

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 2013, including the 15-m radio telescope officially joining geodetic VLBI operations as well as the funding of the first African VGOS site.

1 Geodetic VLBI at HartRAO

Hartebeesthoek is located 65 km northwest of Johannesburg, just inside the provincial boundary of Gauteng, South Africa. The nearest town, Krugersdorp, is 32 km away. The telescopes are situated in an isolated valley which affords protection from terrestrial radio frequency interference. HartRAO currently uses both a 26-meter and a 15-meter radio telescope. The 26-m is an 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 15-m is an alt-az radio telescope built as a Square Kilometre Array (SKA) prototype during 2007 and converted to an operational geodetic VLBI antenna during 2012. The telescopes are collocated with an ILRS SLR station (MOBLAS-6), an IGS GNSS station (HRAO), and an IDS DORIS station (HBMB) at the adjoining South African National

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Space Agency Earth Observation (SANSA EO) site. HartRAO is also a full member of the EVN.



Fig. 1 The HartRAO 26 m under repair after a thunderstorm and lightning strike during the Ultra-rapid R1579 on 2 April 2013 (with the 15 m in the background).

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 and Table 3 contain technical parameters of the HartRAO 26-m and 15-m receivers, respectively. The current data acquisition systems consist of a DBBC terminal and a Mark 5B+ recorder for both the 26 m and the 15 m. A Mark 5B and a Mark 5C recorder are used for e-transfer of data and conditioning and testing of disk packs. Three hydrogen masers are available for use,

namely the iMaser 72, which is currently employed for VLBI on the 26 m, as well as two spares — EFOS-28, currently employed on the 15 m, and the resuscitated EFOS-6.

Table 1 Antenna parameters.

Parameter	HartRAO	Hart15M
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 Dec: 0.5° s ⁻¹	Az: 2° s ⁻¹ El: 1° s ⁻¹

Table 2 26-m receiver parameters (degraded performance due to dichroic reflector being used for simultaneous S-X VLBI).

Parameter	X-band	S-band
Feeds	dual CP conical	dual CP conical
Amplifier type	cryo HEMT	cryo HEMT
T_{sys} (K)	52	40
S_{SEFD} (Jy)	849	1190
PSS (Jy/K)	16.3	29.8
3 dB beamwidth (°)	0.096	0.418

Table 3 15-m co-axial receiver parameters.

Parameter	X-band	S-band
Feeds	stepped horn	wide-angle corrugated horn
Amplifier type	cryo HEMT	cryo HEMT
T_{sys} (K)	40	42
S_{SEFD} (Jy)	1400	1050
PSS (Jy/K)	35	25
3 dB beamwidth (°)	0.16	0.57

3 Current Status

The 15 m was operating in test mode at the start of 2013, participating in three Ultra-Rapid sessions with

Tsukuba and Onsala during January and February 2013. One of these sessions, R1573 on 18 February 2013, was run in tag-along mode. The 15 m made its official debut during another Ultra-rapid session with Tsukuba and Onsala — R1580 on 8 April 2013. It joined the 26 m for the first time on 5 August 2013 during the Ultra-rapid, R1597, with Onsala and Yarragadee. Another seven dual experiments were performed during the year with the 15-m maser having to be offset in frequency to prevent PCAL cross-correlation. R1597 was also to be the first formal session with HART15M using the DBBC under FS control. On the 19th of September, the 15 m participated in its first official R4, followed by another three R4s for 2013, with the last one, R4616 on 19 December 2013, wrapping up 2013 observing session proceedings at HartRAO. The 15 m also replaced the 26 m in the penultimate session of the year adding an RD session to its tally. The 15 m participated in the AUSTRAL sessions, a Southern Hemisphere observing program, together with the AuScope antennas and Warkworth's 12 m. AUSTRAL sessions 10-16 were run over a period stretching from July to November 2013 with a 15-day continuous AUSTRAL-CONT campaign starting on the 28th of November and finishing up on 16 December 2013. All AUSTRALs, and most other sessions in which the 15 m participated, were run under remote control by Jonathan Quick. During 2013, the 26 m participated in, amongst others, nine Ultra-rapid sessions (R1/T2/RD) — seven together with Onsala and Tsukuba and two with Onsala and Yarragadee. The 26 m switched to using DBBC and Mark 5B+ in its penultimate session for 2013, R1616 on the 16th of December. Geodetic VLBI data for all but the RDV sessions (excluding those sessions where disk packs failed) were e-transferred to the correlators. Telescope time allocation for geodetic VLBI in 2013 consisted of 56 and 37 24-hour experiments for the 26 m and 15 m, respectively (Table 4). Webcams installed for both telescopes may be accessed via HartRAO's webpage. During September 2013, Ludwig Combrinck installed a tide gauge on Gough Island. A seismic vault containing a seismometer, gravimeter, and accelerometer has also been installed on site at HartRAO.

