Hartebeesthoek Radio Astronomy Observatory (HartRAO)

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Abstract

HartRAO is the only fiducial geodetic site in Africa, and it participates in VLBI, GNSS, SLR, and DORIS global networks, among others. This report provides an overview of steps taken during 2009 towards the repair of the 26-m radio telescope and the conversion of the 15-m Karoo Array Telescope (KAT) prototype to a radio telescope capable of performing geodetic VLBI tasks.

1. Geodetic VLBI at HartRAO

Hartebeesthoek is located 65 kilometers northwest of Johannesburg, just inside the provincial boundary of Gauteng, South Africa. The nearest town, Krugersdorp, is 32 km distant. The telescope is situated in an isolated valley which affords protection from terrestrial radio frequency interference. HartRAO uses a 26-meter equatorially mounted Cassegrain radio telescope built by Blaw Knox in 1961. The telescope was part of the NASA deep space tracking network until 1974 when the facility was converted to an astronomical observatory. The telescope is co-located with an ILRS SLR station (MOBLAS-6), an IGS GNSS station (HRAO), and an IDS DORIS station (HBMB) at the adjoining Satellite Application Centre (SAC) site.

Figure 1. HartRAO fiducial site: space geodetic techniques of VLBI, GNSS, and SLR. (Credit: M. Gaylard)

2. Technical Parameters of the 26-m Telescope of HartRAO

Table 1 contains the technical parameters of the HartRAO radio telescope and the Karoo Array Telescope (KAT) prototype, XDM (eXperimental Development Model), while Table 2 contains technical parameters of the HartRAO 26-m radio telescope's receivers. The data acquisition system consists of a Mark IV terminal and a Mark 5A recorder.

Table 1. Antenna parameters.

Parameter	**HartRAO-26 m**	**KAT 15-m XDM**
Owner and operating agency	HartRAO	HartRAO
Year of construction	1961	2007
Radio telescope mount	Offset equatorial	Az-El
Receiving feed	Cassegrain	Prime focus
Diameter of main reflector d	25.914 m	15 m
Focal length f	10.886 m	7.5 m
Focal ratio f/d	0.424	0.5
Surface error of reflector	0.5 mm	$\sim$ 2.5 mm
Short wavelength limit	1.3 cm	2 cm
Pointing resolution	0.001°	0.001°
Pointing repeatability	0.004°	not tested
Slew rate on each axis	HA: 0.5° s^{-1}	Az: 2° s^{-1}
	Dec: 0.5° s^{-1}	El: 1° s^{-1}

Table 2. 26-m receiver parameters with dichroic reflector (DR), used for simultaneous S-X VLBI, off or on.

Parameter	**X-band**	**S-band**
Feeds	dual CP conical	dual CP conical
Amplifier type	cryo HEMT	cryo HEMT
T_{sys} (DR off) (K)	60	44
T_{sys} (DR on) (K)	70	50
S_{SEFD} (DR off) (Jy)	684	422
S_{SEFD} (DR on) (Jy)	1330	1350
Point source sensitivity (DR off) (Jy/K)	11.4	9.6
Point source sensitivity (DR on) (Jy/K)	19	27
3 dB beamwidth (°)	0.092	0.332

3. Current Status and Future Plans

Due to the failure of the 26-m radio telescope's south polar bearing on the 3rd of October 2008, shortly after the CONT08 campaign, HartRAO has not been able to participate in any geodetic VLBI experiments during 2009. With its limited drivability, the 26-m could only be operated as a transit instrument. All systems have been kept alive. The breakdown has afforded the opportunity to embark upon thorough and long overdue maintenance tasks. The 26-m's 3.5- and 13-cm HEMT LNAs have been replaced and the old ones passed on to the 15-m XDM.

Midway through 2009 it was decided that the 26-m telescope's failed bearing would be replaced and that it would be returned to service. In October 2009 the NRF obtained the required funds for the international engineering firm, General Dynamics, to repair the 26-m telescope. The first phase consists of the construction of supports to allow the telescope structure above the main polar drive shaft to be lifted so that the south polar bearing may be replaced. The groundbreaking for the erection of the support structure was on March 23, 2010. The 26-m's return to service is currently expected in August 2010.

In order to reduce the number of frequent slews on the 26-m, the 15-m XDM (KAT prototype) will be converted for use in geodetic VLBI experiments. During 2009 and early 2010, a prototype S-X feed/receiver was designed for the XDM and underwent extensive testing. Production of a cryogenic system has begun. The XDM's time to enter geodetic VLBI service is currently not known.

We hope to acquire additional VLBI terminal components (e.g., sampler) so that the 26-m and the 15-m will be able to participate in VLBI simultaneously, with the regular geodetic VLBI sessions being off-loaded to the 15-m. Jonathan Quick has made good progress in adapting the 26-m's NCCS (New Control Computer System) so that it can be used to control the 15-m XDM. Ludwig Combrinck is supposed to survey in the 15-m XDM with the other co-located geodetic instruments. The continued use of the 26-m radio telescope with the addition of the 15-m XDM for geodetic VLBI sessions, should allow sufficient time for the envisaged new fundamental geodetic station with its VLBI2010 radio telescope to establish itself as a fiducial site.

Planning for the construction of a GGOS antenna at the Matjiesfontein outstation site continued at both Space Geodesy Observatory workshops held in Matjiesfontein during 2009. The workshop in March was attended by interested parties from the German Space Operations Center (DLR/GSOC), Hermanus Magnetic Observatory (HMO) as well as the Council for Geosciences (CGS). Plans are also under discussion for the construction of a GGOS antenna in Mozambique in collaboration with South Africa's Department of Science and Technology (DST).

The Space Geodesy Programme is an integrated program, combining VLBI, SLR, and GNSS, and it is active in several collaborative projects with GSFC, JPL, and GFZ (Potsdam) as well as numerous local institutes. Collaboration also includes CNES/GRGS/OCA and the ILRS community in a Lunar Laser Ranger (LLR) project with local support from the University of Pretoria and the National Laser Centre (CSIR), among others. General information as well as news and progress on Geodesy and related activities can be found at `http://geodesy.hartrao.ac.za/`.

Figure 2. 15-m XDM: the KAT prototype is to be converted to a radio telescope capable of performing geodetic VLBI experiments. (Credit: M. Gaylard)

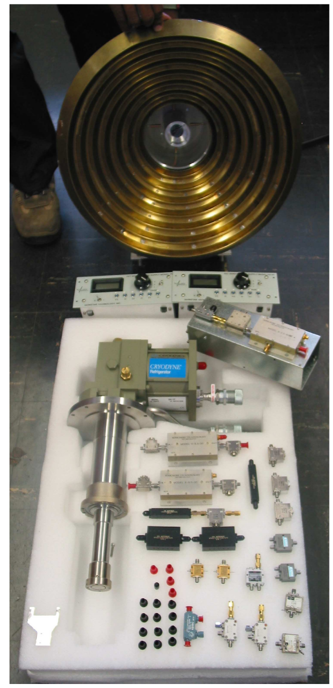

Figure 3. XDM feeds and receiver: prototype S-X feeds and components for the receiver. (Credit: R. Myataza

Figure 4. Groundbreaking: cutting the slab for the construction of the 26-m's A-frame support; in the background, the XDM is being put through its paces using the adapted 26-m observing scheduler. (Credit: M. Gaylard)

Figure 5. Rebars ready: steel reinforcing bars for the A-frame support's three concrete foundation slabs are ready to go into the ground. (Credit: M. Gaylard)