APPENDICES

The appendices hereafter refer to IGN/SGN adjustments, reports and archive.

Appendix 1: Reference documents

In 2003, an IGN Unit started this kind of topographic survey at Hartebeesthoek (SA) with support of NASA, then at Wuhan and Sheshan (China), and later at Tahiti (French Polynesia), Herstmonceux (UK), Grasse (Fr) and Riyadh (KSA). Afterwards, several local ties have been surveyed at Dionysos (Greece), Kourou (French Guiana), Rothera (Antarctica) and Rikitea (French Polynesia). All the relevant reports are publicly available on the ITRF website (see http://itrf.ign.fr/local_surveys.php).

- CIBINONG co-location survey, October 2015
- HARTEBEESTHOEK co-location survey, February 2014
- GRASSE co-location survey, August 2013
- LE LAMENTIN co-location survey, July 2013
- AREQUIPA co-location survey, January 2013
- JIUFENG co-location survey, October 2012
- TRISTAN-DA-CUNHA co-location survey, June 2012
- RIYAD co-location survey, February 2012
- HARTEBEESTHOEK co-location survey, February 2014
- RIKITEA co-location survey, July 2011
- PAPEETE co-location survey, July 2011
- ROTHERA co-location survey, February 2011
- KOUROU co-location survey, February 2011
- DIONYSOS co-location survey, February 2011
- GRASSE co-location survey, August 2009
- HERSTMONCEUX co-location survey, April 2009
- TAHITI GEODETIC OBSERVATORY co-location survey, September 2008
- SHESHAN co-location survey, December 2005
- HARTEBEESTHOEK co-location survey, June 2005
- WUHAN co-location survey, January 2005

IGN intends at performing at least one survey every year on some co-located sites where ties are missing or are inconsistent.

This document is based on the local tie reports written by IGN during the last 10 years for the needs of the Geodetic Research Laboratory and ITRF.

Appendix 2: Site description

This paragraph has a threefold objective:

- to provide useful information in order to organize a mission (host organism, human and equipment resources, communication and power, access details);
- to present the site from a geodetic point of view, see Figure 31;
- to satisfy the reader curiosity and interest with maps, pictures as well as general information on tectonic or seismic activity.

Nevertheless the point on which the surveyor has to focus on is the site geodetic equipment (i.e. the available space geodetic techniques on site as well as the tide gauge or interesting markers or benchmarks).

Note: As soon as a point is associated with coordinate time series, it is relevant to survey it even if the instrument is not currently operating or is not operating anymore.

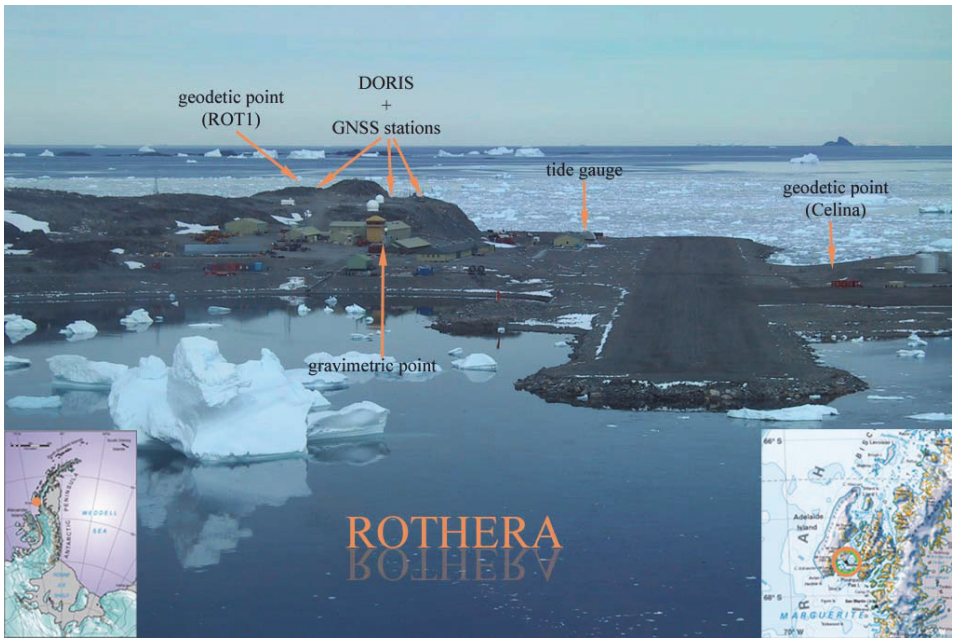


Figure 31: Equipment on the British Antarctic Survey Base at Rothera (2011)

