LOCAL TIE INFORMATION REPORT

YEBES OBSERVATORY, GUADALAJARA, SPAIN

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CONTENTS

1. INTRODUCTION

ITRF is the result of a combination of the different terrestrial reference frames provided by the four space geodetic techniques: GNSS, VLBI, SLR and DORIS. To perform this combination between independent reference frames, it is necessary to have some co-location sites where the various techniques are observing and for which ties have been surveyed in three dimensions.

In Yebes Observatory are co-located four space geodetic technique: two Global Navegation Satellite System (GNSS) antennas and two Very Long Baseline Interferometry (VLBI) radio telescopes, property all of them from the National Geographic Institute (IGN).

The local ties survey accuracy as stated by GGOS should reach 1 mm. In order to get this accuracy, this site has been equipped with a network of geodetic pillars distributed overall the site.

2. ACKNOWLEDGEMENTS

We would like to express our thanks to Geodesy IGN team in Madrid, with special thank to Marcelino Valdés Pérez de Vargas and Jose Antonio Sánchez Sobrino for the working on GNSS calculation as well as the control radiotelescope team of Yebes Observatory who have allowed to us to carry out the tasks related with the radiotelescopes.

We would like also to thank the advices received from BKG (Bundesamt für Kartographie und Geodäsie) and Leica Geosystems.

3. CO-LOCATED SITE DESCRIPTION

3.1. SITE DESCRIPTION

Yebes Observatory is located 70 kilometers far from Madrid, in the center of the Iberian Peninsula, a strategic place in the limit of the European Tectonic Plate.

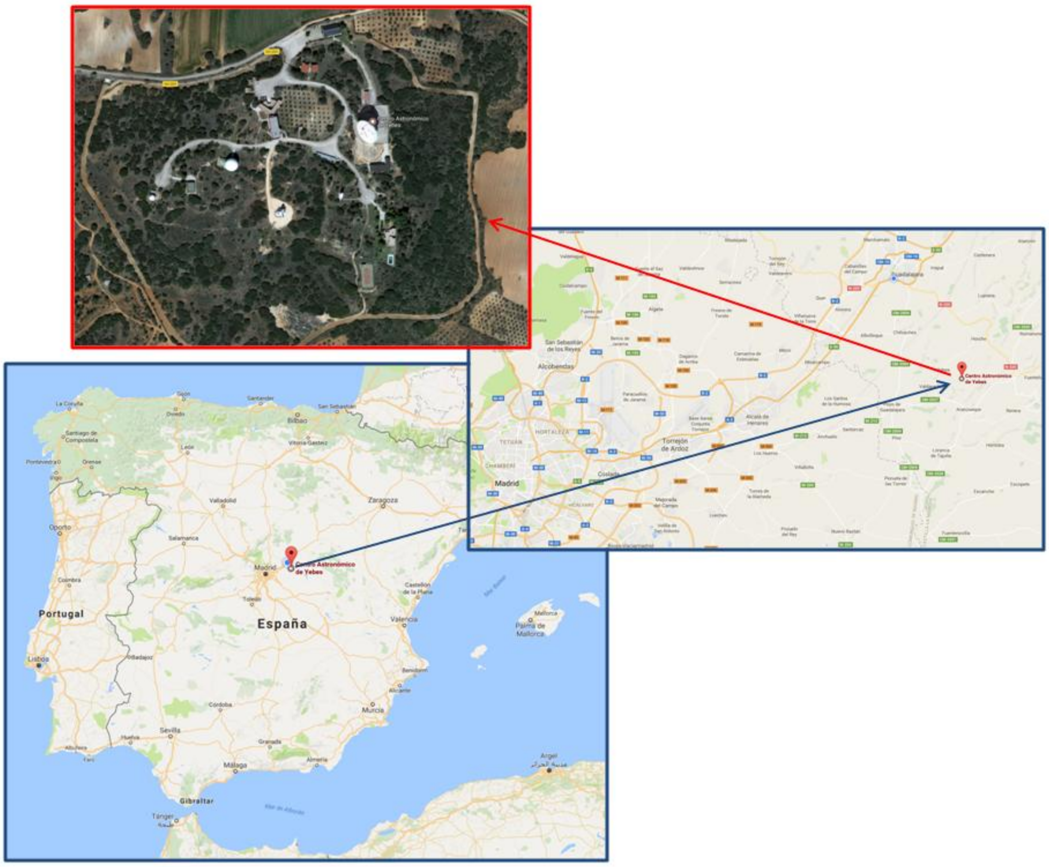


Figure 3.1

3.2. CO-LOCATED POINTS DESCRIPTION

Yebes Observatory is provided with two VLBI antennas (a 40 meter radio telescope and a 13 meters radio telescope), two GNSS antennas, (YEBE, on the roof of the office building and YEB1, on the roof of the gravimeter building) and a Superconducting Gravimeter (SG) inside the gravity building. There is also some complementary instrumentation which can be useful as for example a LAMBRECHT rain gauge, a SENTEK ENVIROMENT humidity sensor with 5 depths and a UNIK piezometric sensor to measure the groundwater level. In Figure 3.2 the distribution around the Observatory of the different techniques can be observed and in Table 3.1 a summary with the information of all the spatial techniques is given.

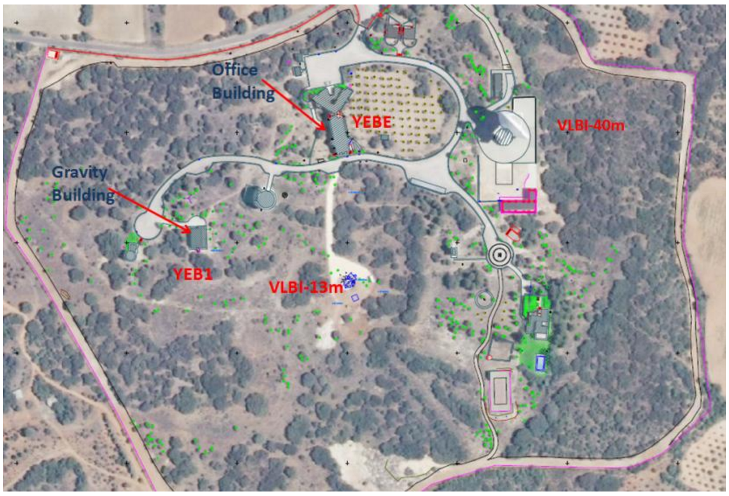


Figure 3.2

Space Geodetic Technique	Name	DOMES number	Antenna type/Receptor type/Support	Code/ 4-CID
VLBI	YEBES40M	13420S002	40 m. RT. Cassegrein-Nasmith.	7389
VLBI	RAEGYEB	13420S003	13 m. RT. VGOS. RAEGE.	7386
GNSS	YEBE	13420M001	TRM29659.00/ TRIMBLE NETRS/1.2 m. concrete pillar	YEBE
GNSS	YEB1	13420M002	LEIAR25/ LEICA GRX+GNSS/1.2 m. concrete pillar	YEB1

Table 3.1

3.2.1. GNSS Stations

3.2.1.1. YEBE

YEBE GNSS station was installed in November of 1992 and it is placed on the office building roof. The antenna is set up on a 1.20 meter concrete pillar. The reference point is on the top of the self centering support coincident with the Antenna Reference Point (ARP). See Annex 1.

It belongs to several networks:

- National GNSS Permanent Network (ERGNSS).
- EUREF Permanent Network (EPN).
- International GNSS Service (IGS).
- TEIDE network.

YEBE	DOME: 13420M001
	
Figure 3.3	Figure 3.4
General views	
	
Figure 3.5	Figure 3.6
Invariant reference point	

3.2.1.2. YEB1

YEB1 GNSS station was installed in April of 2009 and it is placed on the office building roof. The antenna is set up on a 1.20 meter concrete pillar.

It belongs to the National GNSS Permanent Network (ERGNSS). The invariant reference point has 6 cm height over the top of the pillar. See Annex 2.

YEB1	DOME: 13420M001
	
Figure 3.7	Figure 3.8
General views	
	
Figure 3.9	Figure 3.10
Detailed antenna view	Invariant reference point

3.2.2. VLBI Sations

3.2.2.1. YEBES40M- radio telescope

The YEBES40M radio telescope, also called, ARIES XXI, was finished in 2008 and it has a diameter of 40 meters with an alt-azimuth mount. It is dedicated to millimeter and centimeter-wave VLBI and single dish observations. It has receiver to work in S-band (2.2 – 2.37 GHz), CH-band (3.22 – 3.39 GHz), C-band (which is split in two sub-bands, 4.56 – 5.06 GHz and 5.9 – 6.9 GHz), X-band (8.15 -9GHz), K-band (21.77 – 24.45 GHz), and W-band (85-110 GHz). A new Q-band (40-49 GHz) receiver is also in operation.

The VLBI measurements refer to a point in the radio telescope where the elevation axed are projected in to the azimuth axis due to the eccentricity in this radio telescope is near 2 meters. This Invariant Reference Point (IRP) can't be materialized.

Figure 3.11

3.2.2.2. RAEGYEB- radio telescope

The RAEGYEB radio telescope, also called Jorge Juan, has 13.2 meter of diameter with an alt-azimuth mount. It is equipped with a new broadband receiver and it has participated in the first intercontinental VGOS observation in June 2016.

The VLBI measurements refer to a point in the radio telescope where the two rotation axes intersect (azimuth and the elevation axis). This point, IRP, can't be materialized.

This radio telescope has a central pillar, from which measurement to calculate the IRP can be taken.

Figure 3.12

4. LOCAL TIE SURVEY DESCRIPTION

4.1. ORGANIZATION

The local ties survey of Yebes co-location site has been carried out by Javier Lopez Ramasco and Beatriz Córdoba Hita with the cooperation of the IGN (Instituto Geográfico Nacional) geodesy team: Marcelino Valdés Pérez De Vargas, <mvaldes@fomento.es>; José Antonio Sánchez Sobrino, <jassobrino@fomento.es> and Víctor Martín Guijarro <becario.vmg@externomf.es>.

4.2. INSTRUMENT CHARACTERISTICS

All the topometric survey instruments and equipments belong to IGN. Some of them have been brought for the purpose of the survey. Between this instrumentation it can be found:

- A total station Leica TS50 with an accuracy of 0.5” and 0.6mm + 1 ppm in angular and distance respectively. (Figure 4.1)

Figure 4.1

- A Toshiba Satellite Pro NB10T laptop with Bluetooth connection to control the total station. (Figure 4.2)

Figure 4.2

- 8 GPH1P high accurate prisms with an accuracy center of 0.3 mm and 3.500 m reach. (Figure 4.3)

Figure 4.3

- 9 GDF321 tribachs without optical plummet. (Figure 4.4)

Figure 4.4

- 1 GST20-9 wooden tripod. (Figure 4.5)

Figure 4.5

- 8 GRT144 Carrier with 1mm central accuracy. (Figure 4.6)

Figure 4.6

- 5/8” Stub fitting.

- 2 (RRR) Reflector Red-Ring (1.5” diameter). (Figure 4.7)

Figure 4.7

- 1 extra GNSS (Leica GR25 with double frequency and antenna AR20). (Figure 4.8)

Figure 4.8

4.3. SURVEY MONUMENTS

In order to provide the highest accuracy in the determination of the 3D vectors between the different techniques a network of 20 concrete pillars has been built adding the four spatial techniques. In total, 24 survey points have been taken into account. Each geodetic technique is surrounded by pillars that are in the line of sight and so that there is a connection between all the techniques.

The design and construction of the network was not very easy because of the vegetation, trees and low bushes, in the Observatory. It was tried to create baselines with approximately the same length and triangles the most equilateral possible.

To verify the possibility to reach the necessary accuracy for our goal several simulations before the construction the pillars were done.

After the design of the network, pillars were built. They are made of concrete and iron and they are a 30 cm diameter and 1.30 m height cylinder covered by a protecting tube. Between the cylinder pillar and the protecting tube there is a free space of 5 cm to isolate the interior pillar. At the top of the exterior protecting tube, it has a metal lid to prevent the entry of water, and a drainage hole at the bottom of pillar. Fixed to the top of the interior pillar, there is a stainless steel plate of 5 mm thickness, in which center there is a 5/8” standard screw for fixing total station or prism reflector tribrach. (Figures 4.9, 4.10, 4.11).

The construction was done between November 2014 and January 2015.

Figure 4.9

Figure 4.10

Figure 4.11

4.4. OBSERVATION POLYGON

In Figure 4.12 is shown a map of the network with all the visuals between the pillars and in Table 4.1 a list with the information of each pillar.

