Hartebeesthoek Radio Astronomy Observatory (HartRAO)

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Abstract

HartRAO, the only fiducial geodetic site in Africa, participates in VLBI, GPS and SLR global networks. This report provides an overview of our geodetic VLBI activities during 2006. New VLBI research is reported. In order to meet future requirements of geodetic VLBI, we have initiated the first steps towards founding a new space geodetic station which will cater to new developments and challenges as addressed by VLBI2010 and future requirements of GPS and SLR/LLR.

1. Geodetic VLBI at HartRAO

Hartebeesthoek is located 65 kilometers north-west of Johannesburg within the World Heritage Site known as the Cradle of Humankind, 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 interference. HartRAO uses a 26-metre equatorially mounted Cassegrain radio telescope built by Blaw Knox in 1961. The telescope was part of the NASA deep space tracking network until 1975 when the facility was converted to an astronomical observatory. The telescope is co-located with an SLR station (MOBLAS-6) and an IGS GPS station (HRAO). HartRAO joined the EVN as an associate member during 2001. Astronomical and geodetic VLBI have been allocated equal shares (15% each) of telescope time. The allocation for geodetic VLBI has been increased for 2007.

Figure 1. Our new director, Prof. Roy Booth.

Figure 2. The dish - sunset and clouds from an approaching cold front.

2. Technical Parameters of the VLBI Telescope of HartRAO

The feed horns used for 13 cm and 3.5 cm are dual circularly polarised conical feeds. The RF amplifiers are cryogenically cooled HEMTS. Tables 1, 2 and 3 contain the technical parameters of the HartRAO radio telescope, its receivers and recording systems. The Jan/Feb OHIGs were

recorded to tape. Hours before the RDV was due to start on the 25th of April 2006, the Mark IV tape drive failed, forcing the Mark 5 to take over the reins. On the 23rd of May, Cynthia Thomas's e-mail made this official - "[from now on] HartRAO will be on the schedule with disk only".

Table 1. Antenna parameters.

Parameter	**HartRAO-VLBI**
Owner and operating agency	HartRAO
Year of construction	1961
Radio telescope mount	Offset equatorial
Receiving feed	Cassegrain
Diameter of main reflector d	$25.914\,m$
Focal length f	$10.886\,m$
Focal ratio f/d	0.424
Surface error of reflector	$< 0.5\,mm$
Wavelength limit	$< 1.0\,cm$
Pointing resolution	0.001°
Pointing repeatability	0.020°

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

Parameter	**X-band**	**S-band**
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

Table 3. VLBI recording systems.

Parameter	**HartRAO-VLBI**
VLBI terminal	Mark IV
VLBI recorder	Mark 5A, Mark IV, S2

3. Staff Members Involved in VLBI

Dr Roy Booth has taken over as Director from the 1st of July 2006. Table 4 lists the HartRAO station staff who are involved in geodetic VLBI. Jonathan Quick (VLBI friend) has continued to provide technical support for the Field System as well as for hardware problems.

Table 4. Staff supporting geodetic VLBI at HartRAO.

Name	Function	Programme
Ludwig Combrinck	Programme Leader	Geodesy
Jonathan Quick	Hardware/Software	Astronomy
Sarah Buchner	Training	Astronomy
Marisa Nickola	Logistics/Operations	Geodesy
Pieter Stronkhorst	Operator	Technical
Gert Agenbag	Operator	Geodesy - student
Joel Ondego Botai	VLBI research	Geodesy - student
Roelf Botha	Operator	Geodesy - student
Attie Combrink	Operator	Geodesy - post doctoral researcher
Sakia Madiseng	Operator	Geodesy - student
Mojalefa Moeketsi	Operator	Geodesy - student
Vasyl Suberlak	Operator	Geodesy - post doctoral researcher

4. Current Status

During 2006 HartRAO participated in 52 experiments (Table 5), which utilised the telescope time allocated to geodetic VLBI to its fullest extent.

Table 5. Geodetic VLBI experiments HartRAO participated in during 2006.

Experiment	Number of Sessions
R1	28
CRDS	10
OHIG	6
CRF	3
T2	3
RDV	2
Total	52

In 2006, our two Ph.D. students, Joel Ondego Botai and Attie Combrink, in collaboration with the SA Weather Service, started to analyse VLBI-derived precipitable water vapour (PWV) estimates. Comparisons were made with PWV estimates from GPS, radiosondes and two water vapour radiometers (WVR) on loan from BKG (Germany) and ETHZ (Switzerland). Ongoing **research** will include attempts to improve VLBI baseline repeatabilities using WVR-derived tropospheric signal path delays. One of the WVRs is being returned to ETHZ and we would like to thank them for making the instrument available to us for more than a year.

Microwave holography is to be used to obtain the best overall surface shape after the **antenna surface upgrade**. The holographic system is finally phase stable after replacing the original system with a small reference dish on the main antenna and using a common local oscillator. HF low loss cables for the holography dish are being replaced with a much cheaper cylindrical waveguide built with standard A1 pipes.

Figure 3. Holography on the edge - Ben Klein showing off his reference antenna.

Figure 4. XDM - pedestal and mould.

5. Future Plans

The eXperimental Development Model (XDM) is a 15-m diameter radio telescope being built at Hartebeesthoek as a prototype for the Karoo Array Telescope (KAT), which will be used to test technology leading up to development of the Square Kilometer Array (SKA). Once the XDM has been tested and its frequency range determined, geodetic VLBI might prove to be a suitable application.

We have taken initial steps towards the development of a new integrated Space Geodesy Facility which will support SLR, LLR, VLBI and GPS as well as host other earth science instrumentation. This will mean the construction of a new site, development and implementation of new state of the art equipment and will place the southern hemisphere and especially Africa securely in the space geodesy arena for the next several decades. Matjiesfontein in the arid Karoo region of the Western Cape province has been identified as a potential site. Initial geological site surveys have already been conducted and a Working Group on the future of Space Geodesy in South Africa has been established. We would like to invite possible participants in this venture to contact us. The Geodesy Programme is an integrated programme, supporting VLBI, SLR and GPS and is active in several collaborative projects with GSFC, JPL, GFZ (Potsdam) and local institutes.