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II. OUTLINE OF EXPERIMENTS

II. 2 DOMESTIC VLBI EXPERIMENTS AT THE COMMUNICATIONS RESEARCH LABORATORY

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ABSTRACT

Having completed the K-3 VLBI system, the Communications Research Laboratory (CRL) is making progress with VLBI in Japan by conducting domestic VLBI experiments using CRL's facilities in cooperation with other organizations, besides the domestic experiments there are international VLBI experiments, such as the Crustal Dynamic Project (CDP).

CRL is engaged in geodetic VLBI experiments in cooperation with the Geographical Survey Institute (GSI) of the Ministry of Construction. These experiments are between Kashima and Tsukuba and also between Kashima and remote sites in Japan using the GSI's 5-m mobile VLBI station.

CRL started construction in 1984 of a highly transportable VLBI station which has a 3-m antenna. A series of domestic VLBI experiments are performed by using this station.

In 1987 CRL introduced three new antenna systems, and started a new VLBI project called the Western Pacific VLBI Network using these antenna systems.

This paper summarizes the domestic VLBI experiments carried out by CRL.

1. Introduction

CRL's domestic VLBI experiments are in three categories; those in cooperation with GSI; those using a highly transportable VLBI station constructed by CRL; those using the Western Pacific VLBI Network of CRL.

In the 1980's the main purpose of CRL's domestic VLBI experiments was precise geodesy. CRL originally started the VLBI project for the precise measurement of plate motion. In the 1990's the projects will diversify into other areas such as radio-astronomy or precise detection of earth rotation.

2. VLBI Experiments with GSI

CRL and GSI started cooperation in 1984 by developing the GSI mobile antenna system. GSI has introduced the K-3 type VLBI acquisition system [1],[2] which was developed by CRL and constructed a mobile 5-m antenna system[3] in cooperation with CRL. After that, CRL and GSI also cooperated with domestic experiments between the Kashima station and GSI's mobile station, starting in 1986.

CRL and GSI are now performing two series of VLBI experiments: Japanese Experiments for Geodesy (JEG) which are CRL's own VLBI experiments between Kashima and Tsukuba; the others are VLBI Experiments for Geodetic Applications (VEGA) which are GSI's own experiments between Japanese domestic remote sites and Kashima.

Other cooperation involves development of a compact VLBI station with a 2.4-m antenna for sea level monitoring to detect warming of the Earth's environment. This has been supported by the Environment Agency since 1990[4].

(1) JEG Series

The main purposes of the JEG series of VLBI experiments are: to establish a domestic standard VLBI baseline by repeated experiments on the Kashima-Tsukuba baseline of about 54 km, and to check new facilities such as the K-4 type VLBI system[5],[6] developed by CRL. Ten 24 hour VLBI experiments[7] have been performed between Kashima and Tsukuba up to 1990. They are summarized in Table 1. The baseline length obtained by JEG agrees with optical surface measurement to within 9 cm. The optical measurement precision is about 10 cm. The repeatability of the JEG series experiments was better than 1 cm. These show that the Kashima-Tsukuba standard baseline is established.

Table 1 Summary of JEG series VLBI experiments

Experiment name	Date	Notes
JEG-1	July 18, 1984	System level check of GSI station.
JEG-2	Aug. 8, 1985	
JEG-3	Feb. 17, 1986	Included Nobeyama Radio Observatory.
JEG-4	Feb. 23, 1987	
JEG-5	Feb. 9, 1988	
JEG-6	Aug. 25, 1988	
JEG-7	Feb. 22, 1989	Included Shanghai Observatory.
JEG-8	Sep. 29, 1989	First experiment using 34-m antenna in JEG series.
JEG-9	Mar. 1, 1990	
JEG-10	May 10, 1990	System level check of K-4 system at GSI station.

(2) VEGA Series

Since 1986, GSI was moved its mobile VLBI antenna system once a year to different locations around Japan. VLBI experiments have been performed with Kashima VLBI station to make a precise geodetic network of Japan. Figure 1 shows a map of locations and Table 2 shows brief summary of the VEGA series of VLBI experiments[8]. Two experiments using Chichi-jima island in 1987 and 1989 detected movement of the Philippine Sea Plate for the first time.