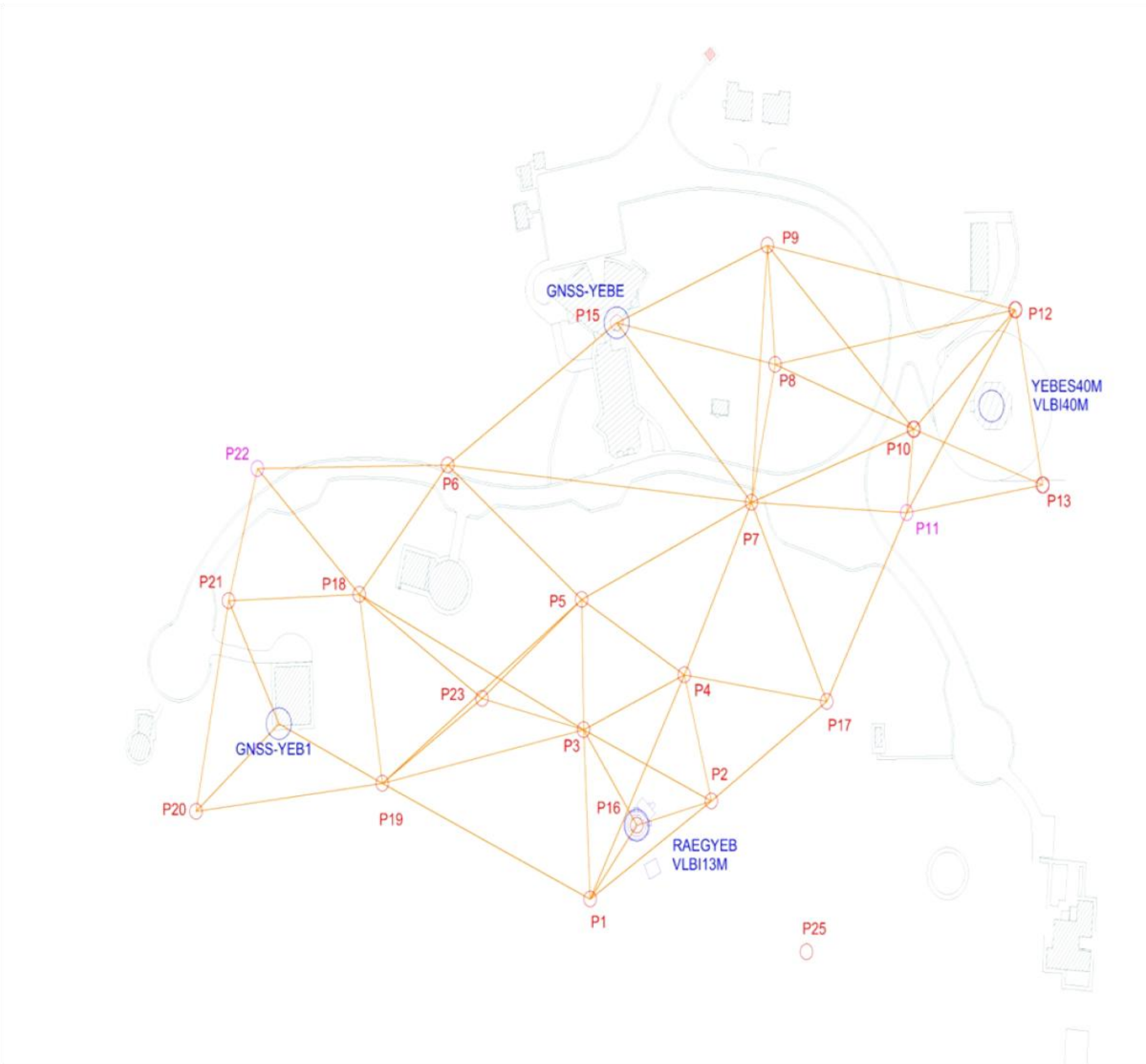


Figure 4.12

Name	DOMES number	Name in adjustment	Code	Description
P1	n/a	1	n/a	Auxiliary concrete pillar
P2	n/a	2	n/a	Auxiliary concrete pillar
P3	n/a	3	n/a	Auxiliary concrete pillar
P4	n/a	4	n/a	Auxiliary concrete pillar
P5	n/a	5	n/a	Auxiliary concrete pillar
P6	n/a	6	n/a	Auxiliary concrete pillar
P7	n/a	7	n/a	Auxiliary concrete pillar
P8	n/a	8	n/a	Auxiliary concrete pillar
P9	n/a	9	n/a	Auxiliary concrete pillar
P10	n/a	10	n/a	Auxiliary concrete pillar
P11	n/a	11	n/a	Reconstructed auxiliary concrete pillar
P12	n/a	12	n/a	Auxiliary concrete pillar
P13	n/a	13	n/a	Auxiliary concrete pillar
YEBES40M	**13420S002**	**VLBI40m**	**7389**	**IRP of the 40m radiotelescope**
P15	n/a	15	n/a	Planimetry IRP of the YEBE GNSS
YEBE	**13420M001**	**YEBE**	**YEBE**	**IRP of the YEBE GNSS**
P16	n/a	16	n/a	Central pillar inside the 13 m radiotelescope.
RAEGYEB	**13420S003**	**VLBI13m**	**7386**	**IRP of the 13m radiotelescope**
P17	n/a	17	n/a	Auxiliary concrete pillar
P18	n/a	18	n/a	Auxiliary concrete pillar
P19	n/a	19	n/a	Auxiliary concrete pillar
P20	n/a	20	n/a	Auxiliary concrete pillar
P21	n/a	21	n/a	Auxiliary concrete pillar
P22	n/a	22	n/a	Reconstructed auxiliary concrete pillar
P23	n/a	23	n/a	Auxiliary concrete pillar
YEB1	**13420M002**	**YEB1**	**YEB1**	**IRP of the YEB1 GNSS**
P25	n/a	-	n/a	Auxiliary concrete pillar not included in the network yet.

Table 4.12

4.5. SURVEY METHOD

4.5.1. GNSS MEASUREMENTS

Before the adjustment of the network is necessary having an approximate coordinates from which to start. With this purpose each pillar has been measured with a LEIAR20 GNSS antenna and a LEICA GR25 receiver during 5 hours. The YEBE IGS GNSS station was taken as reference point for all baselines.

To fix level and orientate the GNSS antenna a 8 cm SECO-MFG leveling platform were used. (Figure 4.13).

Figure 4.13

4.5.2. GROUND NETWORK SURVEY

The observation methodology of the network has been done with the resection with all possible angles and distances. Currently the leveling has been done using trigonometric methodology until we will get a level for more accurate slopes in the next future. It has been used the Leica TS50 total station with an accuracy of 0.5'' and 0.6 mm for angles and distances respectively.

The measurements were taken automatically using own software based on Leica Geocom commands, which controls the Total Station remotely through wire or Bluetooth (Figure 4.14). The methodology consists on doing 5 horizon turns, measuring each visual in direct circle (DC) and in inverse circle (IC).

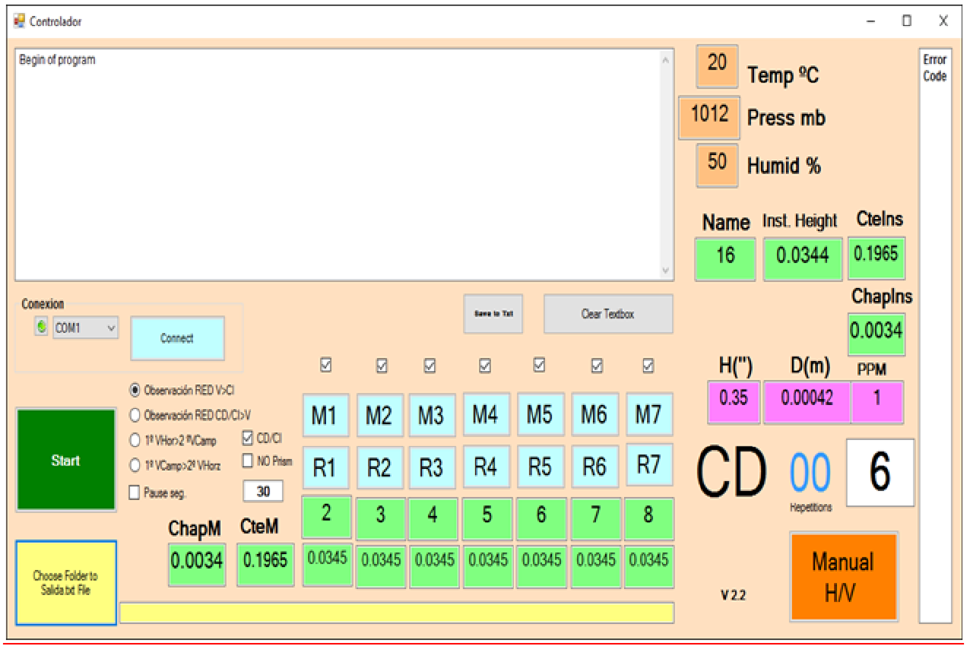


Figure 4.14

In each emplacement temperature, pressure and humidity have been measured and they have been introduced in the total station in order to do the appropriate corrections on to the angles and distances mainly produce by refraction. (Figure 4.15)

Figure 4.15

In each pillar, after placing tribachs, the height until the top of the screw, were the measurements are referenced, were measured. For this purpose was used a caliber and a plate of 3.4 mm width (Figure 4.16). These heights must been taken in to account to introduce the instrument height.

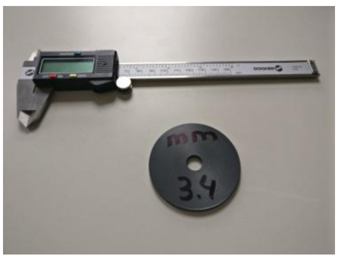


Figure 4.16

Figure 4.17

Figure 4.18

4.5.3. INVARIANT REFERENCE POINT

The Invariant Reference Point (IRP) is a theoretical point and it is defined as the intersection of the azimuth axis with the common perpendicular of the azimuth and elevation axis. It is the point from which the local tie is measured.

4.5.3.1. GNSS ANTENNAS

The IRP of a GNSS antenna is a point that lies on the main axis of symmetry of the antenna at a height that is determined in the specifications and usually coincides with the bottom of the antenna.

4.5.3.1.1. YEBE

Due to the importance and the fragility of this point the antenna could not be replaced by a reflector prism and the IRP was measured using direct intersection from pillars P6, P7, P8 and P9, creating a sub-network (Figure 4.19). The technique that has been used distinguishes between planimetry and altimetry.

To calculate the planimetry of the IRP, it was measured the axis of symmetry of the antenna using the cane that holds it, bisecting with the aiming wire of the total station.

The calculation of the altimetry was carried out pointing to the upper corner of the antenna from each of the pillars that surround it.

Figure 4.19

4.5.3.1.2. YEB1

In this case the methodology was easier because the antenna could be replaced by a GHP1 prism which was measured from each surrounded pillar. The sub-network that was used to measure the IRP is formed by the pillars P18, P19, P20 and P21. (Figure 4.20). From each of these pillars were taken measurements to the prism situated in the position of YEB1 and to the other pillars of the sub-network in order to orientate and re-force the network.

These data were added to the adjustment of the total network from which YEB1 was estimated.

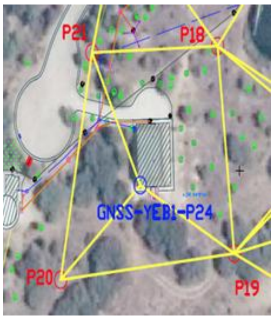


Figure 4.20

4.5.3.2. RADIOTELESCOPES

The IRP of a radio telescope is defined as the intersection between its azimuth axis and the elevation axis and in the case of non-intersection, is defined as the projection of the elevation axis on the azimuth axis. Usually this point is inaccessible or not materialized.

The used methodology to calculate it, has been the classic method of circles, which consists on the adjustment of measured points on the structure of the radio telescope under certain conditions or constraints to 3D circles. In this model the radio telescope is rotated around one of its axes leaving the other fixed, so that the trajectory of each marker corresponds to a circle. This process is repeated for different orientations of the radio telescope and for both axes.

4.5.3.2.1. RAEGEYEB-RADIOTELESCOPE

To calculate the IRP of the 13 meter radio telescope has been used two different methodologies: using a central pillar inside the cabin of the radio telescope and using external pillars which surrounded it.

4.5.3.2.1.1. *Using the central pillar*

In this case, IRP has been calculated placing the total station TS50 on the central pillar of the radio telescope (to which fixed coordinates of (1000, 2000, 3000) have been given) on a tripod integrated on the concrete tower of the radio telescope (Figure 4.21).

Figure 4.21

For a greater safety due to the limited space, the tripod was secured with flanges to the central pillar plate and raised high enough to allow visibility to the exterior pillars through two circular windows located in each of the counterweights allowing an inverse intersection from them (Figure 4.24).