It is relevant to know if the vertical deflection (i.e. geoid undulation) can affect the topographic survey results. A local map of the geoid can be processed before the survey, see Figure 32.

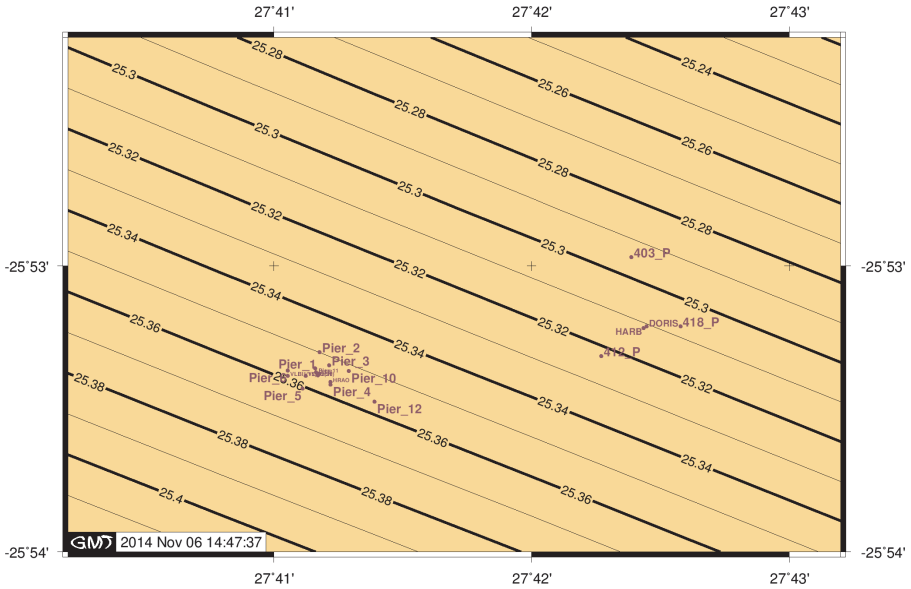


Figure 32: Geoid height (m) at Hartebeesthoek from EGM2008

Appendix 3: Co-located points description

When all the points of primary interest are defined, their description should allow somebody else to identify them **unambiguously**. The best way to succeed in this task is to use as far as possible only one acronym, code and reference per point and to use official names when they exist. The daily updated "codomes.snx" file available at ftp://itrf.ign.fr/incoming/codomes.snx could help in such a work. The point search interface of the ITRF website may be used as well.

Lastly, the addition of pictures (general and close up views) in the final report is a good way to display the surveyed points.

Some sites have a lot of markers and auxiliary markers. Only the surveyed points shall be identified, described and/or referenced with their acronyms and DOMES numbers. Non-surveyed points can be hold up as information.

Acronym, code and DOMES number:

The acronym is a 4-char name. DORIS and GNSS stations all have in theory 4-char codes (generally letters). SLR and VLBI share the so-called CDP numbering which is also a 4-char code in the form of a number larger than 1000 (generally starting by 1, 7 or 8). The International Laser Ranging Service also uses a 4-letter code while they provide CDP code with coordinates in SINEX format, see http://ilrs.gsfc.nasa.gov/network/site_procedures/sod.html. Similarly, the International VLBI service uses preferentially an 8-letter code.

DOMES number is the official 9-char code provided by the IERS ITRS Centre to unambiguously identify a geodetic instrument refer-

ence point and/or geodetic marker. It is independent of the space geodetic technique used and solves potential conflict of station names from different techniques (not necessary on the same site) that have the same 4-char code. This number is associated to a physical point (ex: marker) or to an instrument (ex: rotation axis intersection). In the second case, when the instrument is replaced, the DOMES number should be changed by a new one. DOMES can be requested at any time to IERS ITRS Centre at http://itrf.ign.fr/domes_request.php.

