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DETERMINING HARTRAO ANTENNA PARAMETERS WITH VIEVS

ABSTRACT

The Hartebeesthoek Radio Astronomy Observatory's (HartRAO) 26m and 15m radio telescopes regularly participate in astrometric and geodetic VLBI sessions. The 26m suffered a critical bearing failure in 2008 and returned to operations in 2010 after repair. The 15m was built as SKA prototype during 2007 and converted to an operational geodetic VLBI antenna during 2012. It officially joined geodetic VLBI operations in 2013. In 2014 antenna axis offsets (AO) of both the 26m and 15m were estimated using the Vienna VLBI Software (VieVS). A discrepancy was found to exist between previously determined AO values for the 26m (from ground surveys as well as from analysis with other VLBI analysis software packages before bearing repair) and the values obtained with VieVS in 2014 from geodetic VLBI sessions before and after bearing repair. Additional geodetic VLBI sessions are analysed using VieVS to estimate the AO of both the 26m and 15m antennas and also to determine the local tie between them. Possible seasonal variations in AO as well as baseline length between the 26m and 15m are investigated. Possible displacement of the antennas due to an earthquake occurring in the vicinity of HartRAO during 2014 is also investigated. A local site tie was performed during the early part of 2014. Should results from this ground survey become available, a comparison will be made with VieVS determined values.

HARTRAO 26m

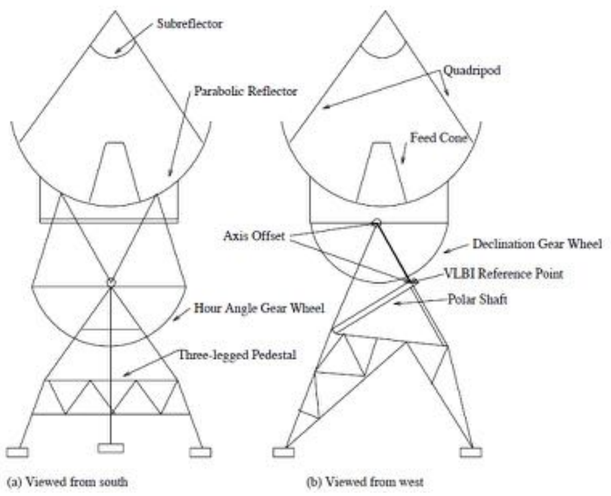

Fig. 1 Main structural components of 26m. Combrinck (1997)

Fig. 2 Ludwig Combrinck surveying 26m polar shaft during 26m's bearing repair. Credit: Mike Gaylard

> Equatorially mounted Cassegrain radio telescope built by Blaw Knox in 1961
> VLBI reference point: intersection of fixed axis (HA) with perpendicular plane containing moving axis (Dec)
> Serves as reference point for co-location of SLR and GNSS stations on-site and as reference datum for South Africa's surveying system
> 3 October 2008: critical failure of south polar bearing
> 11 August 2010: first post repair geodetic session
> Post-repair position time series solutions indicated no noticeable shift in position

HARTRAO 15m

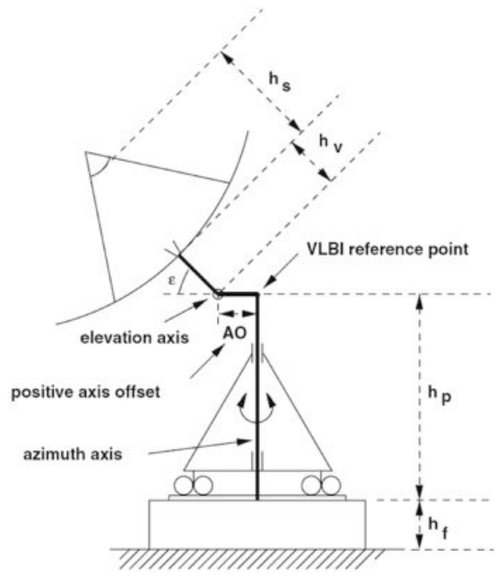

Fig. 3 Alt-azimuth telescope mount with positive axis offset. Nothnagel (2009)

Fig. 4 HartRAO 15m telescope mount with offset elevation axis. Credit: Mike Gaylard

> alt-az radio telescope built as SKA prototype during 2007
> VLBI reference point: intersection of fixed (azimuth) axis with perpendicular plane containing moving (elevation) axis
> Converted to operational geodetic VLBI antenna during 2012
> 11 October 2012: first geodetic session (as part of commissioning)
> As many as possible geodetic sessions offloaded onto quick-slewing, all-sky seeing 15m

AXIS OFFSET COMPARISON

> When telescope's rotation axes do not intersect, VLBI reference point is point represented by intersection of fixed axis with perpendicular plane containing moving axis; causes delays (geometric and dry tropospheric); has to be considered for VLBI results.

