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II. OVERVIEW OF THE EXPERIMENT SYSTEM

II.2 STATIONS IN THE REMOTE ISLANDS

By
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ABSTRACT

This paper describes the system used in two remote islands of the Western Pacific VLBI network. This network was established as a regional VLBI network dedicated to geodetic measurements. The main purpose of the network is to study the plate motion around Japan. Minamitorishima (Marcus) Island and Minamidaitoh Island were selected as respective sites to study the behavior of the Pacific and the Philippine Sea plates. The system is compact and reliable features that are required for construction, transportation and operation of the VLBI system in remote sites.

Keywords: VLBI (Very Long Baseline Interferometry), WPVN (Western Pacific VLBI network), the Pacific Plate, the Philippine Sea Plate. FSS (Frequency Selective Surface)

1. Introduction

The geodynamics of the Earth have been studied in the Crustal Dynamics Project (CDP) organized by NASA. This project employs a space geodetic global network. The Communications Research Laboratory (CRL) cooperated with NASA to conduct the CDP project by developing the Very Long Baseline Interferometry (VLBI) system and to perform experiments[(1)]. It is important to have a regional VLBI network in addition to a global network, so that independent observational activities may be enhanced in each part of the globe. As a regional Japanese VLBI network, the Western Pacific VLBI network (WPVN) was constructed to study the plate motion in this region. The network consists of a main station at Kashima, sub-stations at Minamitorishima Island and at Minamidaitoh Island, and a Shanghai station (Fig. 1). In the WPVN, CRL first deployed VLBI stations on remote islands. Shanghai is the only Chinese VLBI station in the WPVN. It is equipped with a 25 m antenna. These VLBI stations were deployed to examine behavior of plates around Japan. The Kashima station is located on the North American Plate. The Minamitorishima Island station is located on the Pacific Plate. The Minamidaitoh Island station is located on the Philippine Sea Plate. The Shanghai station is founded on the Eurasian plate. To establish the WPVN, the CRL

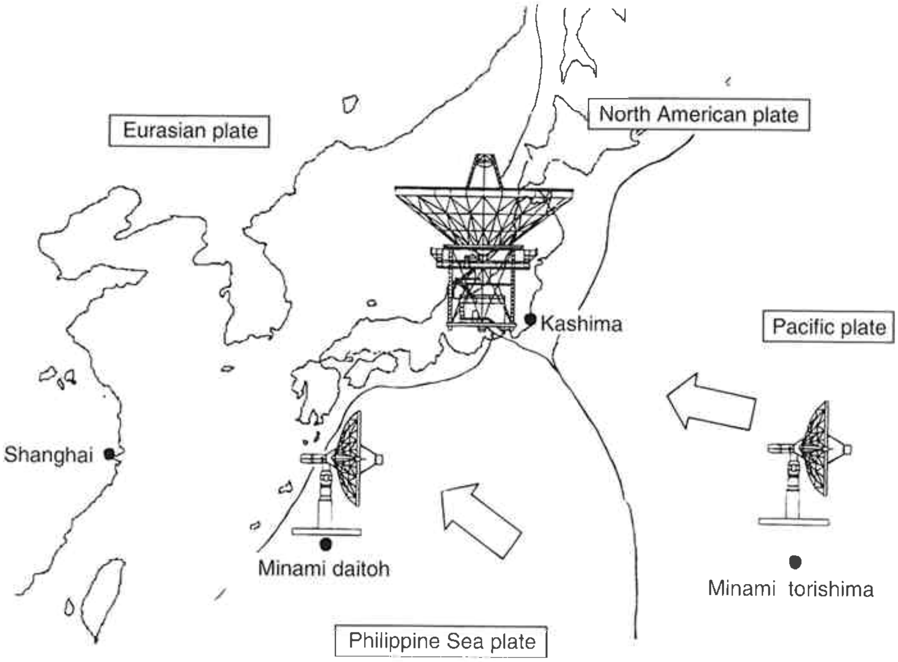

Fig. 1 The Western Pacific VLBI network

constructed new VLBI facilities at Kashima and the Minamitorishima stations. At the Kashima station, a 34 m antenna was constructed as a main station of WPVN (See II-1 in this issue). For the Minamidaitoh station, we utilized a mobile VLBI system with 3 m antenna.