Table 4 Geodetic VLBI experiments in which HartRAO participated during 2013.

Experiment	No. of sessions on 26 m	No. of sessions on 15 m
R1	25	10
RD	8	1
T2	7	0
CRDS	6	0
CRF	4	0
OHIG	3	0
RDV	3	0
R4	0	4
AUST	0	7
AUST13	0	15
Total	56	37

4 Personnel

Table 5 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. Radio astronomer Alet de Witt attended the VLBI Training School and the 21st European VLBI for Geodesy and Astrometry (EVGA) Working Meeting held in Espoo, Finland in March 2013. During this meeting and the subsequent Journées 2013 “Systèmes de Référence Spatio-Temporels” at the Observatoire de Paris, France in September 2013, Alet represented HartRAO in the IAU’s ICRF3 working group. Alet and microwave engineer Ronnie Myataza participated in the Seventh IVS Technical Operations Workshop presented at Haystack Observatory in May 2013. Space Geodesy student Denise Dale and Marisa Nickola (geodetic VLBI support) attended the VieVS Fourth User Workshop in Vienna, Austria during September 2013.

Table 5 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

5 Future Plans

Looking at the preliminary schedule for 2014, the 26-m antenna’s geodetic workload has been reduced significantly, with only 25 of the 131 sessions allocated to HartRAO being run on the 26 m. Hart15M will participate in both the CONT14 and AUST14 continuous campaigns during May 2014 and November/December 2014, respectively. The good news is that funds have been allocated for the VLBI2010 VGOS antenna. It is to be built on site, and an appropriate location for the antenna has already been identified to the north of the 26 m and the SLR station. With funding for the VGOS antenna having been allocated over the next three years (2014-2016), the process of procuring the antenna is expected to start in 2014. A VGOS site investigation, including geotechnical and RFI studies, will be pursued during 2014. A site tie is also planned for the early part of the year. Work on the Lunar Laser Ranger (LLR) project will continue during 2014. HartRAO intends sending a sizeable delegation to the 8th IVS General Meeting to be held in Shanghai, China, in early March 2014, in order to put in a bid for hosting the next IVS General Meeting in 2016. During this meeting, Alet will once again participate in the IAU’s ICRF3 working group discussions.

Acknowledgements

HartRAO is a National facility operating under the auspices of the National Research Foundation (NRF), South Africa. 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/>.



Fig. 2 Ronnie and Lerato in the microwave lab measuring T_{rec} of the 26 m's 3.5-cm Dicke switch cryogenically cooled receiver.



Fig. 5 Ludwig installing a tide gauge on Gough Island in the South Atlantic Ocean.



Fig. 3 T_{sys} measurements of the 26-m antenna's 3.5-cm Dicke switch cryogenically cooled receiver and feed.



Fig. 6 Hardware gecko — luckily these days data are being e-transferred.



Fig. 4 Ronnie at the entrance to the vault with the 26 m and the 15 m behind him and the SLR and the LLR to his right.