Hartebeesthoek Radio Astronomy Observatory (HartRAO)

Ludwig Combrinck, Marisa Nickola

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 2005. The status of the 26m radio telescope surface upgrade 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.

Figure 1. Radio telescope with beam of SLR passing overhead and Moon and Venus to the left.

Figure 2. Anemometer on roof—the radio telescope is parked at zenith for 5 minutes when the wind speed exceeds 50 km/h.

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. Our Mark 5 recording unit has been in use since mid-May 2004 and the majority of 2005 experiments have been recorded to disc (exceptions being the use of tape in an RDV, the 6 OHIGs and 2 CRDSs).

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

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
Attie Combrink	Operator	Geodesy
Gert Agenbag	Operator	Geodesy - student
Roelf Botha	Operator	Geodesy - student
Sakia Madiseng	Operator	Geodesy - student
Mojalefa Moeketsi	Operator	Geodesy - student
Vasyl Suberlak	Operator	Geodesy - post doctoral researcher

4. Current Status

During 2005 HartRAO participated in 69 experiments, including 15 CONT05 experiments (Table 5), compared to 56 in the previous year, which utilised the telescope time allocated to geodetic VLBI to its fullest extent.

Table 5. Geodetic VLBI experiments HartRAO participated in during 2005.

Experiment	Number of Sessions
R1	20
C05	15
CRDS	9
R4	6
OHIG	6
CRFS	4
CRF	4
T2	3
RDV	3
CRF	3
Total	69

During the CONT05 campaign HartRAO was joined by TIGO in Chile, boosting the number of southern hemisphere participants to two. At HartRAO, geodetic VLBI was supported by co-located SLR and GPS, as well as DORIS at the adjacent Satellite Application Centre of the CSIR. Two water vapour radiometers (WVRs) made their home at HartRAO, one on long-term loan from BKG, Germany, the other on a 6-month loan from ETHZ, Switzerland. The new high-accuracy surface on the 26-m telescope and the consequential rebalancing of the structure with three tonnes of lead required the implementation of a new pointing model which Jonathan Quick had ready in

Figure 3. *Attie Combrink inspects one of the water vapour radiometers on the roof of the main observatory building.*

Figure 4. *Holographic setup—reference antenna to collect 12 GHz signal transmitted from geostationary satellite.*

time for the start of the CONT05 campaign on September 12. Astronomer Dr Mike Gaylard, also lent his support for the CONT05 campaign by creating and maintaining a CONT05 webpage.

The **antenna surface upgrade** has now reached the stage where microwave holography is to be used to determine the overall shape of the dish. Based on the results of the holography, individual panels will be adjusted to obtain the best overall surface shape. Several **antenna sub-system upgrades** have been undertaken: A membrane dryer replaced the dry air compressor to supply dry air to the receiver systems and radomes. A new Drytel rotary-vane and turbo combination vacuum pump, which works at any orientation, and remote-controlled electro-pneumatic vacuum valves replaced the old "wet" rotary-vane vacuum pump and manual valves allowing for continued operation *even when pumping and cooling down warmed-up systems.* An anemometer was installed to monitor wind speeds on site. When the computer detects instantaneous wind speeds in excess of 50 km/h, the antenna is automatically stowed to zenith for 5 minutes.

5. Future Plans

We have started 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. 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.