The measurements were made by pointing to a corner cube reflector "RRR Hexagon", with a construction accuracy of 0.0001 mm, that was magnetically attached to the inside of both counterweights (Figures 4.22 and 4.23).

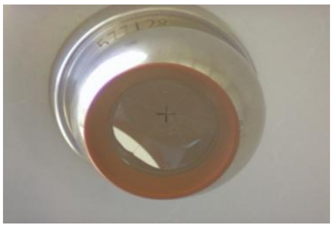


Figure 4.22

Figure 4.23

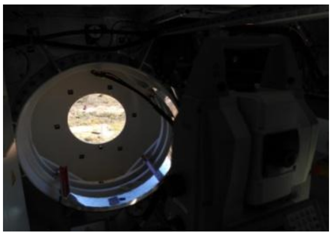


Figure 4.24

To perform the observation, the antenna was moved from 7º to 87° in elevation every 20° and from 0º to 360° in azimuth with a wait time between observations of 40 seconds.

Synchronized to the movement of the radio telescope, the total station was moved by tracking the prism and recording coordinates at every position of reflector prism RRR.

Once the measurements of the circles were finished, measurements were made to the exterior pillars to position the interior pillar of the cabin in the system of our network.

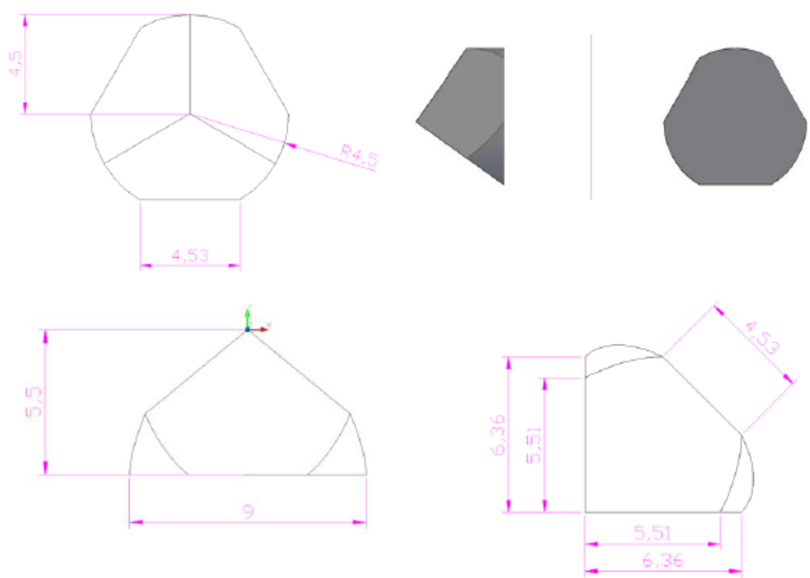
4.5.3.2.1.2. Using external pillars

In this case the IRP has been calculated from the outer pillars P1, P2 and P3 independently by making observations to two multi-prisms placed in the counterweights of the radio telescope. In this case the accuracy of the measurements is somewhat worse because the number of observations for each horizontal circle is reduced due to the lack of visibility from each pillar.

Each multi-prism (Figure 4.26), reflects the signal regardless of the angle at which they are viewed.

Each multiprism has been built in the Observatory using 4 corner cubes smaller of 1 cm and they have been glued to a magnet. Each corner cube was fabricated by an external optic company following the parameters of the Figure 4.25.

Parameters and technical drawing:



Material	N-BK7
Angles	+/- 3 arc secs Return Beam
Flatness	Lambda / 4
Dimension Tolerance	+ 0.00 / - 0.20mm
Surface Quality	60/40 Scratch-Dig
Coating to Entry Face	Uncoated
Coating to Reflective Surfaces	Aluminum & Black paint Protected
Diameter	9 mm
Height	5.50 mm
Straight length sides	4.53 mm
Wavelength to reflect	660 and 785 nm
Units of drawing	millimeters

Figure 4.25

Figure 4.26

4.5.3.2.2. YEBES40M-RADIOTELESCOPE

In the case of the 40 meter antenna it has only been possible to measure the IRP from the outer pillars to the radio telescope since there is no central pillar as in the case of the 13 meter antenna. The methodology was therefore the same as for the calculation of the IRP of the 13-meter antenna, measuring two multi-prisms placed in the counterweights of the 40-meter antenna from three outer pillars with which to compare results. In this case the vertices from which it has been measured are P10, P12 and P13. In each of them a local system with fixed center (1000, 2000, 3000) was considered (Figure 4.27).

Figura 4.27

5. COMPUTATION

5.1. A PRIORI GROUND NETWORK COMPUTATION WITH GNSS.

In order to calculate a priori coordinates, each pillar was measured with GNSS as we have described in section 4.5.1. To calculate the coordinates *X, Y, Z* of each pillar and the matrix of covariance variances in the ETRS89 system it was used the software RTKLIB to calculate base lines with the reference station YEBE. The results were calculated using a static positioning mode, L1 carrier and an elevation mask of 10º. The estimated accuracy of the calculated coordinates was around 5 mm.

In Tables 5.1 and 5.2 are shown the a priori calculated coordinates *X, Y, Z* and the components of the matrix of variance and covariance.

Pillar	*X*	*Y*	*Z*
P1	4848838.46748804	-261648.839139577	4122952.44143507
P2	4848821.66560619	-261599.683776349	4122976.63512653
P3	4848809.1635627	-261648.541254706	4122989.04766349
P4	4848796.15866285	-261609.62171701	4123007.5543382
P5	4848779.00190937	-261649.095467739	4123026.13178675
P6	4848748.72661085	-261700.229575437	4123057.84038744
P7	4848764.06137227	-261579.168770024	4123047.40677275
P8	4848729.1712749	-261570.140406414	4123085.59266132
P9	4848705.96583733	-261572.217857121	4123110.48541736
P10	4848749.97420797	-261515.950059728	4123065.49343124
P11	4848767.45191657	-261519.12610301	4123046.47954681
P12	4848726.91225565	-261473.700467302	4123094.19388918
P13	4848762.95909663	-261463.75561826	4123052.6702999
P17	4848805.2407787	-261553.873025806	4123000.9917535
P18	4848772.65692897	-261737.855024411	4123028.60200104
P19	4848812.57529011	-261730.206234769	4122982.06609655
P20	4848812.44612257	-261800.368005395	4122976.31531809
P21	4848773.76384695	-261786.877460822	4123023.63874769
P22	4848745.04472608	-261776.001969224	4123057.58902675
P23	4848797.21159162	-261689.694742689	4123002.28820101

Table 5.1

Pillar	σ_X	σ_Y	σ_Z
P1	0.002196766474478	0.00124719135701575	0.00156215438221639
P2	0.00261729097557773	0.00132518838428655	0.00251226976233565
P3	0.0019150983744192	0.00109495975739042	0.00157502156044411
P4	0.00225306927595032	0.00106735686630134	0.00136784629577462
P5	0.00235576789823201	0.00222055193935198	0.00731698975887661
P6	0.00262143827441235	0.00202810530902266	0.00312138518487508
P7	0.00351204944143924	0.00118207179332493	0.00389322709913218
P8	0.00191374607735515	0.00180097426462783	0.00274407912124309
P9	0.00265959222608829	0.00100510696737966	0.00136459840497499
P10	0.0056543588709386	0.00399232004534159	0.00230067157369263
P11	0.00443622344914938	0.0020951668287164	0.00453636910702778
P12	0.00649460201584733	0.00572858875364585	0.0108369142968034
P13	0.00954568486137456	0.00556871315446193	0.00450518110261332
P17	0.0037887385133709	0.00169952853862431	0.0025707998925698
P18	0.00174660287917168	0.00100440763489221	0.00149141218588193
P19	0.00667771215159946	0.0046414683508885	0.00693205649036649
P20	0.00356390444814925	0.0018502347709088	0.00250033158859858
P21	0.00939379739690801	0.00602603799346669	0.00705161193806246
P22	0.0046906477360767	0.00175768171542278	0.0032435533814584
P23	0.0028688938186512	0.00121334900907018	0.00163593747476464
Pillar	σ_{XY}	σ_{XZ}	σ_{YZ}
P1	-1.45408375895995E-06	2.28580826047188E-07	6.67913181145218E-07
P2	-2.29098588346398E-07	2.82602762403477E-06	1.22354053530804E-06
P3	-9.42252974444979E-07	4.49994084310835E-07	-1.6814551406918E-07
P4	-7.24038462815066E-07	1.03724953415546E-06	1.91983375102642E-07
P5	8.13971987606157E-07	7.93883462843094E-06	1.234655610335E-05
P6	-4.14909184029205E-06	5.46171627182901E-06	-4.44185964157222E-06
P7	1.05555634819988E-06	1.22508073969545E-05	1.12588069471562E-06
P8	-7.40218614526722E-07	1.86658562175175E-06	-3.67192951169507E-06
P9	2.46368127808443E-07	2.0760226843178E-06	-4.45209554951223E-08
P10	-1.11365486887935E-06	5.98924498838957E-06	3.74163601915279E-06
P11	-2.07726735033935E-06	1.13553213997044E-05	-9.85618163439743E-07
P12	-1.19806006149636E-05	4.76177588091475E-05	-9.25068465065346E-06
P13	4.52051236796396E-05	1.74172300426784E-05	3.15282291267426E-06
P17	1.45308948719966E-06	5.65199067105641E-06	2.06754186265518E-07
P18	-1.5584452772589E-07	1.1624380733851E-06	-2.3997662314702E-07
P19	-4.33711929776131E-06	1.68349903937159E-05	-2.77879323470346E-06
P20	4.69155198464283E-07	4.16587711513841E-06	-1.51499446707649E-06
P21	-3.34832411976026E-05	5.21382888796868E-05	-2.38276514542928E-05
P22	7.61638074223811E-07	1.00052708022447E-05	5.19621271425468E-07
P23	6.04051917867084E-07	3.30935938286857E-06	7.64088942257874E-07

Table 5.2

5.2. NETWORK SURVEY.

Once all measurements are taken and the IRP of the VLBI antennas and one of the GNSS antennas (YEBE) are calculated, the next step is to adjust the pillar network with all the measurements, including the sub-networks used to calculate the IRP of the radio telescopes of 13 and 40 meters and GNSS antennas. The adjustment has been made using GeoLabPX5 version 5.3.2. The input and output Geolab file are accessible in Annexes 3 and 4.

5.3. INVARIANT REFERENCE POINTS (IRPs).

5.3.1. GNSS.

Both YEB1 and planimetry of YEBE were adjusted with Geolab at the same time as the rest of the network. Altimetry of YEBE has been also calculated with Geolab taking into account just the height.

5.3.2. RADIO TELESCOPES.

The methodology to calculate the IRP of the radio telescopes, as in section 4.5.3.2 has been told is the classic method of circles, which consists on the adjustment of measured points on the structure of the radio telescope under certain conditions or constraints to 3D circles and arcs.

Once all the measurements have been taken, the computation that has been carried on is summarized here.

Firstly the azimuth axis is calculated. For this purpose are used observations to a prism during the rotation of the radio telescope around the azimuth axis for different elevations.

Secondly elevation axes are calculated for which observations are made to a prism during the rotation of the radio telescope around the axes of elevation for different azimuths. The centers of the arcs adjusted together with the normal vector of each arc of circumference generate the axes of elevation.

Observations are adjusted to circles in space (intersection between a sphere and a plane), taking into account in addition that the center of the sphere must satisfy the equation of the plane. In the setting, the parameters of each circumference (center and radius) are determined.

The adjustment equations are:

Sphere:

$$F(L, X) = (x_i - a)^2 + (y_i - b)^2 + (z_i - c)^2 - r^2$$

Plane:

$$G(L, X) = A \cdot x_i + B \cdot y_i + C - z_i$$

Constrains:

$$H(L, X) = A \cdot a + B \cdot b + C - c$$

where (a, b, c), r are the center and the radio of the sphere, and A, B, C are the plane parameters.

5.3.2.1. RAEGEYEB-RADIOTELESCOPE

Here are shown the computations that have been done with both methodologies: using a central pillar inside the cabin of the radio telescope and using the external pillars which surrounded it.

