief: Taizoh Yoshino), and one section at Kashima Space Research Center, i.e. the Radio Astronomy Applications Section (chief: Yukio Takahashi). Future correspondence should be addressed to the following new representative of the group as the Technical Develop Center of IERS

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This news was edited by Kosuke Heki, Kashima Space Research Center, who has been the representative of TDC during the last 12 months. I apologize the delay of the issue of the TDC News No.5.