We describe the two remote island stations and report on the performance of their observation systems in these pages. For the experiments that were performed, the VLBI system was transported to the remote islands. Since the newly developed K-4 system[2] is compact and reliable, it was used in the most WPVN experiments. Transportation and operation of the K-4 system was easier than the conventional K-3 system which was developed for the use in a fixed station. The planned term of the WPVN experiment was five years, beginning in 1989.

2. The VLBI Station in the Minamitorishima Island

If we were to study the motion of the Pacific plate using a Japanese island, Minamitorishima Island is the only possible candidate. Hence, this is a Hobson's choice; we have no real choice. However, the position of the island is, in fact, ideal for plate motion study. Since the island is located far from the plate boundary (almost 1,000 km from the closest boundary), motion on this station should clearly indicate Pacific plate behavior. While the Pacific plate is one of the largest on earth, the number of VLBI stations on this plate is small. If we exclude stations close to the plate boundaries, only Kauai and Kwajalein stations remain as suitable sites for the study of plate motion. The Kwajalein station, however, operates only on a temporary basis. Hence, only the Kauai station has been available to date. An additional station was needed. The Minamitorishima island is located on the eastern end of Japan. It is a coral island (Fig. 2). The island is so flat that sea wind blows through the island.

Fig. 2 Photograph of Minamitorishima Island

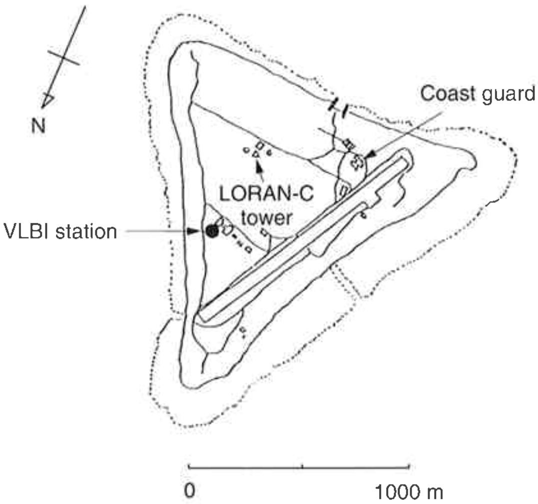

Fig. 3 Map of Minamitorishima Island

The island is owned by the Ministry of Finance and the Forestry Agency. Currently, only staff of the meteorological observatory and maritime self-defense agency are living there. The shape of the island is triangular, and the length of each side is about 1.5 km. Transportation to the island is only by airplane.

The observation system in the Minamitorishima Island consists of a 10 m antenna, a container, a power supply generator and an INMARSAT compact ground terminal for satellite communication. The container is equipped with an antenna control unit, a VLBI data acquisition terminal, a weather monitor terminal and a personal computer for system control. The 10 m antenna is located 100 m away from the coast. A map of the antenna site is provided in Fig. 3. Mechanical system corrosion and winds reaching 60 m/sec were anticipated, so the original design of the 10 m antenna by S/A (Scientific Atlanta) for satellite communications was modified to meet WPVN specification. The antenna was constructed in May, 1989 (Fig. 4).

It was anticipated that radio signal from the LORAN-C transmitter may interfere the weak signals from celestial radio sources for the VLBI experiments. Although the 100 kHz LORAN-C