5.3.2.1.1. Using the central pillar

An example of the adjusted horizontal circles and vertical arcs are shown in Figures 5.1 and 5.2:

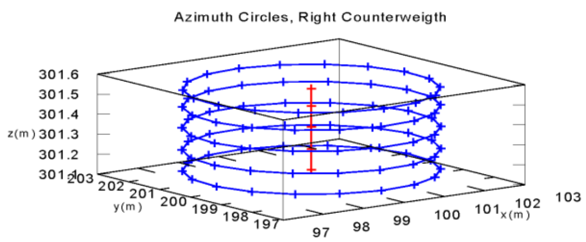


Figura 5.1

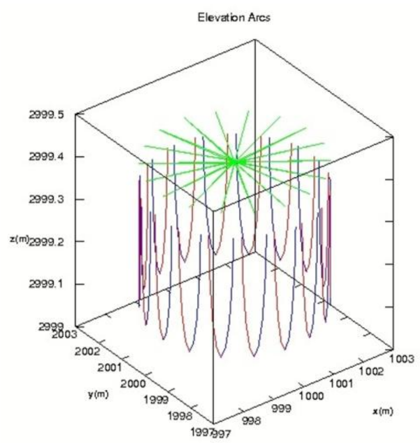


Figura 5.2

Table 5.3 shows the coordinates obtained of the P1, P2 and P3 pillars from the interior of the cab in the local coordinate system with an arbitrary center system (1000, 2000, 3000).

	x	y	Z	σ_x	σ_y	σ_z
P1	978.846658	2020.871601	2990.070556	*0.000074*	*0.000148*	*0.000071*
P2	1004.480675	1969.629860	2991.011311	*0.000135*	*0.000093*	*0.000021*
P3	1025.557567	2017.089360	2991.589699	*0.000043*	*0.000068*	*0.000071*

Table 5.3

5.3.2.1.2. Using the external pillars

An example of the vertical and horizontal circle arcs for both counterweights from one of the pillars can be seen in Figures 5.3, 5.4 and 5.5.

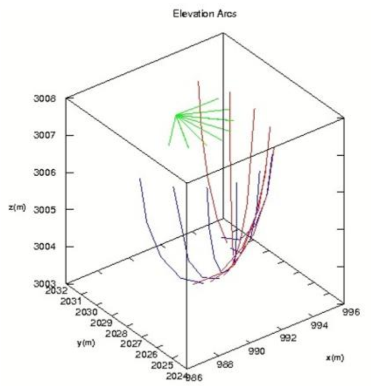


Figura 5.3

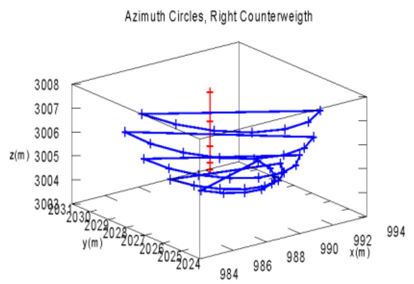


Figura 5.4

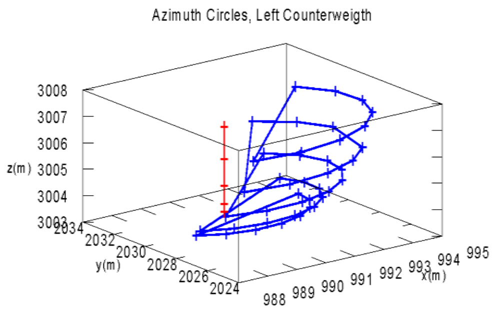


Figura 5.5

From each vertex the IRP of the radiotelescope has been calculated in a different local system. On each pillars an arbitrary system with fixed center (1000, 2000, 3000) was considered.

5.3.2.1.3. Results

All the calculations made have been verified with the AXIS program reaching similar results. In Table 5.4 we can see a summary of all the invariant points calculated by the different methodologies in their local systems.

	IRPs RAEGEYEB radio telescope			Eccentricity (m)
	x (m)	y (m)	z (m)	
INSIDE THE CAB	999.995744 ±0.000005	1999.985069 ±0.000004	2999.4148 ±0.0004	0.0015±0.0008
FROM P1	1016.9103 ±0.0006	2024.4467 ±0.0003	3009.1247 ±0.0007	0.0021±0.0009
FROM P2	991.7959 ±0.0007	1970.4331 ±0.0005	3008.1757 ±0.0009	0.0019±0.0011
FROM P3	990.2755 ±0.0006	2029.1783 ±0.0012	3007.5961 ±0.0018	0.0014±0.0016

Table 5.4

Also the measurement of the 13 and 40 meters radiotelescope IRPs from external pillars have been useful to study the accuracy and validate the use of the multi-prism tecnique. For this purpose, a study of the residuals of the adjusted circles data from the different pillars has been made getting residuals below 1mm in the adjustment of horizontal circles.

5.3.2.2. YEBES40M-RADIOTELESCOPE

In Table 5.5 it can be seen all the calculated IRPs from the different pillars in their arbitrary local systems:

	IRPs YEBES40M radio telescope			Eccentricity (m)
	x (m)	y (m)	z (m)	
FROM P10	1031.587±0.002	1990.7866±0.0007	3020.280±0.002	2.005±0.005
FROM P12	989.8568±0.0009	1969.9515±0.0005	3020.8831±0.0018	2.005±0.003
FROM P13	970.1790±0.0012	1988.57344±0.0004	3020.9055±0.0016	2.007±0.003

Table 5.5

5.4. IRP FROM RADIOTELESCOPES INTO THE GEOCENTRIC NETWORK SYSTEM TRANSFORMATION

Both the IRP of the 13-meter radio telescope and the 40-meter radio telescope are given in their respective local systems. To transform both points into the geocentric network system it is necessary to make 7-parameter Helmert 3D transformations, composed of three translations, three turns and a scale factor. Thus, from several points given in both systems (at least three), any point of a system can be transformed into the other system.

In addition, this transformation, carried out by an own matlab software, has allowed to us to compare, in the case of radio telescopes, the IRPs calculated from the different pillars. In these cases the pillars are given both in the geocentric network system and in the local system in which the measurements of the IRP are calculated, since at least two other pillars were measured from this position.

5.4.1. RAEGEYEB-RADIOTELESCOPE

The IRPs in the case of the 13-meter antenna in the geocentric network system obtained from the Helmert transformation are shown in Table 5.6:

	IRPs RAEGEYEB radio telescope (Geocentric network system)		
	X (m)	Y (m)	Z (m)
Inside the cab	4848831.4580± 0.0003	-261629.951531± 0.000017	4122976.2154± 0.0003
From P1	4848831.4573± 0.0005	-261629.9503± 0.0006	4122976.2150± 0.0005
From P2	4848831.4583± 0.0008	-261629.9509± 0.0006	4122976.2160± 0.0008
From P3	4848831.4575± 0.0016	-261629.9518± 0.0007	4122976.2158± 0.0015

Table 5.6

In order to calculate the 13 meters radiotelescope IRP from outside, the average of the points obtained from the three external vertices P1, P2 and P3 (Table 5.7) was performed.

	IRPs RAEGEYEB radio telescope (Geocentric network system)		
	X (m)	Y (m)	Z (m)
Inside the cab	**4848831.4580± 0.0003**	**-261629.951531± 0.000017**	**4122976.2154± 0.0003**
Average P1P2P3	4848831.4577±0.0005	-261629.9510±0.0008	4122976.2156±0.0005
Difference interior-exterior the cabin.	0.0003	0.0005	0.0002

Table 5.7

These data reflect a great kindness in the adjustment using the measurements made from the three outer pillars with the multi-prism.

5.4.2. YEBES40M -RADIOTELESCOPE

The IRPs in the case of the 40-meter radio telescope obtained in the geocentric network system from the 3D Helmert transformation, as well as the mean values obtained from pillars P10, P12 and P13 are shown in Table 5.8.

	IRPs YEBES40M radio telescope (Geocentric network system)		
	X (m)	**Y (m)**	**Z (m)**
From P10	4848762.1745±0.0017	-261484.6063±0.0018	4123084.7793±0.0016
From P12	4848762.1773±0.0014	-261484.6087±0.0009	4123084.7781±0.0012
From P13	4848762.1760±0.0014	-261484.6080±0.0005	4123084.7816±0.0014
Average P10P12P13	4848762.1759± 0.0014	-261484.6076±0.0012	4123084.7796±0.0018

Table 5.8

5.5. IMPORTING INVARIANTE REFERENCE POINTS INTO TOPOMETRIC COMPUTATION

Once the IRPs of the different techniques and the adjusted network have been calculated, it is necessary to connect these points with the rest of the local network. This work has been carried out with Geolab software, radiating the differences of distances between pillar and IRP (DX, DY, DZ), from the pillars from which these IRPs have been measured and whose coordinates are known in the geocentric network system. The IRP integrated in the network as well as their variance covariance matrix are shown in Table 5.9.

```
* Number of degrees of freedom of adjustment = 2044
* Number of stations in adjusted network = 27
* Number of stations extracted = 4
*
 3DC
 XYZ      VLBI40m          4848762.175895      -261484.607603      4123084.779600 m       0
 XYZ      VLBI13m          4848831.457742      -261629.951571      4122976.215159 m       0
 XYZ      YEBE             4848724.984533      -261632.472188      4123093.985476 m       0
 XYZ      YEB1             4848800.499013      -261769.654085      4123001.164204 m       0
 COV   CT UPPR
 ELEM     2.04995928339998e-06    7.16283500023397e-09     3.1452196037248e-08
 ELEM     2.81335704572559e-07   -6.91525408039266e-08    8.75753167791391e-08
 ELEM     3.05526699759183e-07    1.69516980533409e-08    8.17964690560368e-08
 ELEM     2.24703679820563e-07   -4.43249273950196e-08    1.54269074606231e-07
 ELEM     1.36727295139055e-06   -4.22290921817372e-08   -2.19529302138495e-08
 ELEM     4.74386940699216e-08   -1.20160430429116e-08   -1.34324125046242e-08
 ELEM     1.12748587668803e-07   -1.87858075530456e-08   -5.40408539776911e-08
 ELEM     6.22848744968344e-08     2.5944409203196e-08
 ELEM     3.06137011901663e-06     9.3768488574705e-08    4.54412340251479e-08
 ELEM     1.82919763040765e-07    8.09658039222677e-08   -5.57605744271311e-08
 ELEM     2.04800468550067e-07    1.59617100649855e-07    1.62826807095491e-08
 ELEM     1.04283238378311e-07
 ELEM     3.78593428284535e-07   -3.61090986308904e-08    9.57092626539788e-08
 ELEM     2.78464367188601e-07   -4.14028673559747e-08    9.47962129978466e-08
 ELEM     2.72281713474728e-07    1.78777800157107e-08    1.17035042106254e-07
 ELEM     2.02816254020516e-07    1.19926186566851e-08   -2.18861582964578e-08
 ELEM     4.10368754150812e-08   -1.48256949858608e-08   -3.01058728796443e-08
 ELEM     9.51458726324386e-08    1.72376914062188e-09
 ELEM      2.6869471449628e-07    9.78992062976158e-08    1.27358119889668e-08
 ELEM     1.75699736776599e-07    1.10524801757909e-07   -5.24431562104514e-08
 ELEM     1.55897878476783e-07
 ELEM     4.06079916628841e-07   -1.21485763775982e-08    9.36084279825302e-08
 ELEM     2.58421692040105e-07   -3.20421607374693e-08    1.19683110070407e-07
 ELEM     2.31255716722584e-07   -2.20597058197717e-08   -6.38979587785491e-08
 ELEM      6.1043292203574e-08    3.48713593179878e-08
 ELEM      2.7956390285999e-07    1.22603324421109e-07    1.60471673280528e-09
 ELEM     1.47220120120083e-07
 ELEM     4.18854466536725e-07   -6.06358036832281e-09      3.025026384487e-08
 ELEM     1.73967777537483e-07    -2.6003745015791e-08
 ELEM     3.23591473262172e-07
*
* End of extracted coordinates
*
```

Table 5.9

5.6. TRANSFORMATION INTO IGb08

Finally, it is necessary to transform the IRPs of the geocentric network system into an international global system. In our case we will transform them into the IGb08 international system. For this purpose, the data of three GNSS stations measuring permanently located in the Observatory have been taken in order to be able to perform a 7-parameter Helmert transformation. The used stations have been YEBE, YEB1 and a GNSS LEIAR20 antenna with a LEICA GR25 receiver located on Pillar 17 which has an enough long series of data to be able to carry out this task. Through these data BERNESE coordinates have been calculated in the IGb08 system of these three points using baselines with stations around the world to achieve enough accuracy (these results have been obtained by the IGN calculation center). Taking into account that the coordinates of these three points in the network system are also known we can obtain the parameters of the Helmert transformation between both systems, for which the scale factor has been set to 1.

The processed coordinates with Bernesse for YEBE, YEB1 and Pillar 17 in the IGb08 system are shown in Table 5.10, while the coordinates in the geocentric network system are shown in Table 5.11.

