No. B-10.2.1

Development of a highly transportable VLBI station

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Total Budget for FY1990 - FY1992 46,339,000 Yen

Abstract

CRL and GSI had developed the VLBI station with a 2.4m antenna to monitor the sea level. It is the smallest VLBI station in the world. In the first VLBI experiment between this station and Kashima 26m antenna on 15 October 1992, its position was determined with the precision of 1cm for the horizontal components and of 3cm for the vertical component. This error is better than the theoretical estimate and suggests that 2.4m antenna station has a good performance. This error level means that the vertical movements of tide gauge stations can be measured with an accuracy to 2mm/year after the experiments over ten years. Then we can estimate the sea level change with similar uncertainties. A new stable phase calibrator was developed by CRL and is adopted to this mobile station.

Key Words VLBI, GPS, Tide Gauge, Sea Level

1. Introduction

The sea level change caused by global warming is very important for civilian activities and the geophysics. To estimate the influence of the sea level change, it is very important to construct its precise measurement system. Normally the sea level changes are monitored by a tide gauge station but its position change, especially vertical position, caused by the crustal movement around the tide gauge station hides the real sea level change. Therefore the development of an accurate position change measurement system of tide gauge stations is important for the sea level change monitoring.
Communication Research Laboratory(CRL) which is a pioneer organization of the space geodesy in Japan, especially for the Very Long Baseline Interferometory(VLBI), started a project for constructing a highly compact and mobile VLBI station for above purpose under the cooperation with the Geographical Institute(GSI) of Ministry of Construction.

2. Research Objective

The research objective of this project is a construction of a highly compact and mobile VLBI station to determine the precise and accurate position of reference points for sea gauge stations. And the tide gauge stations' positions will be monitored by GPS survey receivers by using the reference points determined by VLBI.
This VLBI station is designed to make VLBI observations between Kashima 34m antenna of CRL of which location in the global reference frame is accurately determined by numerous international and domestic VLBI observations.

3. Research Method

The main part of the 2.4m antenna was constructed in 1990, the receiver and some of the VLBI equipments were made in 1991, and the development of this VLBI station has been completed in 1992. This VLBI station has only single frequency band because mainly the budget limit, an 8GHz band, while the ordinal VLBI station has dual frequency band, a 2GHz band and an 8GHz band, for the ionospheric delay correction. But it has a wide receiving bandwidth of the 8GHz receiver to increase observation precision. K-4 VLBI backend system which is developed by CRL is used. The K-4 VLBI system is also very compact one, and it makes this 2.4m antenna VLBI station as highly compact and transportable one. To compensate the ionospheric delay, a dual frequency GPS receiver which measure total electron contents along the signal path to the GPS satellite was introduced. Table 1 shows the specification of the 2.4m antenna VLBI station, and figure 1 shows the out-view of the 2.4m antenna.

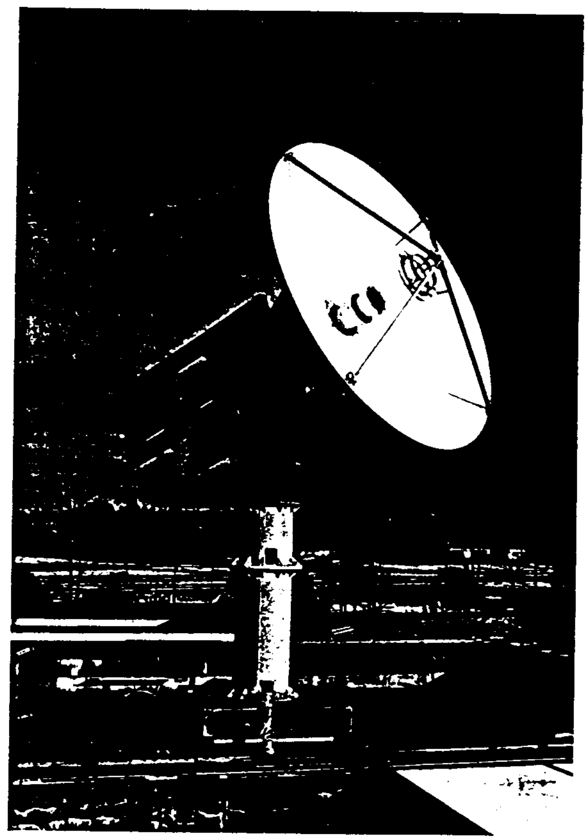

Figure 1 Out-view of 2.4m antenna

Table 1. Specification of the 2.4m antenna VLBI station

Antenna		
	Diameter	2.4m
	Feed type	Cassegrain
	Receiving Frequency band	X-band
	Efficiency	50%

Mount and Driving performance	
Mount type	Az–El mount
Slew rate	1.5 deg./sec
Receiver	
Type	FET type LNA(room temperature)
Tsys	120 K
VLBI facilities	
K–4 type VLBI system	
Frequency Standard	
Cs + X'tal	
or H–maser	

4. Result

After the construction of the 2.4m antenna VLBI station a test VLBI observation was performed between Kashima 26m antenna station on October 15, 1992. At this observation 2.4m antenna station was located at Tsukuba and another transportable 3m antenna VLBI station located at Koganei CRL's Headquarters was also joined this observation. As the Kashima 34m antenna was under repairing at this period, then we used the 26m antenna of which performance was about 3 times worse than the 34m antenna. The observation was made for 16 hours.
The table 1 shows the analysis results of the 2.4m antenna position and its estimated errors. This result was about 20% better than the estimated errors of the 3m antenna result which joined this experiment. This shows 2.4m antenna has good performances as a small dish VLBI station.

Table 2. The measured results of VLBI observation the position and estimated errors of 2.4m antenna station at Tsukuba

Position of 2.4m antenna (referred to Kashima 26m antenna)

X =	–3957200.5316	+/–	0.0219 m
Y =	3310182.8856	+/–	0.0187 m
Z =	54500.4527	+/–	0.0056 m

Error components	
vertical error	3.59 cm
horizontal errors	
north–south	0.50 cm
east–west	0.66 cm

5. Discussion

The test observation results show the performance of vertical compornent error of 2.4m antenna VLBI station is about 3.6cm, and this results were obtained by using 26m antenna. In the case using 34m antenna, the vertical compornent error can be estimated as about σ=3cm which includes the ionospheric compensation error. If we can perform the VLBI observation between 2.4m antenna and 34m antenna twice a year over N years interval, the vertical position changing rate observation error is estimated by the following equation,

$$\text{error} = (6/(N(N^2-1)))^{1/2} \times \sigma$$

Then the vertical position changing rate observation error can be estimated as 6mm/year over 5 years observations and 2mm/year over 10 years observations. These values are comparable to the estimated value of the sea level change, so we must continue the observation more the 5 years continuously.

6. Conclusion

The construction of the 2.4m antenna VLBI station was well performed. It is the smallest antenna VLBI station in the world. By the test VLBI observation with 26m antenna, it shows a good performance for the compensation of the tide gauge stations position change to measure the real sea level change. By using this VLBI system over 5 or 10 years observations, the real sea level change will be accurately estimated.