3. VLBI Experiments Using the Highly Transportable VLBI Station

In 1984 CRL started development of a highly transportable VLBI station with a 3-m antenna. This was completed in 1985[9]. This station is the world's most compact antenna system for VLBI

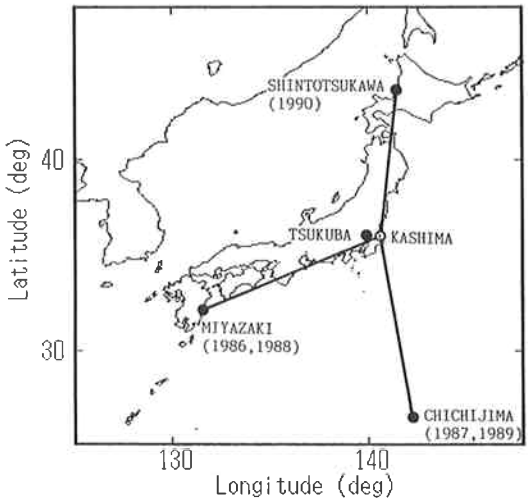

Fig. 1 Locations of the VEGA series VLBI experiment.

Table 2 Summary of VEGA series VLBI experiments between CRL and GSI

Experiment name	Date	Location of 5-m antenna station	VLBI system
VEGA-M1	Oct. 14, 1986	Miyazaki	K-3
VEGA-M2	Oct. 20, 1986	Miyazaki	K-3
VEGA-C1	Nov. 18, 1987	Chichijima	K-3
VEGA-C2	Nov. 25, 1987	Chichijima	K-3
VEGA-M3	Oct. 6, 1988	Miyazaki	K-3
VEGA-M4	Oct. 12, 1988	Miyazaki	K-3
VEGA-C3	Nov. 28, 1989	Chichijima	K-3
VEGA-C4	Dec. 5, 1989	Chichijima	K-3
VEGA-S1	July 24, 1990	Shintotsukawa	K-4
VEGA-S2	July 26, 1990	Shintotsukawa	K-4
VEGA-S3	July 28, 1990	Shintotsukawa	K-4
VEGA-S4	July 30, 1990	Shintotsukawa	K-4

experiments. This station also incorporates the K-4 VLBI system, developed by CRL, with a simple and easy to use frequency standard consisting of a Cesium clock and a high-stability crystal oscillator[10]. In order to achieve measurement precision which matches ordinary VLBI experiments a wide receiving bandwidth is used for this small antenna system. For example, conventional geodetic VLBI observation uses a bandwidth of 400 MHz, whereas the 3-m system uses a bandwidth of 800 MHz. From 1988 to 1989, a series of mobile VLBI experiments were performed at the following CRL centers: the headquarters in Koganei; Wakkanai radio observatory in Hokkaido; Okinawa radio observatory. The aim of these experiments was to test the performance of this station and to establish reference points for determining the precise orbit of GPS satellites[11]. Figure 2 shows the locations of the remote sites of this series of experiment, and Table 3 gives the main aim of each experiment.

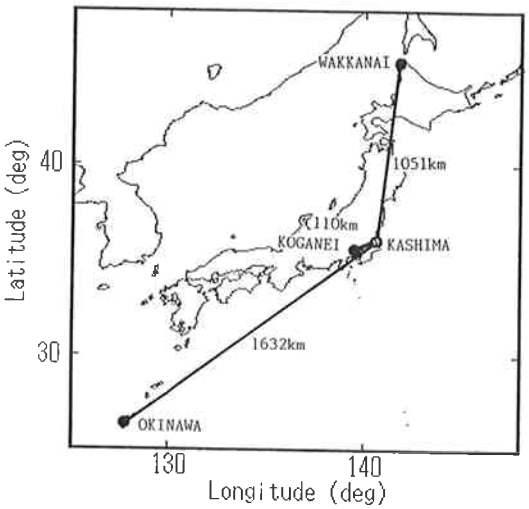

Fig. 2 Locations of the highly transportable VLBI station.