Estación	X (IGb08)	Y(IGb08)	Z(IGb08)
Pilar 17	4848804.8459±0.0009	-261553.3745±0.0006	4123001.3083±0.0012
GNSS YEB1(P24)	4848800.0727±0.0011	-261769.1554±0.0004	4123001.4531±0.0017
GNSS YEBE	4848724.5962±0.0007	-261631.9794±0.0003	4123094.3037±0.0008

Table 5.10

Estación	X (Local)	Y (Local)	Z (Local)
Pilar 17	4848805.241667±0.0006	-261553.870961±0.0003	4123000.994858±0.0005
GNSS YEB1(P24)	4848800.453498±0.0006	-261769.651635±0.0004	4123001.125186±0.0006
GNSS YEBE	4848724.984574±0.0006	-261632.472593±0.0004	4123093.985536±0.0005

Table 5.11

The IRPs that must been transformed are given in Table 5.12.

Estación	X (Local)	Y (Local)	Z (Local)
YEB1	4848800.4991±0.0007	-261769.6541±0.0004	4123001.1641±0.0006
VLBI13m	4848831.4580± 0.0003	-261629.9553±0.000017	4122976.2154± 0.0003
VLBI40m	4848762.1758± 0.0014	-261484.6076±0.0012	4123084.7796±0.0018
YEBE	4848724.9845± 0.0004	-261632.4726±0.0006	4123093.9855±0.0005

Table 5.12

The transformated parameters as well as the transformed IRP in the IGb08 system are found in Tables 5.13 and 5.14.

S:	1.000000	sigma	0.000000		
Giro1(°):	359.997420	sigma(°)	0.000767	sigma(")	2.760278
Giro2(°):	0.000714	sigma(°)	0.001120	sigma(")	4.030657
Giro3(°):	0.004569	sigma(°)	0.000745	sigma(")	2.683528
Tx(m):	-0.388313	sigma(m)	0.001169		
Ty(m):	0.495296	sigma(m)	0.000661		
Tz(m):	0.319840	sigma(m)	0.001366		

Table 5.13

Pilar	X	SX	Y	SY	Z	SZ
YEB1	4848800.120060	0.000632	-261769.158390	0.000414	4123001.488133	0.000552
VLBI13m	4848831.067509	0.000594	-261629.454477	0.000425	4122976.532356	0.000497
VLBI40m	4848761.775169	0.001409	-261484.111184	0.001240	4123085.091274	0.001811
YEBE	4848724.595679	0.000565	-261631.978731	0.000434	4123094.304297	0.000488

Table 5.14

6. RESULTS

6.1. ADJUSTED COORDINATES.

The results of the adjustment are the coordinates of all points as well as their standard deviation in the IGS08 frame at the mean epoch of the observations (i.e. epoch 2016.90). Hereafter is a table with the Geocentric coordinates and the standard deviation of all the points of the network (Table 6.1).

Pillar	X	Y	Z
P1	4848838.0840±0.0005	-261648.3427±0.0004	4122952.7665±0.0004
P2	4848821.2685±0.0006	-261599.1896±0.0003	4122976.9502±0.0005
P3	4848808.7742±0.0005	-261648.0443±0.0003	4122989.3639±0.0004
P4	4848795.7651±0.0005	-261609.1246±0.0003	4123007.8712±0.0004
P5	4848778.6010±0.0005	-261648.5998±0.0003	4123026.4422±0.0004
P6	4848748.3416±0.0005	-261699.7343±0.0003	4123058.1586±0.0004
P7	4848763.6733±0.0005	-261578.6769±0.0003	4123047.7255±0.0004
P8	4848728.7751±0.0006	-261569.64488±0.0004	4123085.9031±0.0005
P9	4848705.5702±0.0006	-261571.7228±0.0004	4123110.8005±0.0005
P10	4848749.5747±0.0006	-261515.4558±0.0004	4123065.8057±0.0005
P11	4848767.0484±0.0006	-261518.6281±0.0003	4123046.7913±0.0005
P12	4848726.5027±0.0006	-261473.2082±0.0004	4123094.4900±0.0006
P13	4848762.5432±0.0006	-261463.2641±0.0004	4123052.9786±0.0006
P16	4848831.5093±0.0006	-261629.4934±0.0004	4122976.9150±0.0005
P17	4848804.8455±0.0006	-261553.3749±0.0003	4123001.3092±0.0005
P18	4848772.2773±0.0006	-261737.3613±0.0003	4123028.9230±0.0005
P19	4848812.1799±0.0006	-261729.7089±0.0003	4122982.3708±0.0005
P20	4848812.0669±0.0006	-261799.8688±0.0004	4122976.6310±0.0006
P21	4848773.3839±0.0006	-261786.3797±0.0003	4123023.9553±0.0005
P22	4848744.6577±0.0006	-261775.5086±0.0004	4123057.9131±0.0005
P23	4848796.8288±0.0006	-261689.2011±0.0003	4123002.6099±0.0004
YEB1	4848800.1199±0.0006	-261769.1584±0.0004	4123001.4882±0.0006
VLBI13m	4848831.0675±0.0006	-261629.4545±0.0004	4122976.5324±0.0005
VLBI40m	4848761.7752±0.0014	-261484.1112±0.0012	4123085.0913±0.0018
YEBE	4848724.5957±0.0006	-261631.9787±0.0004	4123094.3043±0.0005

Table 6.1

The whole covariance matrix was computed. It was possible to extract from it the covariance submatrix for the following points of interest: YEB1, VLBI13m, VLBI40m and YEBE. This covariance submatrix has been converted into the SINEX format with an own matlab software. The resulting SINEX file (13420_IGN_2017-117.snx) is given in Annex 5.

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8. ANNEXES

Annex 1: YEBE GNSS station

GOBIERNO DE ESPAÑA · MINISTERIO DE FOMENTO · INSTITUTO GEOGRÁFICO NACIONAL

Área de Geodesia
Subdirección General de Geodesia y Cartografía

Reseña de Estación Permanente - ERGNSS 4-mar-2017

Situación:

Código.........: YEBE
Nombre........: Yebes
Código IERS: 13420M001
Instalación...: 30 de noviembre de 1992

Municipio: Yebes
Provincia: Guadalajara

Localización.: Guadalajara
Centro Astronómico de Yebes, Aptdo. 143, 19080 - Guadalajara

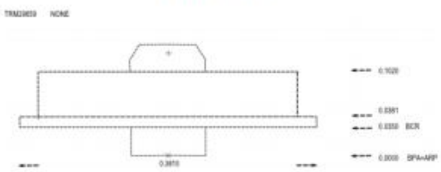
Construcción: Pilar de hormigón armado de 1.2 m de altura.
Marca de coordenadas, parte superior sobre placa metálica.

Coordenadas ETRS89:

Longitud..........:	- 3° 05' 19,06498"	**X....................:**	4848724.914 m.
Latitud..............:	40° 31' 29,63168"	**Y....................:**	-261632.472 m.
Altitud elipsoidal:	972.778 m.	**Z....................:**	4123093.922 m.
X UTM...............:	492492.886 m.	**Altitud sobre el nivel medio del mar:**	920.813 m.
Y UTM...............:	4486022.150 m.		
Huso..................:	30		

Instrumentación:

Receptor: NETRS
Antena: TRM29659.00 NONE **Altura:** 0.0000 m. (ARP)
Offset de centros de fase de antena: L1 0.091 m. L2 0.120 m.
Esquema antena



Información adicional:

Esta estación permanente, además de a la red ERGNSS, pertenece a las siguientes redes:
- Red de EUREF Permanent Network (EPN): http://www.epncb.oma.be
- Red del International GNSS Services (IGS): http://igscb.jpl.nasa.gov
- Red TEIDE

Datos horarios a 1, 5, 15 y 30 segundos y diarios a 30 segundos
ftp://ftp.geodesia.ign.es

Emite correcciones diferenciales a través del Caster http://ergnss-ip.ign.es a través del punto de montaje:
- YEBE0 formato de la corrección RTCM versión RTCM 2.3

E-mail de contacto: buzon-geodesia@fomento.es

Observaciones:

Annex 2: YEB1 GNSS station

GOBIERNO DE ESPAÑA | MINISTERIO DE FOMENTO

Área de Geodesia
Subdirección General de Geodesia y Cartografía

Reseña de Estación Permanente - ERGNSS 4-mar-2017

Situación:

Código.........: YEB1
Nombre........: Yebes 1
Código IERS: 13420M002
Instalación...: 22 de abril de 2009

Municipio: Yebes
Provincia: Guadalajara

Localización.: Guadalajara
Centro Astronómico de Yebes, Aptdo. 143, 19080 - Guadalajara

Construcción: Pilar de hormigón armado de 1.2 m de altura.
Marca de coordenadas, parte superior sobre placa metálica.

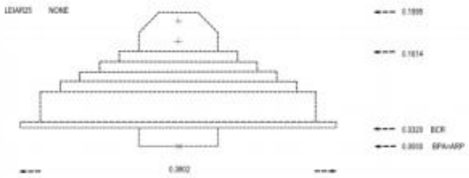
Coordenadas ETRS89:

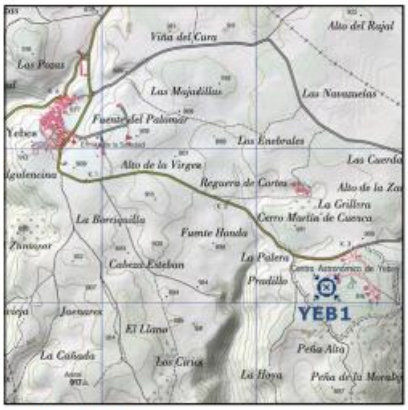
Longitud............:	- 3° 05' 24,71087"	**X.....................:**	4848800.403 m.
Latitud...............:	40° 31' 25,60071"	**Y.....................:**	-261769.653 m.
Altitud elipsoidal:	975.367 m.	**Z.....................:**	4123001.077 m.
X UTM................:	492359.920 m.	**Altitud sobre el nivel medio del mar:**	923.378 m.
Y UTM................:	4485897.996 m.		
Huso...................:	30		

Instrumentación:

Receptor: GRX1200+GNSS
Antena: LEIAR25 NONE **Altura:** 0.0600 m. (ARP)
Offset de centros de fase de antena: L1 0.155 m. L2 0.164 m.

Esquema antena





Información adicional:

Esta estación permanente pertenece a la red ERGNSS.

Datos horarios a 1, 5, 15 y 30 segundos y diarios a 30 segundos
ftp://ftp.geodesia.ign.es

Emite correcciones diferenciales a través del Caster http://ergnss-ip.ign.es
a través de los puntos de montaje:
- YEB10 formato de la corrección RTCM versión RTCM 3.1
- YEB11 formato de la corrección RTCM versión RTCM 2.3

E-mail de contacto: buzon-geodesia@fomento.es

Observaciones:

