

REPROCESSING OF THE HARTEBEESTHOEK 2014 CO-LOCATION SURVEY

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2014 Survey

Hartebeesthoek observatory (South Africa) is one of the few sites in the world that hosts instruments of the four space geodesy techniques: DORIS, GNSS, SLR and VLBI.

In February 2014, a local tie survey was carried out by a team of surveyors from:

- Rural Development & Land Reform,
- University of KwaZulu-Natal,
- NASA,
- IGN France.

This survey was processed using IGN's adjustment software, Comp3D v4.3.

Two SINEX files were provided in 2014 [Muller and Poyard, 2014], one for each sub-site

Hartebeesthoek Radio Astronomy Observatory sub-site



Satellite Application Center sub-site



GNSS

DORIS

Fig.1 Instruments on Hartebeesthoek observatory

Motivation for a new processing of the Hartebeesthoek Radio Astronomy Observatory sub-site

- In 2020, the International VLBI Service and Hartebeesthoek observatory asked for the precision of the offsets between the VLBI primary and secondary axes.
- Those could not be extracted from the 2014 computation due to a processing in multiple steps.
- The new version of Comp3D (5.19, 2020) has several new features, allowing to improve the computation and extract this information.

	2014 processing	2021 processing
Axes	Each VLBI, SLR and LLR rotation axis were determined separately.	Full integration of axis determination in a unique least square adjustment including all topometry data
Referencing	Two-stage procedure using a 6-parameter similarity on 4 GNSS points	Integrated in the adjustment, based on 3 azimuths determined by GNSS and vertical deflection computed from EGM2008
Weighting	• Horizontal angles: 0.0008 gon • Vertical angles: 0.0012 gon • Distances: 0.0010 m These weights were not determined accurately due to the multi-stage process	• Horizontal angles: 0.0008 gon + 0.0001/distance • Vertical angles: 0.0014 gon + 0.0001/distance • Distances: 0.0007 m + 2 ppm • Target stability: 0.0006 m on 26 m antenna, 0.0003 m on 15 m antenna, 0.0005 m on LLR, 0.0003 m on SLR

Tab.1 Comparison of local tie vector processing options

SLR/LLR and VLBI Axis processing

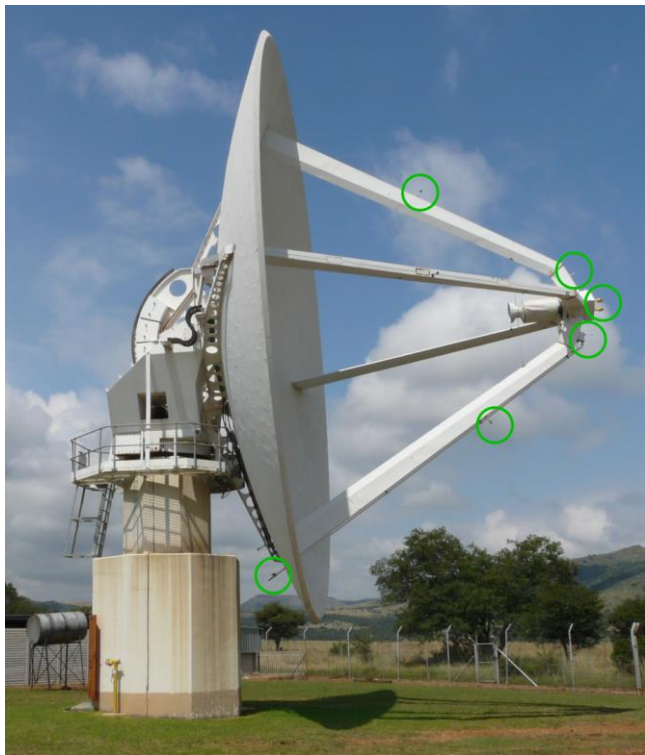


Fig.2 Targets used to determine the axes of the 15 m VLBI telescope

Due to telescope rotation, each target moves along a circle. The rotation axis connects the circle centers. Circles are orthogonal to the axis. The axis has 4 degrees of freedom and each target adds two unknowns, its circle radius and abscissa along the axis.

In the new computation, all the parameters are fitted simultaneously with all topometric observations.

Axis parametrization			
Vector		Origin	
1.0000 ± 0.0010		-80.2385	
-0.6841 ± 0.0011	$* \lambda +$	44.2766	
-0.0013 ± 0.0007		1410.0112	
Target ID	Abscissa	Radius	Positions
1	-0.27239	0.66568	4
2	-0.13788	0.73809	4
3	-0.73581	0.25815	4
4	-0.09843	0.77696	4
5	-0.90578	0.00167	2

Tab. 2 Parametrization of the horizontal axis of the SLR mount, where λ represents the abscissa on the axis

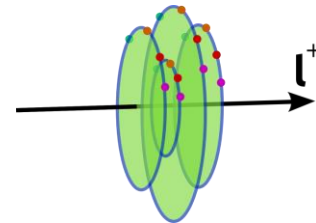


Fig. 3 Targets, circles and axis

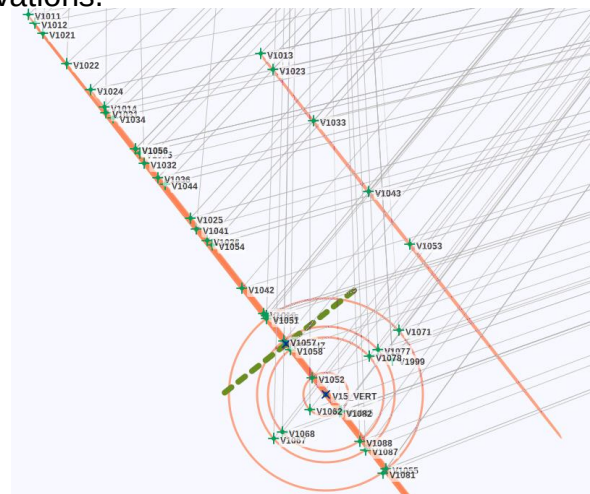


Fig. 4 Targets, observations and fitted axes on 15 m VLBI telescope

Reference points

Reference points are defined as the orthogonal projection of the secondary axis on the primary axis.