Table 3 Summary of VLBI experiments using 3 m antenna

Location	Date	Freq. standard	Purpose
Koganei	Sep. 8, 1988	H-Maser	System check and establishment of Koganei reference point
Wakkanai	Oct. 5, 1988	Cs + X'tal	Establishment of reference point for GPS orbit determination
Okinawa	Feb. 3, 1989	transportable H- Maser	Establishment of reference point for GPS orbit determination
Minami-daito isl.	Nov. 1990	Cs + X'tal	A part of Western Pacific VLBI Network

The highly transtortable VLBI station was also moved to Minami-daito island on the Philippine Sea Plate as part of CRL's Western Pacific VLBI Network. This network is described in the next section.

4. VLBI Experiments Using the Western Pacific VLBI Network

In 1987, CRL set up three antenna systems from the USA. They were the 34-m antenna at the Kashima main station and two 10-m class antennas for the remote islands[12],[13]. The 34-m antenna replaced the 26-m antenna which had previously played the main role in CRL's VLBI experiments. The Western Pacific VLBI Network project is a new 5 year VLBI project started by CRL. The main purpose of this project is precise measurements of movement of the four plates in and around Japan, i.e. the North American Plate, the Pacific Plate, the Philippine Sea Plate and the Eurasian Plate. This should contribute towards knowledge of how and why large earthquakes occur around the Japanese Islands. Figure 3 shows the station locations of the Western Pacific VLBI Network.

In 1989, after a system check of the antenna system, one of the 10-m antenna was transported to Minami-torishima (Marcus Reef) which is the only Japanese territory on the Pacific Plate. The first

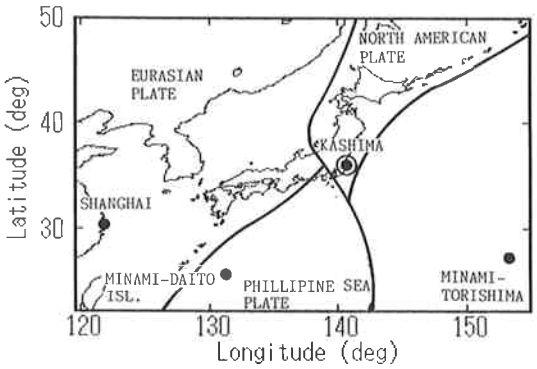

Fig. 3 Locations of the Western Pacific Network stations.

VLBI experiment between Minami-torishima and Kashima was performed in July 1989 and the second was in June 1990. These experiments detected movement of the Pacific Plate using only the Japanese domestic VLBI network[14]. For the Philippine Sea Plate the 3-m antenna station described in Section 3 was moved and used for a VLBI experiment with the Kashima 34-m antenna in 1990. For the Eurasian Plate, the Shanghai station of the Shanghai Observatory joined with the Western Pacific VLBI Network.

5. Other Domestic VLBI Experiments

The main purpose of CRL's domestic VLBI experiments in the 1980's was precision geodesy. However, other experiments were started at the end of the 1980's using the 34-m antenna which is multi-purpose system. In paticular radio astronomical applications were pursued jointly with the 45-m antenna of the Nobeyama Radio Observatory belonging to the National Astronomical Observatory. Higher frequency bands, such as the 22-GHz and 43-GHz bands were used. This series of VLBI experiments were called the KNIFE (Kashima-Nobeyama Interferometry) experiment. This pair of higher frequency VLBI system is one of the most powerful combination in the world, and it has great potential for increasing our knowledge of the universe. Its results can also be used for VLBI geodetic purposes with a precision of the order of millimeters.

6. Conclusion

This paper outlined domestic VLBI experiments performed by CRL in the 1980's. CRL has played a leading role in Japanese VLBI by developing VLBI equipment, and by performing international and domestic VLBI experiments, CRL's role is becoming more important, not only in development of new VLBI systems and geodetic experiments, but also in various applications of VLBI, such as earth rotation monitoring for IERS (International Earth Rotation Service), radio astronomy, and space VLBI in the 1990's.

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