Whereas the 4-char code, in case of GNSS mainly, refers to the receiver and can be multiple when sharing the same antenna, the DOMES number is unique for a reference point.

Appendix 4: Map or sketch of points

If available a sketch of the positions of all these points allows a better overall view of the site equipment.

As an example, a satellite view with the most interesting points of Grasse co-location site is given in Figure 33.

Figure 33: Illustrated map of the Grasse co-location site

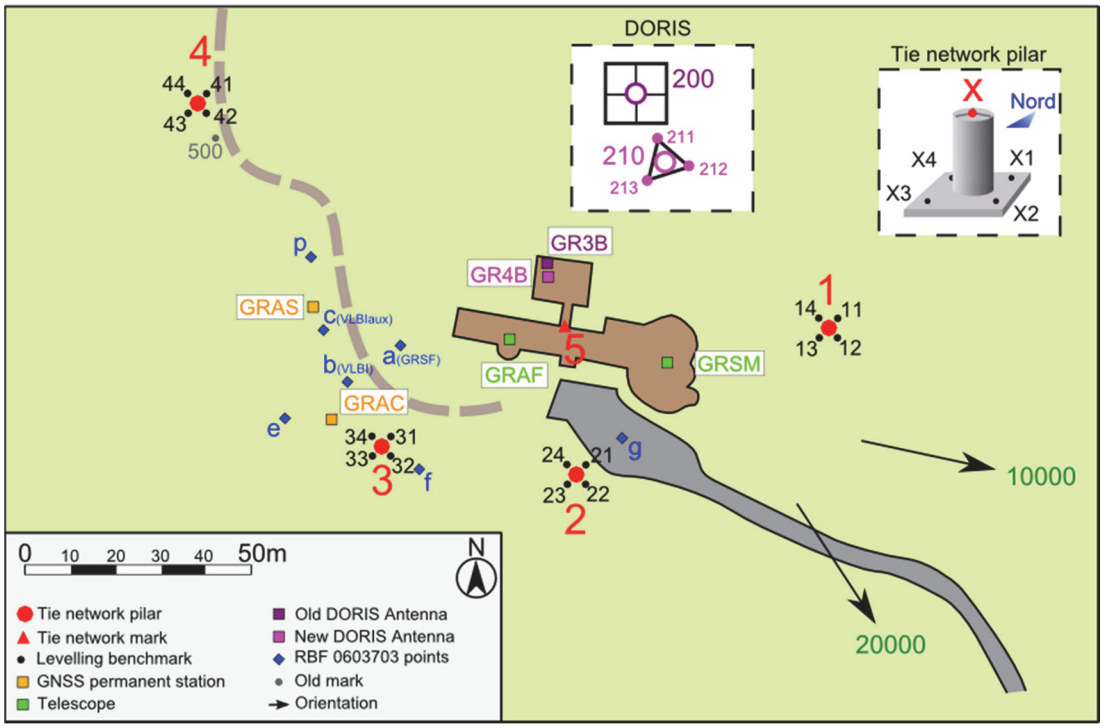


Figure 34: Site map and stations location at Grasse

Appendix 5: Example of instrument characteristics

N.B.: All the survey equipments used should be listed in the final report with their reference number for the sake of traceability. Also instrument specifications allow a better understanding of the report, calculation and accuracy. Examples are provided below.

Total station, prism

Total station : trademark, type, serial ref number	Example: Leica TDA5005 n° ….
EDM distance standard deviation Angular standard deviation Who made the calibration check and when Control of the laser or optical plumb line.	EDM st. dev. 1mm + 1 pmm Angular st. dev. 0.15 mgon Checked by IGN on 15/01/2016 –
Prism : trademark, type, ref number	Ex.: Leica GPH 1P n°20304
Distance correction (checked on…)	Dist. Corr. 0.0 mm (IGN determination on 31/01/16)

Meteorological station

Weather tracker : trademark, type, reference	Ex.: Kestrel 4500NV serial n°672710
Specifications and calibration	Temp. st. dev. 0.5°C Pressure st. dev. 1 hPa