Annex 3: Local survey adjustment input file

```
XTMR UTM 30  w  3  0  0.000000 n  0  0  0.000000     0.000000 500000.00000          1 m
 COMP ADJ
 MAXI        50

 SIGM dis    0.00045         1     0.0007     0.0007     0.0007              m
 SIGM ver       0.35               0.0007     0.0007     0.0007
 SIGM azi       0.35               0.0007     0.0007     0.0007

*Aproximate coordinates and variance covariance matrix
 3DC
 XYZ  000 1            4848838.467488040  -261648.839139577  4122952.441435070 m  0
 XYZ  000 2            4848821.665606191  -261599.683776349  4122976.635126530 m  0
 XYZ  000 3            4848809.163562700  -261648.541254706  4122989.047663490 m  0
 XYZ  000 4            4848796.158662850  -261609.621717010  4123007.554338200 m  0
 XYZ  000 5            4848779.001909370  -261649.095467739  4123026.131786750 m  0
 XYZ  000 6            4848748.726610850  -261700.229575437  4123057.840387440 m  0
 XYZ  000 7            4848764.061372270  -261579.168770024  4123047.406772750 m  0
 XYZ  000 8            4848729.171274900  -261570.140406414  4123085.592661320 m  0
 XYZ  000 9            4848705.965837330  -261572.217857121  4123110.485417360 m  0
 XYZ  000 10           4848749.974207970  -261515.950059728  4123065.493431240 m  0
 XYZ  000 11           4848767.451916570  -261519.126103010  4123046.479546810 m  0
 XYZ  000 12           4848726.912255650  -261473.700467302  4123094.193889180 m  0
 XYZ  000 13           4848762.959096630  -261463.755618260  4123052.670299900 m  0
 XYZ  000 17           4848805.240778700  -261553.873025806  4123000.991753500 m  0
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 XYZ  000 22           4848745.044726080  -261776.001969224  4123057.589026750 m  0
 XYZ  000 23           4848797.211591620  -261689.694742689  4123002.288201010 m  0
 COV  CT UPPR
 ELEM          0.0000048258          -0.0000014541          0.0000002286
 ELEM          0.0000000000           0.0000000000          0.0000000000
```

```
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DIR 1 4 153 35 23.0528
DIR 1 2 183 16 29.1083
DIR 1 19 59 51 11.666
DIR 1 3 124 28 47.0527
DIR 1 4 153 35 23.2911
DIR 1 2 183 16 29.2838
DIR 1 19 59 51 11.9634
DIR 1 3 124 28 47.2787
DIR 1 4 153 35 23.5718
DIR 1 2 183 16 29.583
DIR 1 19 59 51 11.6415
DIR 1 3 124 28 47.6155
DIR 1 4 153 35 23.1724
DIR 1 2 183 16 29.6544
DSET azi
DIR 2 1 87 48 5.3294
DIR 2 3 138 19 28.5804
DIR 2 4 194 41 38.7905
DIR 2 17 266 7 22.4711
DIR 2 1 87 48 5.457
DIR 2 3 138 19 29.0154
DIR 2 4 194 41 38.791
DIR 2 17 266 7 22.743
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DIR 2 3 138 19 28.7679
DIR 2 4 194 41 38.7305
DIR 2 17 266 7 22.7551
DIR 2 1 87 48 4.9914
DIR 2 3 138 19 28.7706
DIR 2 4 194 41 38.2645
DIR 2 17 266 7 22.4765
DIR 2 1 87 48 5.0425
DIR 2 3 138 19 28.7998
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DIR 2 17 266 7 22.4168
DSET azi
DIR 4 17 63 45 52.4196
DIR 4 2 128 51 3.7563
DIR 4 1 172 16 26.4971
DIR 4 3 202 42 14.1932
DIR 4 5 265 20 16.4147
DIR 4 7 353 31 13.05
DIR 4 17 63 45 51.5585
DIR 4 2 128 51 4.0092
DIR 4 1 172 16 24.3925
DIR 4 3 202 42 14.0451
DIR 4 5 265 20 16.0617
DIR 4 7 353 31 12.3267
DIR 4 17 63 45 51.9035
DIR 4 2 128 51 3.4379
DIR 4 1 172 16 25.4838
DIR 4 3 202 42 13.7897
DIR 4 5 265 20 16.0365
DIR 4 7 353 31 13.1682
DIR 4 17 63 45 50.558
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DIR 4 5 265 20 15.7923
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DIR 17 11 245 53 1.8434
DIR 17 7 193 13 57.9488
DIR 17 4 136 28 54.1589
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DSET azi
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DIST dis 7	8	52.50642898	m
DIST dis 7	10	67.24965214	m
DIST dis 7	11	60.15052246	m
DIST dis 7	9	86.03932772	m
DIST dis 7	5	74.6006882	m
DIST dis 7	6	122.4696498	m
DIST dis 7	8	52.50652898	m
DIST dis 7	10	67.24975215	m
DIST dis 7	11	60.15067246	m
DIST dis 7	9	86.03942773	m
DIST dis 7	5	74.6006382	m
DIST dis 7	6	122.46969981	m
DIST dis 7	8	52.50657898	m
DIST dis 7	4	59.54206837	m
DIST dis 7	17	67.00598378	m
DIST dis 7	4	59.54206837	m
DIST dis 7	17	67.00603378	m
DIST dis 7	4	59.54196837	m
DIST dis 7	17	67.00598378	m
DIST dis 7	4	59.54201837	m
DIST dis 7	17	67.00603378	m
DIST dis 7	4	59.54201837	m
DIST dis 7	17	67.00598378	m
DIST dis 8	7	52.50662133	m
DIST dis 8	9	34.09800549	m
DIST dis 8	12	96.84516378	m
DIST dis 8	10	61.42457123	m
DIST dis 8	7	52.50677134	m
DIST dis 8	9	34.09805549	m
DIST dis 8	12	96.84501378	m
DIST dis 8	10	61.42452123	m
DIST dis 8	7	52.50667133	m
DIST dis 8	9	34.09800549	m
DIST dis 8	12	96.84496378	m
DIST dis 8	10	61.42452123	m
DIST dis 8	7	52.50672134	m
DIST dis 8	9	34.09770548	m
DIST dis 8	12	96.84496378	m
DIST dis 8	10	61.42457123	m
DIST dis 8	7	52.50672134	m
DIST dis 8	9	34.09790549	m
DIST dis 8	12	96.84501378	m
DIST dis 8	10	61.42432122	m
DIST dis 9	12	102.0262191	m
DIST dis 9	10	84.42132403	m
DIST dis 9	8	34.09800888	m
DIST dis 9	7	86.03941953	m
DIST dis 9	12	102.0261691	m
DIST dis 9	10	84.42117403	m
DIST dis 9	8	34.09795888	m
DIST dis 9	7	86.03951954	m
DIST dis 9	12	102.0261191	m
DIST dis 9	10	84.42112403	m
DIST dis 9	8	34.09770887	m
DIST dis 9	7	86.03936953	m
DIST dis 9	12	102.0260191	m
DIST dis 9	10	84.42102402	m
DIST dis 9	8	34.09780887	m
DIST dis 9	7	86.03946954	m
DIST dis 9	12	102.0261691	m
DIST dis 9	10	84.42107403	m
DIST dis 9	8	34.09780887	m
DIST dis 9	7	86.03921953	m
DIST dis 10	12	56.03542752	m
DIST dis 10	13	55.28735379	m
DIST dis 10	11	26.01822533	m
DIST dis 10	7	67.24978325	m
DIST dis 10	8	61.42454847	m
DIST dis 10	9	84.42132795	m
DIST dis 10	12	56.03557752	m
DIST dis 10	13	55.28730378	m
DIST dis 10	11	26.01787532	m
DIST dis 10	7	67.24983325	m
DIST dis 10	8	61.42459847	m
DIST dis 10	9	84.42142796	m
DIST dis 10	12	56.03557752	m
DIST dis 10	13	55.28750379	m
DIST dis 10	11	26.01802533	m
DIST dis 10	7	67.24983325	m
DIST dis 10	8	61.42474847	m
DIST dis 10	9	84.42147796	m
DIST dis 10	12	56.03567752	m
DIST dis 10	13	55.28755379	m
DIST dis 10	11	26.01797532	m
DIST dis 10	7	67.24978325	m
DIST dis 10	8	61.42464847	m
DIST dis 10	9	84.42132795	m
DIST dis 10	12	56.03557752	m
DIST dis 10	13	55.28745379	m
DIST dis 10	11	26.01802533	m
DIST dis 10	7	67.24983325	m
DIST dis 10	8	61.42479847	m
DIST dis 10	9	84.42132795	m
DIST dis 11	17	68.58975017	m
DIST dis 11	7	60.15077947	m
DIST dis 11	10	26.01793458	m
DIST dis 11	13	55.89029281	m
DIST dis 11	12	77.34428099	m
DIST dis 11	17	68.58985017	m
DIST dis 11	7	60.15082947	m
DIST dis 11	10	26.01818459	m
DIST dis 11	13	55.89039281	m
DIST dis 11	12	77.34433099	m
DIST dis 11	17	68.58995018	m
DIST dis 11	7	60.15087948	m
DIST dis 11	10	26.01823459	m
DIST dis 11	13	55.89044281	m
DIST dis 11	12	77.34433099	m
DIST dis 11	17	68.58995018	m
DIST dis 11	7	60.15082947	m
DIST dis 11	10	26.01808459	m
DIST dis 11	13	55.89049281	m
DIST dis 11	12	77.344381	m
DIST dis 11	17	68.58980017	m
DIST dis 11	7	60.15077947	m
DIST dis 11	10	26.01793458	m
DIST dis 11	13	55.89029281	m
DIST dis 11	12	77.34428099	m
DIST dis 12	9	102.02649535	m
DIST dis 12	8	96.84507799	m
DIST dis 12	10	56.03560989	m
DIST dis 12	11	77.34439814	m
DIST dis 12	13	55.86605441	m
DIST dis 12	9	102.02654535	m
DIST dis 12	8	96.845178	m
DIST dis 12	10	56.03570989	m
DIST dis 12	11	77.34454815	m
DIST dis 12	13	55.86615442	m
DIST dis 12	9	102.02654535	m
DIST dis 12	8	96.84507799	m
DIST dis 12	10	56.03555989	m
DIST dis 12	11	77.34434814	m
DIST dis 12	13	55.86600441	m
DIST dis 12	9	102.02629534	m
DIST dis 12	8	96.845128	m
DIST dis 12	10	56.03565989	m
DIST dis 12	11	77.34434814	m
DIST dis 12	13	55.86620442	m
DIST dis 12	9	102.02639535	m
DIST dis 12	8	96.84507799	m
DIST dis 12	10	56.03565989	m
DIST dis 12	11	77.34439814	m
DIST dis 12	13	55.86605441	m
DIST dis 13	10	55.28742946	m
DIST dis 13	11	55.89029832	m
DIST dis 13	12	55.86614756	m
DIST dis 13	10	55.28747946	m
DIST dis 13	11	55.89029832	m
DIST dis 13	12	55.86624756	m
DIST dis 13	10	55.28747946	m
DIST dis 13	11	55.89029832	m
DIST dis 13	12	55.86614756	m
DIST dis 13	10	55.28742946	m
DIST dis 13	11	55.89024831	m
DIST dis 13	12	55.86609756	m
DIST dis 13	10	55.28742946	m
DIST dis 13	11	55.89029832	m
DIST dis 13	12	55.86624756	m

*GPSGrav antenna

DSET azi			
DIR	19	20	209 10 36.7761
DIR	19	YEB1	242 19 6.2636
DIR	19	18	295 33 12.8269
DIR	19	20	209 10 36.4245
DIR	19	YEB1	242 19 6.0846
DIR	19	18	295 33 12.4898
DIR	19	20	209 10 36.6927
DIR	19	YEB1	242 19 6.3113
DIR	19	18	295 33 12.5489
DIR	19	20	209 10 36.2321
DIR	19	YEB1	242 19 5.742
DIR	19	18	295 33 12.3801
DIR	19	20	209 10 36.4069
DIR	19	YEB1	242 19 5.8425
DIR	19	18	295 33 12.2918
DSET azi			
DIR	20	21	10 50 48.6461
DIR	20	YEB1	47 39 11.3733
DIR	20	19	84 52 14.3908
DIR	20	21	10 50 48.0677
DIR	20	YEB1	47 39 10.8391
DIR	20	19	84 52 13.0417
DIR	20	21	10 50 47.9793
DIR	20	YEB1	47 39 10.2567
DIR	20	19	84 52 13.6473
DIR	20	21	10 50 47.6055
DIR	20	YEB1	47 39 10.9257
DIR	20	19	84 52 13.5567
DIR	20	21	10 50 48.039
DIR	20	YEB1	47 39 10.9391
DIR	20	19	84 52 13.3518
DSET azi			
DIR	21	18	203 33 17.8853
DIR	21	YEB1	271 56 22.5152
DIR	21	20	311 16 35.6243
DIR	21	18	203 33 17.3241
DIR	21	YEB1	271 56 22.6393
DIR	21	20	311 16 35.9247
DIR	21	18	203 33 17.8881
DIR	21	YEB1	271 56 22.8524
DIR	21	20	311 16 35.7436
DIR	21	18	203 33 17.6915
DIR	21	YEB1	271 56 22.7
DIR	21	20	311 16 35.7609
DIR	21	18	203 33 17.1281
DIR	21	YEB1	271 56 22.6832
DIR	21	20	311 16 35.242
DSET azi			
DIR	18	19	348 45 17.3964
DIR	18	21	80 37 57.1432
DIR	18	19	348 45 17.3717
DIR	18	21	80 37 58.4946
DIR	18	19	348 45 17.1624
DIR	18	21	80 37 57.1097
DIR	18	19	348 45 17.093
DIR	18	21	80 37 57.0413
DIR	18	19	348 45 17.0144
DIR	18	21	80 37 56.913

HI 19		0.229 m		
HT 20		0.2292 m		
ZANG ver 19	20		90 46 2.0571	0.13
HT YEB1		0.1186 m		
ZANG ver 19	YEB1		83 58 33.8736	0.13
HT 18		0.2262 m		
ZANG ver 19	18		89 45 4.0954	0.13
HT 20		0.2292 m		
ZANG ver 19	20		90 46 3.3083	0.13
HT YEB1		0.1186 m		
ZANG ver 19	YEB1		83 58 34.9343	0.13
HT 18		0.2262 m		
ZANG ver 19	18		89 45 4.4265	0.13
HT 20		0.2292 m		
ZANG ver 19	20		90 46 3.1351	0.13
HT YEB1		0.1186 m		
ZANG ver 19	YEB1		83 58 34.3346	0.13
HT 18		0.2262 m		
ZANG ver 19	18		89 45 4.5994	0.13
HT 20		0.2292 m		
ZANG ver 19	20		90 46 2.1209	0.13
HT YEB1		0.1186 m		
ZANG ver 19	YEB1		83 58 34.6407	0.13
HT 18		0.2262 m		
ZANG ver 19	18		89 45 4.4215	0.13
HT 20		0.2292 m		
ZANG ver 19	20		90 46 3.6993	0.13
HT YEB1		0.1186 m		
ZANG ver 19	YEB1		83 58 34.0447	0.13
HT 18		0.2262 m		
ZANG ver 19	18		89 45 4.6353	0.13
HI 20		0.2292 m		
HT 21		0.2271 m		
ZANG ver 20	21		89 14 37.9393	0.13
HT YEB1		0.1186 m		
ZANG ver 20	YEB1		82 2 37.6586	0.13
HT 19		0.229 m		
ZANG ver 20	19		89 14 11.2227	0.13
HT 21		0.2271 m		
ZANG ver 20	21		89 14 37.2313	0.13
HT YEB1		0.1186 m		
ZANG ver 20	YEB1		82 2 37.8654	0.13
HT 19		0.229 m		
ZANG ver 20	19		89 14 11.4119	0.13
HT 21		0.2271 m		
ZANG ver 20	21		89 14 36.358	0.13
HT YEB1		0.1186 m		
ZANG ver 20	YEB1		82 2 37.1272	0.13
HT 19		0.229 m		
ZANG ver 20	19		89 14 11.1138	0.13
HT 21		0.2271 m		
ZANG ver 20	21		89 14 35.4812	0.13
HT YEB1		0.1186 m		
ZANG ver 20	YEB1		82 2 36.9801	0.13
HT 19		0.229 m		
ZANG ver 20	19		89 14 11.2186	0.13

