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HARTRAO SITE TIE MEASUREMENTS: VLBI AND GROUND SURVEY

ABSTRACT

A first short baseline VLBI experiment between the Hartebeesthoek Radio Astronomy Observatory's 26-m legacy and co-located 15-m radio telescopes has been conducted. Such short baseline experiments allow for determining the local tie between the telescopes. It also allows for discovering instrumental effects, as the telescopes share a common location, atmosphere and, for future experiments, a common clock. Once the VGOS telescope has been furnished with receivers, it will be included in these short baseline sessions. Measurements obtained by conventional survey with a total station will be used to complement the VLBI determined values. The local automated site tie system at HartRAO is currently being implemented and tested. Measurements to various on-site GNSS reference stations, NASA and Roscosmos SLRs as well as to various reference piers will be performed on a regular basis towards fully automating the system. The HartRAO 26-m, 15-m and VGOS radio telescopes will form part of these local tie measurements in due course.The methodology of these two approaches to local tie measurement as well as results from a first short baseline experiment are presented here.

VLBI: SHORT BASELINE EXPERIMENT

Description:

- Must at least be able to meet GGOS goal of 1 mm on short baseline of ~113 m between HartRAO 26-m legacy antenna and 15-m co-located antenna
- Short baseline provides for common station position, atmosphere , local geophysics (not able to run off same clock yet); short tie allows for investigating instrumental effects, antenna structure
- First short baseline session, SBL500, observed on 11 May 2018 during 4-hour session conducted from 22:00 UT to 02:00 UT (12 May 2018), away from sunset/sunrise for temperature stability
- SBL500 scheduled with VieVS - ICRF2 defining sources, X-band, 2 Gbps, covering full range of azimuth, elevation, cable wrap

Correlation and post-processing:

- SBL500 correlated at Vienna correlator with DiFX - spectral resolution of 0.2 MHz, LO frequency offsets of 9999.9 Hz applied to HARTRAO
- Post-processing, fringe fitting at Vienna correlator with HOPS, fourfit

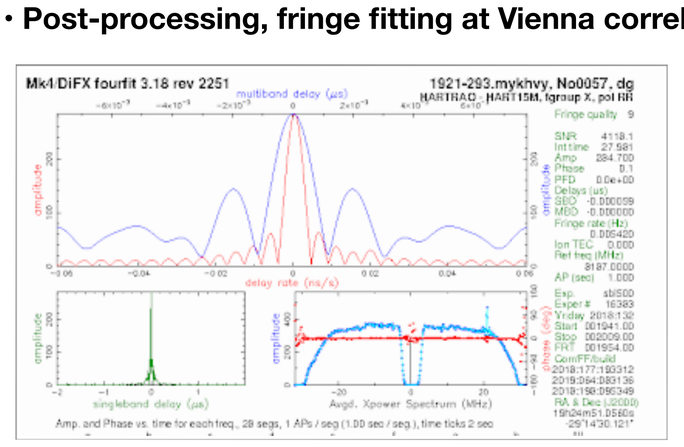

Figure 2: Fringe plot of cross-correlation of SBL500 scan No 0057.

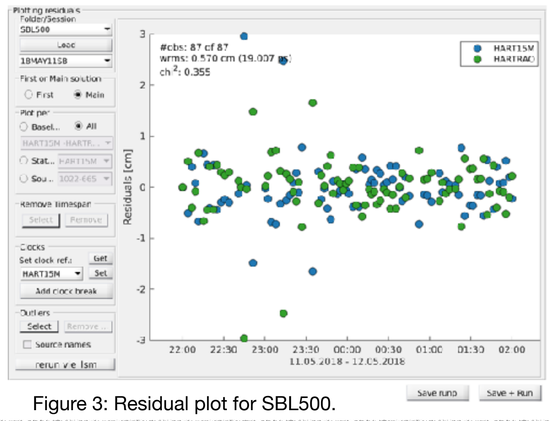

Figure 3: Residual plot for SBL500.

Figure 1: Short baseline of ~ 113 m between the HartRAO 26-m and 15-m antennas with the total station in the foreground. The planned position of a second total station installation on the roof of the control room for in-house ground survey / local tie measurements is indicated by the red arrow.

Results:

- SBL500 correlator output made available as vgosDB file
- SBL500 analysed with VieVS (not estimating EOPs, coordinates of sources with NNR condition

Table 1: Comparison of VieVS estimated values for baseline components and length in SBL500 and corresponding values measured during the 2014 local tie survey (after Phogat *et al.* 2018).