On SLR and LLR, the vertical axis has been determined with a direct observation: a survey point has been placed precisely on the axis.

The SLR official reference point (SLM) is a geodetic marker under the telescope.



Fig.5 Survey point on LLR vertical axis

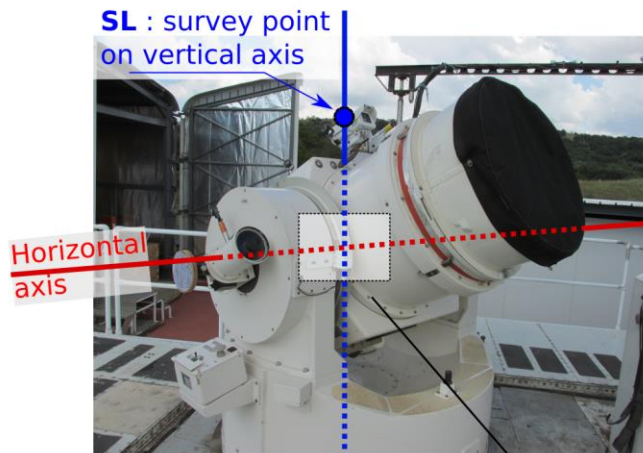
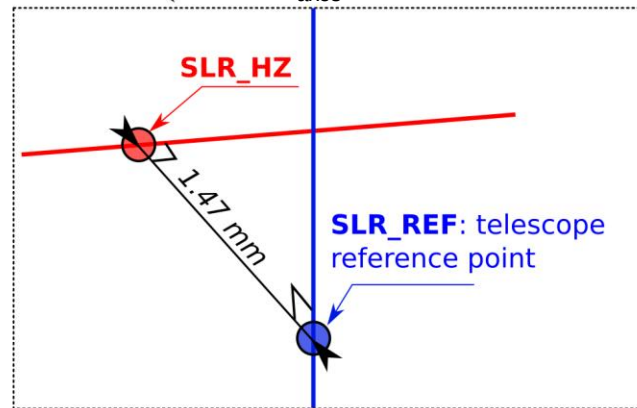


Fig.6 SLR telescope estimated axes



Results

VLBI Axis offsets:

15 m radio telescope: 1.4900 m +/- 0.0013 m (1σ)

26 m radio telescope: 6.6945 m +/- 0.0007 m (1σ)



Fig.7 26m VLBI antenna axes

SLR eccentricity

Comparison of the estimated vector from the axis pseudo-intersection to the reference mark determined by the survey and the eccentricity provided by the International Laser Ranging Service (https://cddis.nasa.gov/archive/slr/slocc/ecc_xyz_200420.snx)

	ΔX (m)	ΔY (m)	ΔZ (m)
From 2014 processing	2.5712	1.3416	-1.4096
From 2021 processing	2.5702	1.3406	-1.4102
From ecc_xyz.snx	2.5720	1.3420	-1.4120

Difference 2021 with ecc_xyz.snx (mm)			
	1.8	1.4	-1.8

Tab.3 Eccentricities between MOBLAS axis telescope reference point and the reference mark

Comparison with 2014 processing

The multi-technique combination residuals are significantly smaller for the new reprocessed local tie vectors compared to the 2014 processing.

		Residual norm 2014 (mm)	Residual norm 2021 (mm)	Residual norm 2003 (mm)
HRAO	7378	13,8	12,1	
(GNSS)	(VLBI)			
HRAO	7232	16,9	14,5	4,7
(GNSS)	(VLBI)			
HRAO	7501	21,3	10,0	6,2
(GNSS)	(SLR)			
7232	7501	8,7	5,7	
(VLBI)	(SLR)			
7232	7378	6,7	5,1	
(VLBI)	(VLBI)			

However, the local tie vectors from the 2003 survey fits better space geodesy results.

The differences between 2014 and 2021 computed coordinates are due to:

- referencing procedure
- computation changes: weights on observations, axis combination methods
- corrections in observations



Tab. 4 Residuals of a multi-technique combination using solutions submitted to ITRF2014 and local tie results from 2014 processing [Muller and Poyard, 2014], the new 2021 processing and 2003.

Local tie vectors submission to IERS

The report of the 2021 processing is available at
http://itrf.ign.fr/local_survey.php

A SINEX file and a metadata file has been
submitted to ITRF product center (itrf@ign.fr).

References

- J.-M. Muller, D. Pesce, and X. Collilieux (2021), *2014 Hartebeesthoek co-location survey reprocessing report*, IGN technical report, https://itrf.ign.fr/local_surveys.php
- J.-M. Muller and J.-C. Poyard (2014), *Hartebeesthoek local tie survey*, IGN report n°28519, version 1.
- J.-C. Poyard, X. Collilieux, J.-M. Muller, B. Garayt, and J. Saunier (2017), *IERS technical note 39 - IGN best practice for surveying instrument reference points at ITRF co-location sites*, Frankfurt am Main: Verlag des Bundesamts für Kartographie und Geodäsie (ISBN 978-3-86482-129-5)