Table 1. HartRAO 26m antenna axis offset determined by independent techniques (a priori value = 6695.3 mm)

Method	Determined by	Value
Standard value	JPL, 1961	6706 mm
Conventional survey	M. Newling, 1993	6695 ± 3 mm
VLBI solution	C. Ma, 1995	6693.6 ± 2.5 mm
VLBI solution	M. Eubanks, 1995	6692.5 ± 1.5 mm
HartRAO GPS	L. Combrinck, 1995	6695.6 ± 2.3 mm
VLBI solution	C. Ma, 1996	6688.8 ± 1.8 mm
Local tie survey	Michel et al. (2005)	6695 ± 2.5 mm
VieVS solutions: Before repair (2010.8-2014.11) After repair (2010.6-2014.0) 1986-2014.0	Krasna et al. (2014)	 6699.2 ± 0.5 mm 6707.3 ± 0.8 mm 6707.3 ± 0.8 mm
VieVS solution: After repair (2010.8-2014.11) 180 sessions	Current study	6707.9 ± 0.7 mm

Table 2. HartRAO 15m antenna axis offset determined by independent techniques (a priori value = 1495.0 mm)

Method	Determined by	Value
GPS survey	A. Combrink, 2007	1495 mm
VLBI solution (from 1st IVS sessions)	GSFC, D. Gordon & S. Bolotin, 2012	1464 mm
VLBI solution	D. MacMillan, 2014	1494.1 ± 2.6 mm
VieVS solution	Krasna et al. (2014)	1495.0 ± 3.4 mm
VieVS solution: (2012.11-2015.03) 134 sessions	Current study	1499.8 ± 0. mm

SEASONAL VARIATION

Table 3. HartRAO 26m and 15m difference in antenna axis offset between a priori value and VieVS estimated value for specified months/season

Month/Season	26m dAO	15m dAO
DecJanFeb (Summer) 26m: 46 sessions 15m: 42 sessions	17.30 ± 1.67 mm	7.09 ± 2.12 mm
MarAprMay (Autumn) 26m: 31 sessions 15m: 27 sessions	5.77 ± 1.97 mm	1.41 ± 2.22 mm
JunJulAug (Winter) 26m: 44 sessions 15m: 27 sessions	13.25 ± 1.56 mm	6.67 ± 2.37 mm
SepOctNov (Spring) 26m: 59 sessions 15m:38 sessions	12.03 ± 1.06 mm	6.02 ± 2.47 mm

Table 4. HartRAO 26m and 15m difference in antenna axis offset between a priori value and VieVS estimated value for specified six monthly period

Months	26m dAO	15m dAO
Sep - Feb (Spring and Summer) 26m: 105 sessions 15m: 80 sessions	13.14 ± 0.91 mm	7.11 ± 3.78 mm
Mar - Aug (Autumn and Winter) 26m: 75 sessions 15m: 54 sessions	9.749 ± 1.23 mm	3.74 ± 1.64 mm

BASELINE

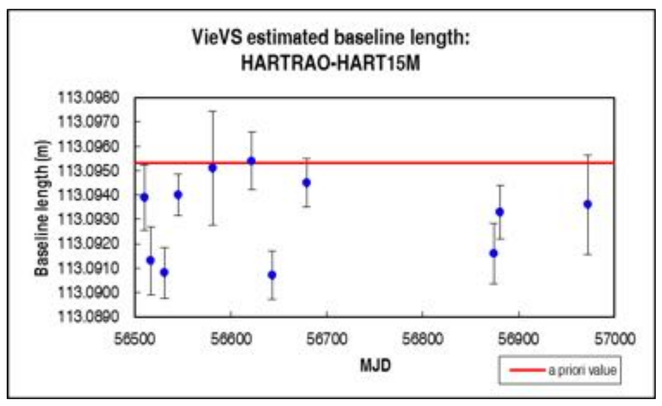

Fig. 5 Baseline lengths between 26m and 15m for 11 dual sessions during 2013 and 2014 estimated using VieVS.

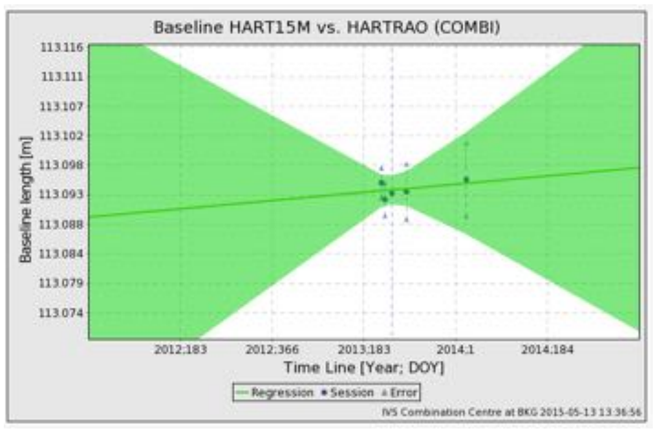

Fig. 6 Baseline lengths between 26m and 15m for 5 dual sessions during 2013 and 2014 according to BKG Combination Centre IVS.

FURTHER INVESTIGATION REQUIRED

> Discrepancy in VieVS estimate for 26m axis offset values before and after bearing repair.
> Seasonal variation of antenna axis offset: large deviation in values for autumn months (MarAprMay) compared to other months as well as large difference in values between 6 months of Spring/Summer and 6 months of Autumn/Winter for both antennas.
> Station position before and after earthquake (magnitude 5.5) of 4 August 2014 occurring within 100 km from site.

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