Fig. 4 Photograph of the 10 m antenna

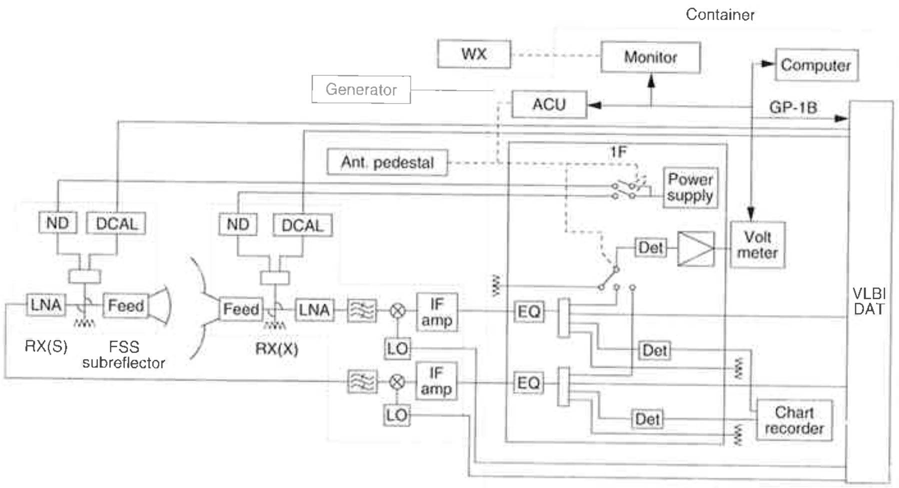

Fig. 5 Block diagram of the observation system of the Minamitorishima station

signal is transmitted at 1.2 MW from the 110 m tower on the island, spurious signal to interfere the VLBI was not detected by measurements.

A block diagram of the Minamitorishima station is depicted in Fig. 5. Performance of the 10 m antenna and receivers is shown in Table 1. As a geodetic VLBI station, both S and X band receiving systems were implemented. A Frequency Selective Surface (FSS) was mounted as a sub reflector for the 10 m antenna to enable frequency separation. The S band signal is fed through the sub reflector to the prime focus, while the X band signal is reflected at the sub reflector and then fed to the receiver at the Cassegrain focus. The antenna slew rate was 11 deg/sec and 5 deg/sec in El. A short slewing time to change radio sources during the VLBI experiment improves the precision of the baseline

Table 1 Performance of (a) the 10 m antenna and (b) receivers for the Minamitorishima Island

(a) a 10 m antenna		
Main reflector		10 m
Subreflector		0.8 m
Mount		Az-El
Polarization		RHCP
Surface accuracy		0.86 mm rms
Maximum drive speed		11 deg/sec (Az) 5 deg/sec (El)
Cable wrap		+360/−360 deg (Az) −2/+182 deg (El)
Wind velocity		Max. 25 m/sec (operable) Max. 60 m/sec (survival)
Weight		25 ton
(b) Receivers		
S band	2.20–2.32 GHz	100 K
X band	8.18–8.60 GHz	170 K

measurements. Electric power to drive antenna is provided by the 70 kVA generators. Source tracking and other automatic VLBI operations are made by an HP personal computer. As a stable frequency source, an oscillator composed of a Cs clock and a stable crystal oscillator (Cs-X'tal)[(3)] was used in most experiments.

CRL staff visited the island only during VLBI experiments and for maintenance. Damage of the 10 m antenna from severe environmental condition remains one of the biggest problems. In severe conditions, the G/T of the antenna at the island was lower than the value at Kashima. We believe salt adhesion is one cause.

3. The VLBI Station in the Minamidaitoh Island

The Great Kanto earthquake, which occurred in 1923 in the Tokyo Metropolitan area, was triggered by the motion of the Philippine Sea plate. The motion of this plate is not well understood from geological surveys because only information from past earthquakes is available[(4)]. Hence, observed results by modern techniques are important. With this plate, there are many possible VLBI antenna sites. Okinotorishima Island is at an ideal location from the plate boundary. It is, however, too small for a VLBI station. Minamidaitoh Island was selected as the site.

This island is located 392 km east of Okinawa. It is for 5.78 km east to west and 6.54 km from north to south (Fig. 6). At the highest point, the island is 75.8 m above sea level. The antenna position is also indicated in Fig. 6. Most of the island is used for agriculture. Access to the island is possible by a small airplane for operators and by a ship for transportation of experimental equipment.