GNSS units

Receiver : trademark, type, ref number	Ex.: Leica GX1230+ n°….
Antenna : Trademark, type, ref number Horizontal and vertical specifications for static GPS survey	Ashtech ASH701945E_M Static post-processing accuracies (as supplied by manufacturer) Horiz. 3 mm + 0.5 ppm Vert. 6 mm + 0.5 ppm

Levelling instruments, rods

Electronic level : trademark, type, ref number	Ex.: Leica Na3003 n°…..
Rod : trademark, size, invar rod, ref number Specifications	Ex.: 2 m Leica invar rod n°… Accuracy better than 1mm/km

Tripods, pillars & divers

Tripods : trademark, made of	Ex.: Aluminum or heavy tripod
All the tripod screws should be regularly checked	Checked on 31/05/2016

Note:

Sometimes we are using very stable heavy wood tripods. Because of expedition problems most of the time standard wood or aluminum tripods are used.

Appendix 6: Centering equations and perpendicularity projection

Field observations as well as sitelogs or antenna height may provide centering equations.

Indeed, sometimes when there is only a DORIS support or antenna change without location change, or to check the laser ranging station vertical (azimuthal) rotation axis position with respect to its marker or also to check a GNSS station eccentricity, we perform a “perpendicularity survey”.

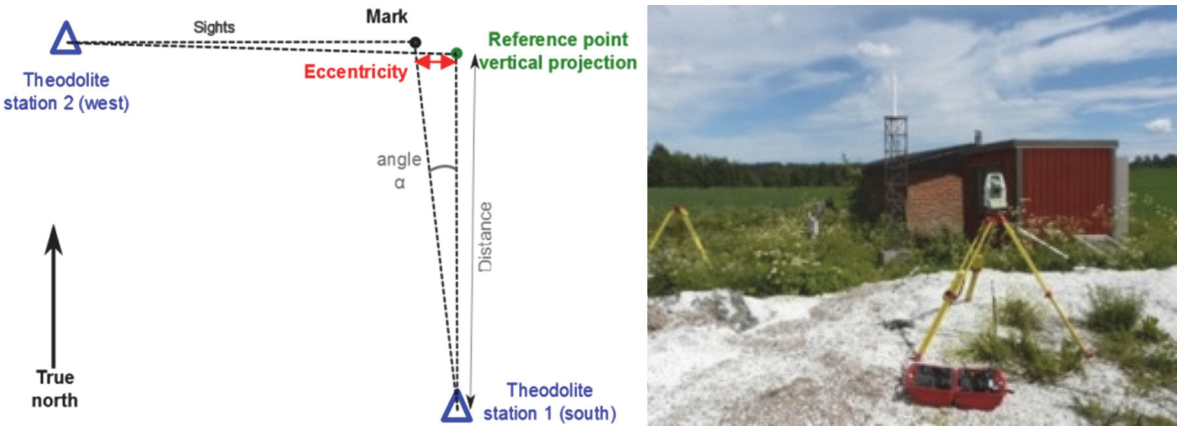


Figure 35: Left) Principle of verticality measurement (overhead view) Right) Example with DORIS antenna

The purpose is to estimate the east / west and north / south eccentricities. Firstly, from a station oriented to the True North (or South) with respect to the instrument to observe, the angle between the reference point vertical projection and the marker as well as the distance between the theodolite and the marker are measured. Secondly, the same measurements are made from a second station oriented to the east (or west) corrected from magnetic declination in order to estimate the north / south eccentricity.

To stake out the station to the True North we formerly used a compass and corrected the bearing from the magnetic declination. But as there are sometimes metallic items in the antennas surroundings, as some magnetic anomalies can also exist, the easiest and more accurate way to stake out the station is to use a map or an aerial view. Eccentricity (in m) = Distance * α (in radian). Be aware that this method does not give a precise bearing.

Advantage ☺: could be done alone, quickly, with not much equipment.

Disadvantage ☹: risk of error (magnetic correction and anomaly, station location), poor accuracy, centering equations have to be manually introduced in the adjustment.