Baseline component	2014 Local tie survey measurement (m)	VieVS estimation for SBL500 (m)
X	-48.0326 ± 0.0029	-48.0353 ± 0.0015
Y	102.2991 ± 0.0207	102.2991 ± 0.0020
Z	-4.1238 ± 0.0073	-4.1286 ± 0.0012
Length	113.0895 ± 0.0187	113.0908 ± 0.0019

VLBI: LOCAL TIE GROUND SURVEY

- A local automated site tie system for continuous monitoring of vector ties is being implemented
- Measurement system: one total station (Leica MS50 Multistation) under test; additional Leica MS50 Multistation to be installed on the roof of the Control room (ref. Figs. 1 & 4) for measurement to prisms affixed to the antennas and to the reference system
- Reference system: Russian, DLR and ESA GNSS (ref. Fig. 4) to tie the measurement system in with GNSS observations to link it to the ITRF
- Targets: on 26-m - a prism mounted on each of the east and west ends of the Dec shaft as well as on the south end of the polar shaft (the north end is obscured); on 15-m - a prism at one end of the elevation shaft (the other end is obscured); also to make use of existing targets on the antenna structure; the targets will be measured by the two total stations, simultaneously, for various positions of the primary and secondary axes, respectively
- Need to determine the VLBI reference point, where the rotation axes of each of antenna intersect
- Rotation axes of 26-m polar-mount and 15-m az-el mount do not intersect, axis offset (AO) exists
- VLBI reference point is then the intersection of the fixed axis (26-m: Hour Angle, 15-m: azimuth) with the perpendicular plane containing the moving axis (26-m: Declination, 15-m: elevation)
- Indirect measurement of VLBI reference point: (1) prism is mounted with optical reference point coincident with rotation axis; (2) prism is mounted off-axis and antenna is moved about one of the rotation axes with other axis being held fixed in a particular position; targets trace an arc in a circular plane normal to axis being measured; axis intersects plane in centre of circle

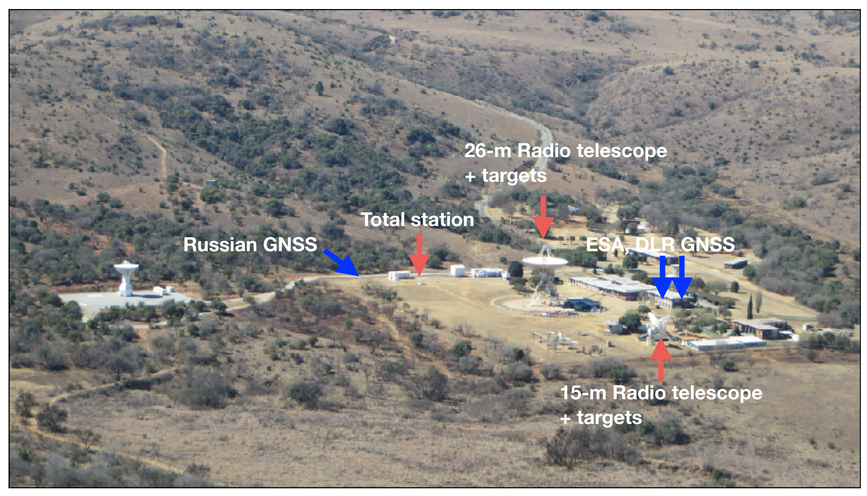

Figure 4: VLBI local tie observing system - components of measurement (red arrows) and reference (blue arrows) networks.

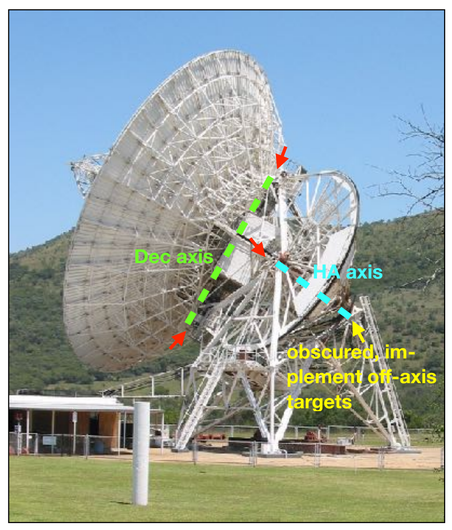

Figure 5: HartRAO 26-m polar mount - rotation axes and prism mounting points (red arrows).

Figure 6: HartRAO 15-m - cable wrap obscuring one end of elevation shaft.

Figure 7: Leica MS50 Multistation.

Figure 8: Combination of Leica prisms.

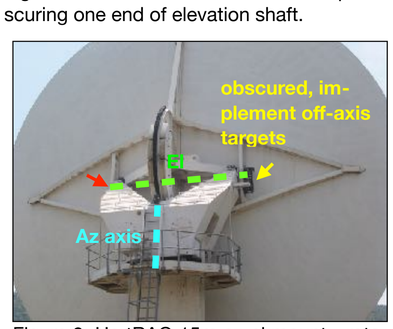

Figure 9: HartRAO 15m az-el mount - rotation axes and prism mounting point.

NEXT

- Local tie survey including all geodetic techniques on site
- Run 26-m and 15-m antennas off the same clock during SBL sessions
- Monthly SBL sessions, local tie measurements
- Investigate possible variation of the baseline length and build an error budget for SBL ties
- Include VGOS in SBL sessions (once the receiver has been installed)