```
HT       21                 0.2271 m
ZANG ver 20       21                          89 14 37.1384          0.13
HT       YEB1               0.1186 m
ZANG ver 20       YEB1                        82  2 37.0868          0.13
HT       19                  0.229 m
ZANG ver 20       19                          89 14 11.9151          0.13
HI       21                 0.2271 m
HT       18                 0.2262 m
ZANG ver 21       18                          89 33 25.4228          0.13
HT       YEB1               0.1186 m
ZANG ver 21       YEB1                        82 47 37.7531          0.13
HT       20                 0.2292 m
ZANG ver 21       20                          90 45 34.0235          0.13
HT       18                 0.2262 m
ZANG ver 21       18                          89 33 24.9168          0.13
HT       YEB1               0.1186 m
ZANG ver 21       YEB1                        82 47 37.2739          0.13
HT       20                 0.2292 m
ZANG ver 21       20                          90 45 33.5676          0.13
HT       18                 0.2262 m
ZANG ver 21       18                          89 33 25.6605          0.13
HT       YEB1               0.1186 m
ZANG ver 21       YEB1                        82 47 37.5356          0.13
HT       20                 0.2292 m
ZANG ver 21       20                          90 45  34.146          0.13
HT       18                 0.2262 m
ZANG ver 21       18                          89 33 25.3839          0.13
HT       YEB1               0.1186 m
ZANG ver 21       YEB1                        82 47 37.5588          0.13
HT       20                 0.2292 m
ZANG ver 21       20                          90 45  33.904          0.13
HT       18                 0.2262 m
ZANG ver 21       18                          89 33 25.0305          0.13
HT       YEB1               0.1186 m
ZANG ver 21       YEB1                        82 47 37.4399          0.13
HT       20                 0.2292 m
ZANG ver 21       20                          90 45 33.6487          0.13
HI       18                 0.2262 m
HT       19                  0.229 m
ZANG ver 18       19                          90 15  7.9973          0.13
HT       21                 0.2271 m
ZANG ver 18       21                          90 26 48.5139          0.13
HT       19                  0.229 m
ZANG ver 18       19                          90 15   8.268          0.13
HT       21                 0.2271 m
ZANG ver 18       21                          90 26 48.2511          0.13
HT       19                  0.229 m
ZANG ver 18       19                          90 15  8.6794          0.13
HT       21                 0.2271 m
ZANG ver 18       21                          90 26 48.4013          0.13
HT       19                  0.229 m
ZANG ver 18       19                          90 15  7.6942          0.13
HT       21                 0.2271 m
ZANG ver 18       21                          90 26 47.2266          0.13
HT       19                  0.229 m
ZANG ver 18       19                          90 15  7.9506          0.13
HT       21                 0.2271 m
ZANG ver 18       21                          90 26 48.1326          0.13


DIST dis 19       20                            70.39357755          m
DIST dis 19       YEB1                          45.45424779          m
DIST dis 19       18                            61.78896027          m
DIST dis 19       20                            70.39362755          m
DIST dis 19       YEB1                           45.4544478          m
DIST dis 19       18                            61.78901027          m
DIST dis 19       20                            70.39352755          m
DIST dis 19       YEB1                          45.45429779          m
DIST dis 19       18                            61.78886027          m
DIST dis 19       20                            70.39357755          m
DIST dis 19       YEB1                           45.4544478          m
DIST dis 19       18                            61.78891027          m
DIST dis 19       20                            70.39362755          m
DIST dis 19       YEB1                           45.4545478          m
DIST dis 19       18                            61.78901027          m
DIST dis 20       21                            62.58636487          m
DIST dis 20       YEB1                          41.25561449          m
DIST dis 20       19                            70.39346631          m
DIST dis 20       21                            62.58641487          m
DIST dis 20       YEB1                          41.25566449          m
DIST dis 20       19                            70.39356631          m
DIST dis 20       21                            62.58636487          m
DIST dis 20       YEB1                          41.25561449          m
DIST dis 20       19                            70.39346631          m
DIST dis 20       21                            62.58641487          m
DIST dis 20       YEB1                          41.25566449          m
DIST dis 20       19                            70.39356631          m
DIST dis 20       21                            62.58651487          m
DIST dis 20       YEB1                          41.25576449          m
DIST dis 20       19                            70.39366631          m
DIST dis 21       18                            49.28210637          m
DIST dis 21       YEB1                           38.9241713          m
DIST dis 21       20                            62.58647254          m
DIST dis 21       18                            49.28200637          m
DIST dis 21       YEB1                           38.9242213          m
DIST dis 21       20                            62.58652254          m
DIST dis 21       18                            49.28220638          m
DIST dis 21       YEB1                           38.9242713          m
DIST dis 21       20                            62.58657255          m
DIST dis 21       18                            49.28215637          m
DIST dis 21       YEB1                           38.9242213          m
DIST dis 21       20                            62.58662255          m
DIST dis 21       18                            49.28200637          m
DIST dis 21       YEB1                           38.9241713          m
DIST dis 21       20                            62.58642254          m
DIST dis 18       19                            61.78882087          m
DIST dis 18       21                            49.28193266          m
DIST dis 18       19                            61.78882087          m
DIST dis 18       21                            49.28203267          m
DIST dis 18       19                            61.78892087          m
DIST dis 18       21                            49.28203267          m
DIST dis 18       19                            61.78897088          m
DIST dis 18       21                            49.28213267          m
DIST dis 18       19                            61.78887087          m
DIST dis 18       21                            49.28203267          m
```

* Observation from plnimetric observation of YEBE

```
DSET azi
DIR      9        7                          265  6 50.3473
DIR      9        8                          256 58 16.2128
DIR      9        7                          265  6 50.3472
DIR      9        8                          256 58 15.8367
DIR      9        7                          265  6 51.6963
DIR      9        8                          256 58 16.1855
DIR      9        7                          265  6 51.6908
DIR      9        8                          256 58 16.5646
DIR      9        7                          265  6 50.8088
DIR      9        8                          256 58 15.9621
DIR      9        15                         328  2 28.7536
DIR      9        15                         328  2  27.401
DIR      9        15                         328  2 25.7459
DIR      9        15                         328  2 25.9733
DIR      9        15                         328  2 24.8324
DSET azi
DIR      8        7                          150 15 55.5078
DIR      8        9                          316 50 40.1339
DIR      8        7                          150 15 54.9625
DIR      8        9                          316 50 39.5283
DIR      8        7                          150 15 55.3941
DIR      8        9                          316 50 39.7968
DIR      8        7                          150 15 55.0115
DIR      8        9                          316 50 39.6528
DIR      8        7                          150 15 54.2947
DIR      8        9                          316 50  39.672
DIR      8        15                         238 45 44.9413
DIR      8        15                         238 45 43.9545
DIR      8        15                         238 45 45.1883
DIR      8        15                         238 45 44.3013
DIR      8        15                         238 45 44.7746
DSET azi
DIR      7        5                          179 22 19.5859
DIR      7        6                          208  4 30.5163
DIR      7        8                          299 30  4.8865
DIR      7        9                          294 13   25.48
DIR      7        5                          179 22 19.1442
DIR      7        6                          208  4 30.4303
DIR      7        8                          299 30  4.6075
DIR      7        9                          294 13  23.664
DIR      7        5                          179 22 20.2372
DIR      7        6                          208  4 29.7405
DIR      7        8                          299 30  4.9023
DIR      7        9                          294 13 24.4466
DIR      7        5                          179 22 20.5743
DIR      7        6                          208  4 30.3431
DIR      7        8                          299 30  4.8923
DIR      7        9                          294 13 23.8121
DIR      7        5                          179 22 20.0916
DIR      7        6                          208  4 30.8351
DIR      7        8                          299 30  4.9292
DIR      7        9                          294 13 23.7299
DIR      7        15                         248 28  5.4604
DIR      7        15                         248 28  5.5422
DIR      7        15                         248 28  3.0026
DIR      7        15                         248 28  3.0644
DIR      7        15                         248 28   5.221
DSET azi
DIR      5        6                          100 30  43.989
DIR      5        7                          219 40 21.0924
DIR      5        6                          100 30 41.3861
DIR      5        7                          219 40 22.1945
DIR      5        6                          100 30  42.568
DIR      5        7                          219 40 22.7481
DIR      5        6                          100 30 42.0098
DIR      5        7                          219 40 22.2283
DIR      5        6                          100 30 42.3281
DIR      5        7                          219 40 22.4197
DSET azi
DIR      6        7                           90 44 40.8035
DIR      6        5                          122 52 48.2876
DIR      6        7                           90 44 41.2377
DIR      6        5                          122 52 49.2109
DIR      6        7                           90 44 41.5217
DIR      6        5                          122 52 49.1144
DIR      6        7                           90 44 39.9265
DIR      6        5                          122 52 48.1603
DIR      6        7                           90 44 40.0275
DIR      6        5                          122 52 48.9471
DIR      6        15                          50  3 53.6649
DIR      6        15                          50  3 56.8406
DIR      6        15                          50  3 56.8927
DIR      6        15                          50  3 55.9403
DIR      6        15                          50  3 55.3806