The observation system at this island consists of a 3 m antenna, an X band receiver, a back end, a data recorder and a Cs-X'tal clock. Although an 11 m antenna was planned for the island after an experimental test using the 3 m antenna, financial constraints have prevented this. Hence, we have conducted our experiments with the 3 m antenna. A picture of this antenna is shown in Fig. 7. The

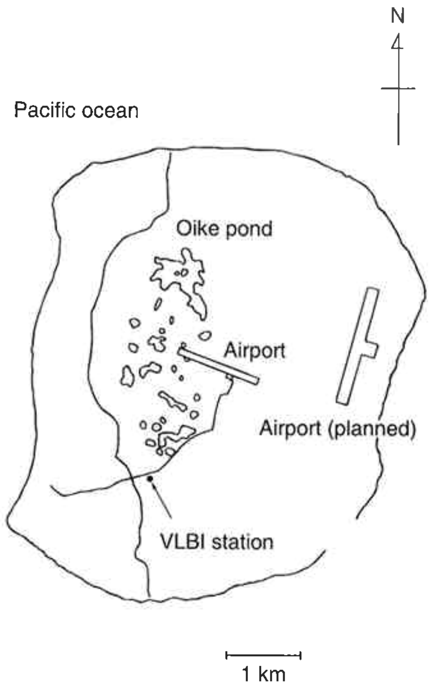

Fig. 6 Map of Minamidaitoh island

Fig. 7 Photograph of the 3 m antenna

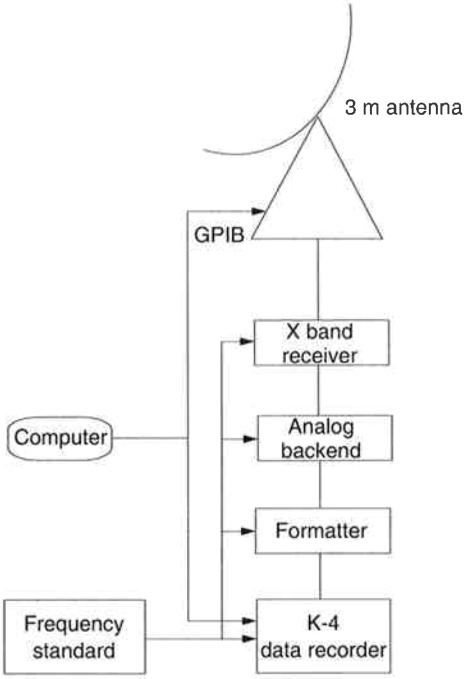

Fig. 8 Schematic diagram of the observation system of the Minamidaitoh station

Table 2 Performance of the 3 m antenna and receiver used at Minamidaitoh Island

3 m antenna and a receiver	
Main reflector	3 m
Mount	Az-El
Polarization	RHCP
Maximum drive speed	10 deg/sec (Az) 10 deg/sec (El)
Cable Wrap	+270/–270 deg (Az) –2/+182 deg (El)
Weight	1.4 ton
RX (Low)	7.86–8.28 GHz
RX (High)	8.18–8.60 GHz
System noise temperature	120 K

antenna system was originally developed for a mobile VLBI experiment. The antenna was also utilized for experiments at Koganei, Wakkanai and Okinawa. It was the smallest antenna for VLBI before development of the 2.4 m antenna(5). Following the tests, the antenna was transported to the island. Since this system has only an X band receiving capability (Fig. 8), ionospheric correction was necessary to be made independently. Performance of this antenna and its receiver are shown in Table 2.

The signal-to-noise ratio of this system is lower than that in the system of the larger antenna. To overcome this problem, bandwidth synthesis with a wide band was made by high and low frequency band receivers in the X band. Automatic operation of the VLBI system is possible by personal computer.

4. Conclusions

The VLBI facilities, including their antennas, were deployed on the remote islands in the WPVN. These are compact and reliable systems. Antenna size on the remote islands is smaller because a large dish antenna (34 m) was constructed at Kashima as a main WPVN station. The K-4 VLBI data acquisition system was used in most experiments, because the weight of the K-4 back end system is 167 kg without a frequency standard. This is one third of the K-3 back end weight. Furthermore the K-4 system is also highly reliable and easy to use.

WPVN data has been obtained and analyzed. The results are reported in this issue and by Yoshino(6). This data is provided to NASA to improve the global terrestrial reference frame.

5. Acknowledgments

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