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. This report provides an overview of geodetic VLBI activities at HartRAO during 2012, including the conversion of a 15-m alt-az radio telescope to an operational geodetic VLBI antenna.

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 away. 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 is a full member of the EVN.

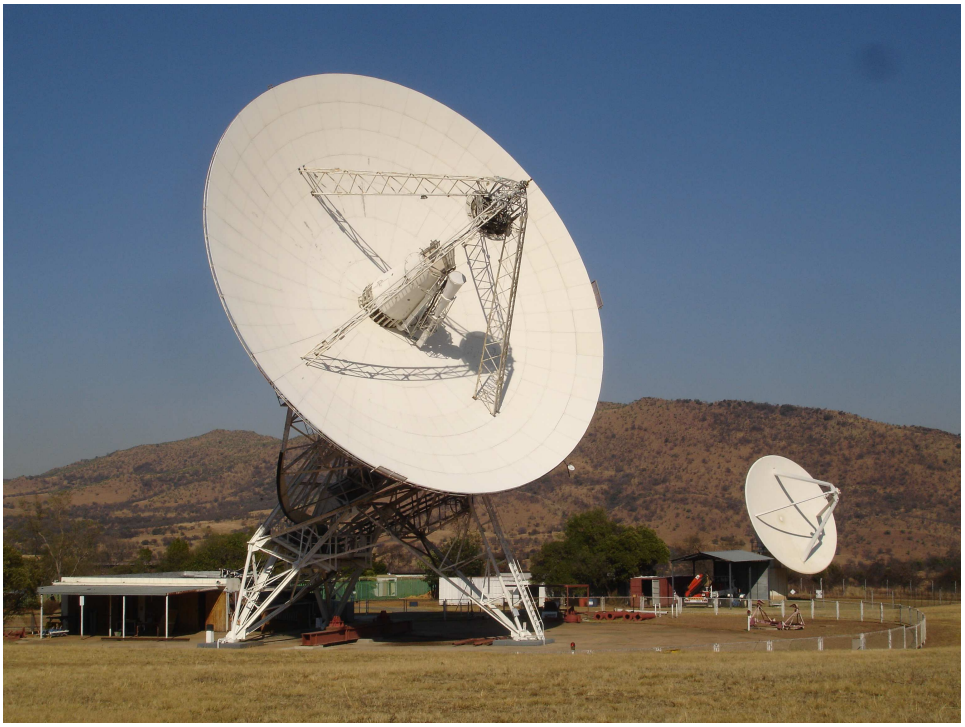

Figure 1. The HartRAO 26-m observing a source during R1551 on September 11, 2012, with the 15-m operating in tag-along mode as part of a commissioning test. (Credit: M. Gaylard)

2. Technical Parameters of the 26-m and 15-m Telescopes of HartRAO

Table 1 contains the technical parameters of the HartRAO 26-m and 15-m radio telescopes, while Table 2 contains technical parameters of the HartRAO 26-m and 15-m receivers. The current data acquisition system consists of a Mark 5 terminal and a Mark 5B+ recorder. Another two Mark 5B+ recorders are used, one with the 15-m and one for e-transfer of data. Two DBBC terminals have been acquired and will replace the Mark 5 terminal once FS support is available and recorders have been upgraded to Mark 5C. Three hydrogen masers are available for use, namely the iMaser 72, which is currently employed during geodetic VLBI, as well as two spares - EFOS-28 and the resuscitated EFOS-6.

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	0.42	0.5
Surface error of reflector (RMS)	$0.5\,mm$	$1.6\,mm$
Short wavelength limit	$1.3\,cm$	$2\,cm$
Pointing resolution	0.001°	0.001°
Pointing repeatability	0.004°	0.004°
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 and 15-m receiver parameters. The degraded performance of the 26 m is due to the use of the dichroic reflector for simultaneous S- and X-band VLBI.

	26-m Dish		**15-m Dish**	
Parameter	**X-band**	**S-band**	**X-band**	**S-band**
Feeds	dual CP conical	dual CP conical	stepped horn	wide-angle coaxial corrugated horn
Amplifier type	cryo HEMT	cryo HEMT	cryo HEMT	cryo HEMT
T_{sys} (K)	52	40	40	42
S_{SEFD} (Jy)	849	1190	1400	1050
PSS (Jy/K)	16.3	29.8	35	25
3 dB beamwidth (°)	0.096	0.418	0.16	0.57

3. Current Status

Conversion of the 15-m KAT prototype to an operational telescope for geodetic VLBI started on March 30, 2012 with the installation of the S/X (2.3 and 8.4 GHz) prime-focus cryogenic receiver. On June 6, 2012, during cooled operation, the 15-m co-observed the radio galaxy 3C123 in test mode, together with the 26-m. As part of its commissioning, the 15-m participated in four R4 sessions during October and November 2012, and it produced data of acceptable quality. On November 29, it joined in Ultra-Rapid sessions for the determination of EOP. The last of these three sessions for 2012, UR1203 on December 17, was run remotely from home by Jonathan Quick. The 26-m had already started participating in Ultra-Rapid sessions with Tsukuba, Japan, at the end of August 2012, but the 15-m is capable of much faster slewing rates, making it ideally suited for these types of observations. The 15-m can also observe down to horizon level in all directions, whereas the equatorially-mounted 26-m has limited sky coverage to the south. Currently, geodetic VLBI data from all sessions, barring the RDV sessions, are being e-transferred to the correlators. Telescope time allocation for geodetic VLBI consisted of 59 24-hour experiments in 2012 (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.

Table 3. Geodetic VLBI experiments in which HartRAO participated during 2012.

Experiment	Number of Sessions
R1	29
RD	8
CRDS	7
T2	6
CRF	3
OHIG	3
RDV	3
Total	59

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
C. Zondi	Operator	Technical

4. Future Plans

The idea is to lighten the 26-m antenna's workload considerably, offloading as many of the geodetic VLBI observations as possible onto the quick-slewing, all-sky seeing 15 m. We are actively pursuing implementation of VLBI2010, for which extra funding will be needed. HartRAO will be represented by radio astronomer Alet de Witt in the IAU's working group aimed at creating the next generation full-sky celestial reference frame (ICRF3). A tide gauge and seismometer will be added to the 2012 installation of a new GNSS station at Gough Island. Lunar Laser Ranger (LLR) refurbishment and design will proceed during 2013.

Figure 2. 15-m XDM's S/X receiver package being hoisted into position for prime-focus installation. (Credit M. Gaylard)

Figure 3. The 15-m, with cryogenically cooled receiver, co-observing radio galaxy 3C123 together with the 26-m. (Credit M. Gaylard)

Figure 4. On August 7, these visitors enjoyed the first snow at HartRAO since the NASA days in the 1960s. (Credit: F. Majola)

Figure 5. Ludwig Combrinck with the GNSS antenna installed on Gough Island in the South Atlantic Ocean.

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/`.