Kashima 34-m Radio Telescope

Junichi Nakajima, Yasuhiro Koyama, Eiji Kawai

Abstract

Kashima 34-m radio telescope is a facility of the Kashima Space Research Center, Communications Research Laboratory. The telescope is mainly used for geodetic and astronomical VLBI observations. Brief reports of the current status and on-going projects are presented in this report.

1. Introduction

Communications Research Laboratory (CRL) constructed the Kashima 34-m telescope in 1988 [1]. Since the operation started, 11 years have passed. The telescope has been kept in a good condition and it has joined various VLBI observations continuously. The station is located in the Kashima Space Research Center of CRL which was founded in 1964 near the Pacific ocean. The 34-m telescope (Figure 1) is currently operated and improved by staff in the Radio Astronomy Applications Section. The structure of the telescope below the alidade section is almost identical to NASA DSN 34-m stations, but the equipped frequency range and other electronics are different.

Figure 1. The Kashima 34-m Radio Telescope.

2. Antenna Specifications

2.1. Mechanical System

Although the Kashima 34-m telescope has an ability of the maximum slew rate of 1 degree per second in azimuth, we reduced its speed slightly to prevent mechanical wear in several parts of the telescope expecting to extend the life time of the telescope. The mechanical performance and related parameters of the telescope are shown in Table 1. Annual inspections of the motors and preparations of spare units substantially reduced unexpected troubles. Since last year, there has been no observation failures due to mechanical troubles of the telescope. The sub-reflector was re-furnished in 1998. Most of the parts in 5-axis positioning were renewed. Sub-reflector FRP surface was cleaned and re-painted from metal paint layer.

Table 1. Mechanical specification and related parameters of the 34-m radio telescope.

Maximum Speed in Azimuth	0.8°/sec.
Maximum Speed in Elevation	0.64°/sec.
Drive Range in Azimuth	±270°
Drive Range in Elevation	7-88°
Operation Wind Speed	13 m/sec.
Panel Surface Accuracy	0.17 mm (RMS)
Latitude	35°57.3′
Longitude	140°39.4′
Mailing Address	893-1 Hirai, Kashima, Ibaraki 314-0012 Japan

2.2. Receiver System

Currently available receivers are L, C, K and S/X bands. A computer controls the receivers and feed groups in the cassegrain secondary focus. A group of feeds is mounted on an elevator unit called "trolley". With the trolley, selected frequency feeds and receivers are moved to the cassegrain focus. The other receivers are retracted to lower positions. In the case of the C-band receiver, additional sub-reflector adjustments are required because of the offset position of the feed. For all the receivers except C-band, HEMT or FET low noise amplifiers are cooled down to a physical temperature of around 12 K. The C-band receiver is placed in ambient temperature. It takes from 15 minutes to 1 hour to switch observing receivers depending on which receiver is demanded. Intermediate frequency (IF) signals from all the receivers except for the K-band receiver are in the range of commonly used 100-600 MHz band. On the other hand, IF signal of the K-band receiver is in the frequency range of 5-7 GHz. The IF signals are converted to optical signals and sent to the observation room through optical fibers. The wide-band IF signal of the K-band receiver is converted to lower frequency signals in the observation room. Recently, we are experiencing strong interferences which are generated from artificial satellites and mobile phone base stations, especially in L-band. As a result, the observations in the L-band are sometimes very difficult. Current performance of the receiver systems are summarized in Table 2.

Table 2. Receiver performance of the 34-m radio telescope.

Band	Frequency (MHz)	Tsys (K)	Efficiency	SEFD (Jy)
L	1350-1750	43	0.68	
S	2150-2350	83	0.65	348
C	4600-5100	150	0.70	
X	7860-8680	50	0.68	254
K	21900-23900	300	0.57	

2.3. Hydrogen Maser Systems and Time Comparison

Two K4 type hydrogen maser systems are available at the telescope and one of them is used for the frequency reference. The same frequency reference is used at the 11-m antenna station of the Key Stone Project (KSP). Another Hydrogen maser system developed by a Russian group (CHI-80) is also kept running as a backup system. To compare the station clock maintained by the hydrogen maser system with the UTC, a GPS time receiver (AOA) and a Totally Accurate Clock-2 unit are in operation.

2.4. VLBI Back-end System

As of March 1999, K3A (Mark IIIA compatible system developed by CRL), K4, VSOP, and VLBA data recorder systems are available. For observations with the K4 and VSOP data recorder systems, an automatic tape changer unit can be used for a continuous unattended operations for more than a day. For the K4 type 2 and VSOP video converter systems which require IF signal in the range of 500-1000MHz, an IF up converter unit is used to convert the IF signals.