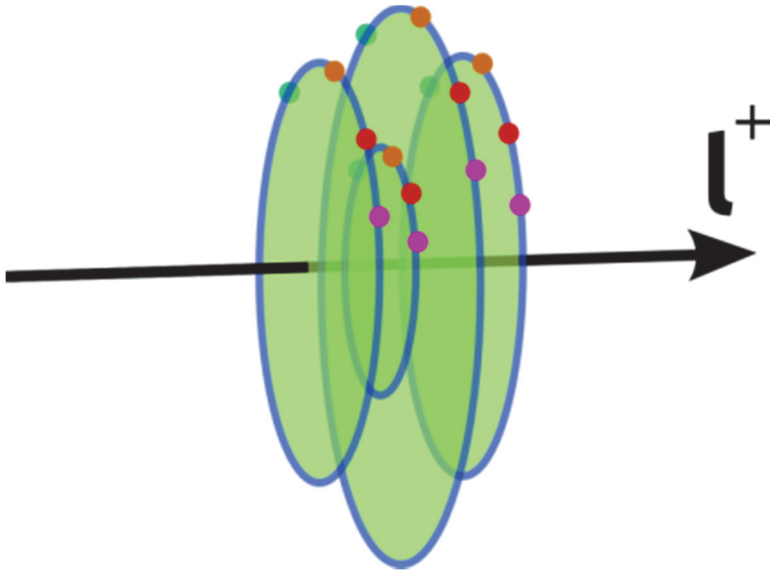
Appendix 7: Axis and offset determination

This appendix describes an algorithm to determine the intersection of axes determined by an indirect method for SLR or VLBI stations. This description is extracted from the report of the 2014 survey at Hartebeesthoek.

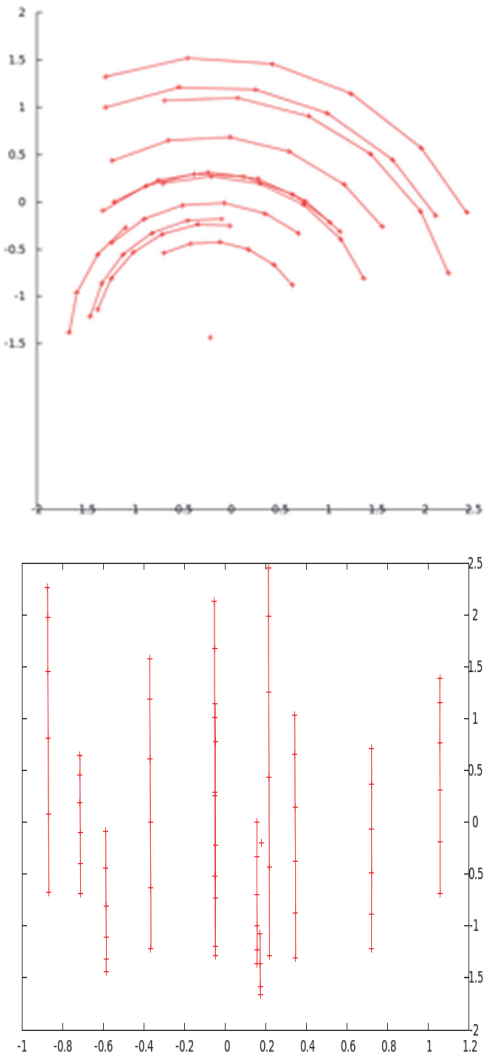
We used a Gauss-Helmert model least squares adjustment to estimate the axis position and orientation in a local frame.

Horizontal axis

For each position of the instrument we determined several target coordinates. With several positions, we could have an estimate of the displacement of each target when the instrument was rotating. The displacement of each target should fit a circle, orthogonal to the axis.



The centers of the circles are on the axis, the circles are orthogonal to the axis.



Displacement of the targets, side and top view

The observations are the 3D coordinates of points, with their precisions.

The relations between observations and parameters are:

- the distance between a point and the center of the circle is the radius;
- the vector between the center and the point is orthogonal to the axis.

To know more about the parametrization and process, refer to the example at § 4.2.3 of RT/G 199 Hartebeesthoek local tie survey report.