Hartebeesthoek Radio Astronomy Observatory (HartRAO)

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Abstract

HartRAO provides the only fiducial geodetic site in Africa, and it participates in global networks for VLBI, GNSS, SLR, and DORIS (located at the adjoining South African National Space Agency Earth Observation (SANSA EO)). This report provides an overview of the geodetic VLBI activities and HartRAO's 50th anniversary during 2011.

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 currently 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 South African National Space Agency Earth Observation (SANSA EO) site. HartRAO became a full member of the EVN on the 11th of May 2011.

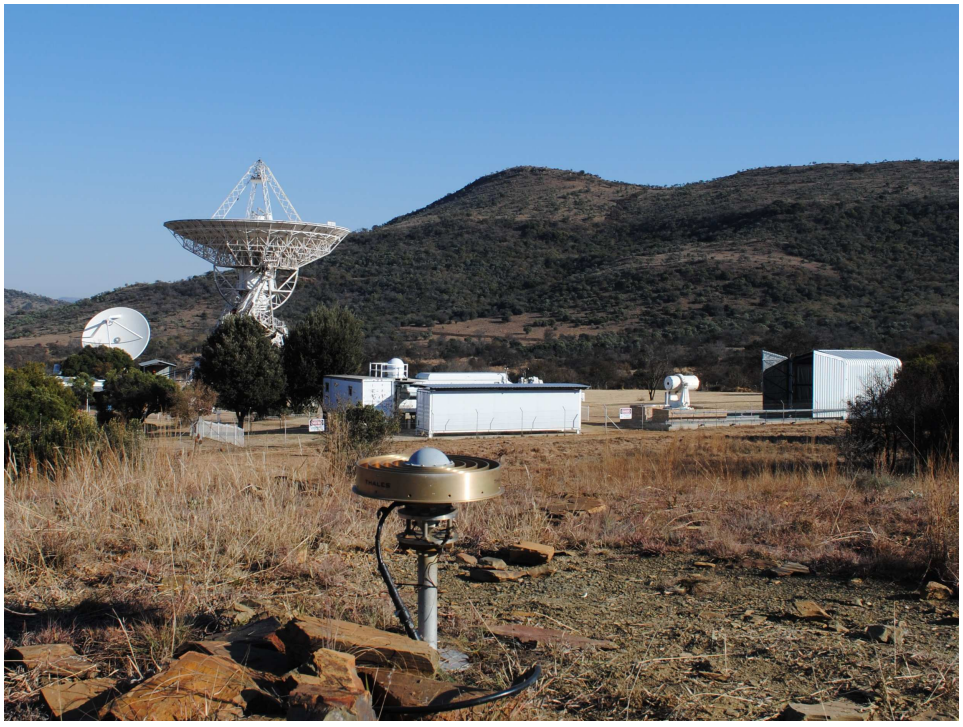

Figure 1. The 26-m antenna and 15-m KAT-prototype antenna, IGS GPS antenna, NASA Moblas-6 SLR and LLR under development. (Credit: L. Combrinck)

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

Table 1 contains the technical parameters of the HartRAO 26-m radio telescope and the 15-m Karoo Array Telescope (KAT) prototype antenna, while Table 2 contains technical parameters of the HartRAO 26-m radio telescope's receivers. The current data acquisition system consists of a Mark 5 terminal and a Mark 5B recorder.

Table 1. Antenna parameters.

Parameter	**HartRAO 26-m**	**HartRAO 15-m**
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 (RMS)	$0.5\,mm$	$\sim 2.5\,mm$
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: $0.5^\circ\ s^{-1}$	Az: $2^\circ\ s^{-1}$
	Dec: $0.5^\circ\ s^{-1}$	El: $1^\circ\ s^{-1}$

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 $(^\circ)$	0.092	0.332

3. Current Status

A bearing replacement before age 50 did not hamper the performance of the HartRAO 26-m radio telescope. Position time series solutions indicate that the repair of the 26-m's south polar bearing did not cause any noticeable shift in the telescope's position. During September 2011, shortly after celebrating its 50th birthday on the 1st of July 2011, the 26-m successfully participated

in the CONT11 campaign, needing to make use of only one of the scheduled maintenance periods. Earlier the data acquisition system was upgraded with a Mark 5 (VSI-4) sampler and the recorder upgraded to Mark 5B, with the first experiment following the upgrade taking place on the 11th of July. Another first was the commencement of e-transfers of geodetic VLBI data starting on the 21st of February 2011 with R1 data destined for the Bonn correlator. Telescope time allocation for geodetic VLBI was increased to 63 24-hour experiments in 2011 to include the CONT11 campaign (Table 3). Table 4 lists the HartRAO station staff who are involved in geodetic VLBI. Jonathan Quick (VLBI friend) provides technical support for the Field System as well as for hardware problems. Further progress was made with the conversion of the 15-m KAT prototype to a geodetic VLBI capable antenna with the new co-axial dual circular polarization S/X (2.3 and 8.4 GHz) prime-focus cryogenic receiver now successfully calibrated in laboratory tests, showing average system temperatures of ∼32K at S and ∼29K at X. In preparation for the installation of the S/X receiver, the original XDM (eXperimental Design Model) multi-feed receiver system "Stargate" and its parallactic rotation stage have been removed from the 15-m's prime focus, and installation of helium and vacuum lines is in process.

Table 3. Geodetic VLBI experiments HartRAO participated in during 2011.

Experiment	**Number of Sessions**
R1	26
CONT11	15
CRDS	6
RDV	5
RD	4
OHIG	3
CRF	2
T2	2
Total	63

Table 4. Staff supporting geodetic VLBI at HartRAO.

Name	**Function**	**Program**
L. Combrinck	Program Leader	Geodesy
J. Quick	Hardware/ Software	Astronomy
R. Botha	Operator	Geodesy
J. Grobler	Operator	Technical
L. Masongwa	Operator	Technical
R. Myataza	Operator	Technical
M. Nickola	Logistics/ Operations	Geodesy
P.Stronkhorst	Operator	Technical

4. Future Plans

Conversion of the 15-m KAT prototype antenna for use in geodetic VLBI experiments should hopefully be completed during early 2012. Two DBBC back-ends have recently arrived at HartRAO and are undergoing acceptance testing. A spare Mark 5B+ recorder has also been procured with a third recorder (for electronic data shipment) on order. The Lunar Laser Ranger (LLR) housing has been completed, and refurbishment of the telescope and design of other LLR subsystems will proceed during 2012.

Figure 2. 15-m XDM's S/X receiver package looking at sky during noise temperature tests. (Credit K. Jones)

Figure 3. S/X receiver with integral feed to be installed at XDM prime focus. (Credit M. Nickola)

Figure 4. A coin minted in 1961 indicates the year the foundation for the 26-m was laid. (Credit: M. Gaylard)

Figure 5. Mechanical supervisor, André van der Merwe, inspects the LLR telescope and its housing. (Credit: L. Combrinck)

Acknowledgements

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/`.