3. On-going Projects

Followings are the major VLBI observation projects which are currently running at Kashima 34-m radio telescope. Schedule of the telescope is determined in the telescope operation meetings based on the pre-determined priorities and requests from users.

K4-TIE experiments A K4 data recorder system has been shipped to the Gilmore Creek Geophysical Observatory at Fairbanks and a geodetic VLBI experiment was performed with the station in January 1999. Four VLBI stations in the KSP VLBI network were also included in the experiment. The main purpose of the experiment was to tie the KSP VLBI network to a global terrestrial reference frame (ITRF). Another experiment with the same stations and Wettzell VLBI station was performed in March 1999.

APT and APSG The Kashima 34-m radio telescope has been participating in APT (Asia Pacific Telescope) and APSG (Asia Pacific Space Geodetic Program) VLBI experiments for geodesy and astronomical purposes.

Pulsar VLBI Since 1997, regular observations were carried out with Kalyazin 64-m radio telescope in Russia. A K4 recorder system has been installed at the Kalyazin 64-m radio telescope. Repeated observations revealed the proper motion of a pulsar [2].

VSOP (VLBI Space Observatory Program) Under the collaboration with the Institute of

Space and Astronautical Science (ISAS), Kashima 34-m telescope joined the space VLBI experiments as a ground telescope. C-band and L-band receivers are mainly used. The Kashima 34-m telescope has an important role especially when the Usuda 64-m telescope is not available.

J-net (Japanese domestic astronomical VLBI network) With three other radio telescopes in Japan which are 45-m telescope at Nobeyama, 10-m telescope at Mizusawa and 6-m telescope at Kagoshima, VLBI observations based on qualified astronomical proposals are performed as the J-net. The purposes of the observations are focused in astronomical studies and most of the J-net observations are done towards K-band water maser emission regions. Intensive monitoring observations of the burst of the Orion-KL were done in 1998.

GALAXY (Giga-bit Astronomical Large Array with cross connect) Utilizing optical networks for the KSP VLBI network and another network for the OLIVE project which is connecting 64-m telescope at Usuda and 45-m telescope at Nobeyama with the correlator facility at Mitaka (National Astronomical Observatory: NAO), three large telescopes have been successfully connected via the Asynchronous Transfer Mode (ATM) high speed network. The network has been established under close cooperation with the the Telecommunication Network Laboratory Group of Nippon Telegraph and Telephone Corporation (NTT). Kashima 34-m and Usuda 64-m telescopes were connected in September 1998. Nobeyama 45-m telescopes will also be connected in 1999. The first fringes between Usuda 64-m and Kashima 34-m telescopes were detected at the correlator facility for the KSP network which is located at Koganei, Tokyo.

4. Technical Staff for the Kashima 34-m Radio Telescope

Engineering and technical staff members who are contributing to observations and operations of the Kashima 34-m are listed below.

- Noriyuki Kurihara, Chief of the Radio Astronomical Applications Section.
- Eiji Kawai, Responsible for operations and maintenances.
- Junichi Nakajima, Responsible for the overall performance and improvements of the 34-m radio telescope.
- Yasuhiro Koyama, Field system and monitoring software development.
- Mamoru Seiko, Hydrogen maser systems and reference frequency signals.
- Hiroshi Okubo, Technical staff for mechanical and receiver systems.
- Hiroo Osaki, Technical staff for software and mechanical systems.
- Yuki Watababe, Engineer from Rikei Corporation.

5. Future Plans

Several mechanical modifications and preventive work are planned for the radio telescope. The antenna system is currently controlled from software developed on a mini computer (HP1000 model A400). The operating system of the antenna and the observation facilities are being replaced with

Field System version 9 under close corporation with Goddard Space Flight Center of NASA. As for the backend system, S-2 recording system will become available for pulsar VLBI observations in 1999. The ambient C-band receiver will be replaced with a new HEMT amplifier packaged in a closed cycle gas cooling system in 1999. Two Giga-bit VLBI recoeder systems and a correlator system have been placed at the observation room of the 34-m radio telescope. Experimantal observations are performed at the sampling rate of 1024Msps with the 1-bit sampling mode. These systems will be used for general observations after the performance of the system is evaluated.

References

[1] Hitoshi Takaba: VLBI Antennas of the Communications Research Laboratory, J. Commun. Res. Lab., Vol. 38, No. 3, pp. 417-433, November 1991

[2] Mamoru Sekido, Michito Imae, Yuko Hanado, Sin'ichi Hama, Junichi Nakajima, Eiji Kawai, Yasuhiro Koyama, Tetsuro Kondo, Noriyuki Kurihara, Mizuhiko Hosokawa, Yuri P. Ilyasov, Vasilli V. Oreshko, and Alexander E. Rodin: Astrometric Observation of PSR0329+54, submitted to Pub. Astron. Soc. Jpn.