Hartebeesthoek Radio Astronomy Observatory (HartRAO)

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Abstract

HartRAO, the only fiducial geodetic site in Africa, participates in VLBI, GNSS, and SLR global networks, among others. This report provides an overview of our geodetic VLBI activities and research during 2007. Further developments regarding the proposed new fundamental space geodetic observatory in the Karoo are presented.

1. Geodetic VLBI at HartRAO

Hartebeesthoek is located 65 kilometers northwest 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 GNSS station (HRAO). HartRAO joined the EVN as an associate member during 2001. Geodetic VLBI has been allocated 16% of the available telescope time. The allocation for geodetic VLBI was increased from 52 24-hour experiments in 2006 to 58 in 2007.

Figure 1. The 26-m HartRAO radio telescope with the 15-m XDM in the background. The XDM is a testbed prototype for the Karoo Array Telescope (KAT), which, in turn, will be used to test technology leading up to development of the Square Kilometer Array (SKA).

Figure 2. Andrew Masiteng and Richard Moralo install the dichroic reflector, which permits simultaneous observing at 3.5 and 13 cm. The dichroic has to be installed before and removed after every geodetic VLBI experiment.

2. Technical Parameters of the VLBI Telescope of HartRAO

The feed horns used for 13 cm and 3.5 cm are dual circularly polarized conical feeds. The RF amplifiers are cryogenically cooled HEMTs. Tables 1 and 2 contain the technical parameters of the HartRAO radio telescope and its receivers. The data acquisition system consists of a Mark IV terminal and a Mark 5A recorder. The obsolete Mark IV and S2 tape recorders have been removed from the control room. A 22 GHz receiver was installed on the 26-m telescope on the 1st of February 2007 and was put to the test observing Jupiter. The surface upgrade proved its worth when measurements of aperture efficiency showed the surface error near zenith to be 0.5 mm.

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	$< 1.3\,cm$
Pointing resolution	0.001°
Pointing repeatability	0.004°

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

3. Staff Members Involved in VLBI

Antenna systems technician, Jacques Grobler, and electronics technician, Lerato Masongwa, have joined the Geodetic VLBI Team as trainee operators during the second half of 2007. Table 3 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 3. Staff supporting geodetic VLBI at HartRAO.

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

4. Current Status

During 2007 HartRAO participated in 58 experiments (table 4), which utilised the telescope time allocated to geodetic VLBI to its fullest extent.

Table 4. Geodetic VLBI experiments HartRAO participated in during 2007.

Experiment	Number of Sessions
R1	32
CRDS	7
OHIG	5
RDV	5
CRF	3
R&D	2
T2	2
CRFS	1
R4	1
Total	58

The 3.5-cm receiver was removed for maintenance on the 22nd of August 2007 and, after replacing the expander, microwave technician Ronnie Myataza ran several tests to verify the receiver's performance.

Ph.D. student Joel Ondego Botai has been researching the effects of the atmosphere on the geodetic VLBI delay observable. To this end, Joel has been investigating limited area Numerical Weather Prediction (NWP) models and resolving high-frequency fluctuations of tropospheric parameters that affect VLBI observations. This should hopefully add value to station-dependent strategies of improving the accuracy of the geodetic VLBI observable.

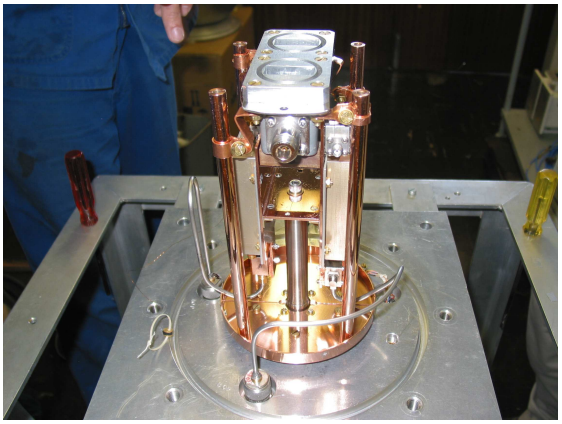

Figure 3. The 3.5-cm receiver being reassembled after repairs.

Figure 4. Some of our geodetic VLBI staff—from left to right, Jacques, Pieter, Marisa, Lerato, Jonathan, and Roelf.

5. Future Plans

Planning towards the development of a new fundamental space geodetic observatory for South Africa, the proposed International Institute for Space Geodesy and Earth Observation (IISGEO), continued during 2007. The possibility of incorporating two KAT-type dishes into the future equipment arsenal of IISGEO has been proposed by the Director of HartRAO, Prof. R. Booth. One such prototype, the 15-m diameter eXperimental Development Model (XDM), has been constructed at HartRAO, and it is expected that future models, such as smaller and lighter next-generation KAT-7 12-m paraboloid and MeerKAT 12-m offset paraboloid dishes, will be able to meet higher specifications of pointing and surface accuracy. This would enable operations for geodetic VLBI purposes in the 2-18 GHz range, compatible with VLBI2010.

The Earth Observation research unit (Space Geodesy & Remote Sensing) was conceived during 2007 in collaboration with the University of Pretoria (UP). It is to be housed at UP and is eagerly anticipated for the coming year. Lectures in Space Geodesy will be presented at undergraduate level from 2008 and such courses extended to Honours level during 2009.

The Space Geodesy Programme is an integrated programme, combining VLBI, SLR, and GNSS, and 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).