HI       9                  0.2277 m
HT       7                  0.2183 m
ZANG ver 9        7                           87 44 32.1966          0.13
HT       8                  0.2263 m
ZANG ver 9        8                           87 44  1.4131          0.13
HT       7                  0.2183 m
ZANG ver 9        7                           87 44  30.843          0.13
HT       8                  0.2263 m
ZANG ver 9        8                           87 44  1.4215          0.13
HT       7                  0.2183 m
ZANG ver 9        7                           87 44  30.875          0.13
HT       8                  0.2263 m
ZANG ver 9        8                           87 44  1.2616          0.13
HT       7                  0.2183 m
ZANG ver 9        7                           87 44 30.7535          0.13
HT       8                  0.2263 m
ZANG ver 9        8                           87 44  1.3097          0.13
HT       7                  0.2183 m
ZANG ver 9        7                           87 44 31.0238          0.13
HT       8                  0.2263 m
ZANG ver 9        8                           87 44  1.5797          0.13
*HT      15                      0 m
*ZANG ver 9       15                          84 39 41.6836          0.13
*HT      15                      0 m
*ZANG ver 9       15                          84 39 41.2870          0.13
*HT      15                      0 m
*ZANG ver 9       15                          84 39 41.2976          0.13
*HT      15                      0 m
*ZANG ver 9       15                          84 39 42.9165          0.13
*HT      15                      0 m
*ZANG ver 9       15                          84 39 43.5838          0.13
HI       8                  0.2263 m
HT       7                  0.2183 m
ZANG ver 8        7                           87 46 16.5901          0.13
HT       9                  0.2277 m
ZANG ver 8        9                           92 16  8.0978          0.13
HT       7                  0.2183 m
ZANG ver 8        7                           87 46 16.5898          0.13
HT       9                  0.2277 m
ZANG ver 8        9                           92 16  8.2867          0.13
HT       7                  0.2183 m
ZANG ver 8        7                           87 46 16.0618          0.13
HT       9                  0.2277 m
ZANG ver 8        9                           92 16  7.5102          0.13
HT       7                  0.2183 m
ZANG ver 8        7                           87 46 15.6735          0.13
HT       9                  0.2277 m
ZANG ver 8        9                           92 16  7.7405          0.13
HT       7                  0.2183 m
ZANG ver 8        7                           87 46 16.0202          0.13
HT       9                  0.2277 m
ZANG ver 8        9                           92 16  7.5426          0.13
*HT      15                      0 m
*ZANG ver 8       15                          85 42  6.5101          0.13
*HT      15                      0 m
*ZANG ver 8       15                          85 42 11.2801          0.13
*HT      15                      0 m
*ZANG ver 8       15                          85 42  9.0291          0.13
*HT      15                      0 m
*ZANG ver 8       15                          85 42 10.0090          0.13
*HT      15                      0 m
*ZANG ver 8       15                          85 42  9.8589          0.13
HI       7                  0.2183 m
HT       5                  0.2271 m
ZANG ver 7        5                           89 42 50.6998          0.13
HT       6                  0.2274 m
ZANG ver 7        6                           89 57  21.828          0.13
HT       8                  0.2263 m
ZANG ver 7        8                           92 13 53.5007          0.13
HT       9                  0.2277 m
ZANG ver 7        9                           92 15 40.1926          0.13
HT       5                  0.2271 m
ZANG ver 7        5                           89 42 52.1658          0.13
HT       6                  0.2274 m
ZANG ver 7        6                           89 57 21.7687          0.13
HT       8                  0.2263 m
ZANG ver 7        8                           92 13 53.6709          0.13
HT       9                  0.2277 m
ZANG ver 7        9                           92 15 41.7654          0.13
HT       5                  0.2271 m
ZANG ver 7        5                           89 42 51.5703          0.13
HT       6                  0.2274 m
ZANG ver 7        6                           89 57  22.467          0.13
HT       8                  0.2263 m
ZANG ver 7        8                           92 13 53.8369          0.13
HT       9                  0.2277 m
ZANG ver 7        9                           92 15 41.1653          0.13
HT       5                  0.2271 m
ZANG ver 7        5                           89 42 51.9186          0.13
HT       6                  0.2274 m
ZANG ver 7        6                           89 57 22.2925          0.13
HT       8                  0.2263 m
ZANG ver 7        8                           92 13 53.0792          0.13
HT       9                  0.2277 m
ZANG ver 7        9                           92 15 42.2441          0.13
HT       5                  0.2271 m
ZANG ver 7        5                           89 42 51.9093          0.13
HT       6                  0.2274 m
ZANG ver 7        6                           89 57 23.1807          0.13
HT       8                  0.2263 m
ZANG ver 7        8                           92 13 53.3781          0.13
HT       9                  0.2277 m
ZANG ver 7        9                           92 15 41.5378          0.13
*HT      15                      0 m
*ZANG ver 7       15                          88  6 23.3940          0.13
*HT      15                      0 m
*ZANG ver 7       15                          88  6 23.7320          0.13
*HT      15                      0 m
*ZANG ver 7       15                          88  6 23.4717          0.13
*HT      15                      0 m
*ZANG ver 7       15                          88  6 27.9696          0.13
*HT      15                      0 m
*ZANG ver 7       15                          88  6 24.1021          0.13
HI       5                  0.2271 m
HT       6                  0.2274 m
ZANG ver 5        6                           90 14 10.7739          0.13
HT       7                  0.2183 m
ZANG ver 5        7                           90 17 22.3228          0.13
HT       6                  0.2274 m
ZANG ver 5        6                           90 14 12.9983          0.13
HT       7                  0.2183 m
ZANG ver 5        7                           90 17 22.7894          0.13
HT       6                  0.2274 m
ZANG ver 5        6                           90 14 11.4735          0.13
HT       7                  0.2183 m
ZANG ver 5        7                           90 17 22.1929          0.13
HT       6                  0.2274 m
ZANG ver 5        6                           90 14 12.9411          0.13
HT       7                  0.2183 m
ZANG ver 5        7                           90 17 22.8166          0.13
HT       6                  0.2274 m
ZANG ver 5        6                           90 14 10.7653          0.13
HT       7                  0.2183 m
ZANG ver 5        7                           90 17 23.4599          0.13
HI       6                  0.2274 m
HT       7                  0.2183 m
ZANG ver 6        7                           90  2 54.3752          0.13
HT       5                  0.2276 m
ZANG ver 6        5                           89 46  0.2034          0.13
HT       7                  0.2183 m
ZANG ver 6        7                           90  2 52.2156          0.13
HT       5                  0.2276 m
ZANG ver 6        5                           89 45 57.3968          0.13
HT       7                  0.2183 m
ZANG ver 6        7                           90  2 53.2316          0.13
HT       5                  0.2276 m
ZANG ver 6        5                           89 45  57.818          0.13
HT       7                  0.2183 m
ZANG ver 6        7                           90  2 51.4281          0.13
HT       5                  0.2276 m
ZANG ver 6        5                           89 45 57.8868          0.13
HT       7                  0.2183 m
ZANG ver 6        7                           90  2 50.4306          0.13
HT       5                  0.2276 m
ZANG ver 6        5                           89 45  59.198          0.13
*HT      15                      0 m
*ZANG ver 6       15                          88  9 55.8717          0.13
*HT      15                      0 m
*ZANG ver 6       15                          88  9 54.7851          0.13
*HT      15                      0 m
*ZANG ver 6       15                          88  9 56.2012          0.13
*HT      15                      0 m
*ZANG ver 6       15                          88  9 57.3764          0.13
*HT      15                      0 m
*ZANG ver 6       15                          88  9 54.4083          0.13


DIST dis 9        7                             86.03914667          m
DIST dis 9        8                             34.09771018          m
DIST dis 9        7                             86.03909667          m
DIST dis 9        8                             34.09746017          m
DIST dis 9        7                             86.03914667          m
DIST dis 9        8                             34.09756018          m
DIST dis 9        7                             86.03899667          m
DIST dis 9        8                             34.09746017          m
DIST dis 9        7                             86.03909667          m
DIST dis 9        8                             34.09746017          m
DIST dis 8        7                             52.50684028          m
DIST dis 8        9                             34.09747036          m
DIST dis 8        7                             52.50679028          m
DIST dis 8        9                             34.09737036          m
DIST dis 8        7                             52.50654027          m
DIST dis 8        9                             34.09747036          m
DIST dis 8        7                             52.50659027          m
DIST dis 8        9                             34.09742036          m
DIST dis 8        7                             52.50679028          m
DIST dis 8        9                             34.09732036          m
DIST dis 7        5                              74.6008968          m
DIST dis 7        6                              122.469946          m
DIST dis 7        8                             52.50667022          m
DIST dis 7        9                             86.03904529          m
DIST dis 7        5                              74.6009468          m
DIST dis 7        6                            122.46974599          m
DIST dis 7        8                             52.50662022          m
DIST dis 7        9                             86.03904529          m
DIST dis 7        5                              74.6008468          m
DIST dis 7        6                            122.46979599          m
DIST dis 7        8                             52.50657022          m
DIST dis 7        9                             86.03889529          m
DIST dis 7        5                              74.6007968          m
DIST dis 7        6                              122.469946          m
DIST dis 7        8                             52.50662022          m
DIST dis 7        9                             86.03904529          m
DIST dis 7        5                              74.6009468          m
DIST dis 7        6                            122.46974599          m
DIST dis 7        8                             52.50657022          m
DIST dis 7        9                             86.03899529          m
DIST dis 5        6                             67.35619658          m
DIST dis 5        7                             74.60092907          m
DIST dis 5        6                             67.35604658          m
DIST dis 5        7                             74.60082906          m
DIST dis 5        6                             67.35604658          m
DIST dis 5        7                             74.60082906          m
DIST dis 5        6                             67.35614658          m
DIST dis 5        7                             74.60087907          m
DIST dis 5        6                             67.35609658          m
DIST dis 5        7                             74.60077906          m
DIST dis 6        7                             122.4696684          m
DIST dis 6        5                             67.35627006          m
DIST dis 6        7                             122.4696184          m
DIST dis 6        5                             67.35627006          m
DIST dis 6        7                            122.46956839          m
DIST dis 6        5                             67.35617006          m
DIST dis 6        7                            122.46956839          m
DIST dis 6        5                             67.35617006          m
DIST dis 6        7                            122.46946839          m
DIST dis 6        5                             67.35612006          m
```

*Observations of the inverse for the central pilar of VLBI13m

```
DSET azi
DIR      16       1                          314 36  58.907
DIR      16       2                          171 36 27.5861
DIR      16       3                           56 13 52.0113
DIR      16       1                          314 36 57.0684
DIR      16       2                          171 36 25.2194
DIR      16       3                           56 13 50.5912
DIR      16       1                          314 36  55.755
DIR      16       2                          171 36 25.7242
DIR      16       3                           56 13 51.3583
DIR      16       1                          314 36 57.4786
DIR      16       2                          171 36 26.9475
DIR      16       3                           56 13 51.2624
DIR      16       1                          314 36 56.7617
DIR      16       2                          171 36 26.8271
DIR      16       3                           56 13  51.152
DIR      16       1                          314 36 57.2014
DIR      16       2                          171 36 27.1179
DIR      16       3                           56 13 50.6379

DIST dis 16       1                             31.26328782          m
DIST dis 16       2                             31.92431293          m
DIST dis 16       3                             31.81470877          m
DIST dis 16       1                             31.26308781          m
DIST dis 16       2                             31.92441294          m
DIST dis 16       3                             31.81470877          m
DIST dis 16       1                             31.26308781          m
DIST dis 16       2                             31.92431293          m
DIST dis 16       3                             31.81470877          m
DIST dis 16       1                             31.26308781          m
DIST dis 16       2                             31.92426293          m
DIST dis 16       3                             31.81470877          m
DIST dis 16       1                             31.26313781          m
DIST dis 16       2                             31.92436294          m
DIST dis 16       3                             31.81470877          m
DIST dis 16       1                             31.26323782          m
DIST dis 16       2                             31.92451294          m
DIST dis 16       3                             31.81470877          m

HI       16                      0 m
HT       1                  0.2187 m
ZANG ver 16       1                          108  5 46.6782          0.13
HT       2                  0.2283 m
ZANG ver 16       2                          105 55 37.5948          0.13
HT       3                  0.2286 m
ZANG ver 16       3                          104 54  7.5848          0.13
HT       1                  0.2187 m
ZANG ver 16       1                          108  5 46.2714          0.13
HT       2                  0.2283 m
ZANG ver 16       2                          105 55 37.2342          0.13
HT       3                  0.2286 m
ZANG ver 16       3                          104 54  6.6454          0.13
HT       1                  0.2187 m
ZANG ver 16       1                          108  5 46.3016          0.13
HT       2                  0.2283 m
ZANG ver 16       2                          105 55 37.3899          0.13
HT       3                  0.2286 m
ZANG ver 16       3                          104 54   6.936          0.13
HT       1                  0.2187 m
ZANG ver 16       1                          108  5 46.6471          0.13
HT       2                  0.2283 m
ZANG ver 16       2                          105 55  37.381          0.13
HT       3                  0.2286 m
ZANG ver 16       3                          104 54  7.6068          0.13
HT       1                  0.2187 m
ZANG ver 16       1                          108  5 46.8909          0.13
HT       2                  0.2283 m
ZANG ver 16       2                          105 55 37.0712          0.13
HT       3                  0.2286 m
ZANG ver 16       3                          104 54  7.4156          0.13
HT       1                  0.2187 m
ZANG ver 16       1                          108  5 47.2133          0.13
HT       2                  0.2283 m
ZANG ver 16       2                          105 55 37.0208          0.13
HT       3                  0.2286 m
ZANG ver 16       3                          104 54  7.9372          0.13
```

```
DSET azi
DIR      1        2                           53 27  6.8842
DIR      1        3                          354 39 29.3804
DIR      1        2                           53 27  6.7043
DIR      1        3                          354 39 28.7415
DIR      1        2                           53 27  6.9353
DIR      1        3                          354 39 28.8898
DIR      1        2                           53 27  6.8724
DIR      1        3                          354 39 29.1939
DIR      1        2                           53 27   6.677
DIR      1        3                          354 39  29.425
DSET azi
DIR      2        1                          177 20  8.6729
DIR      2        3                          227 51 32.3835
DIR      2        1                          177 20  8.5776
DIR      2        3                          227 51 32.1032
DIR      2        1                          177 20    8.98
DIR      2        3                          227 51 33.0108
DIR      2        1                          177 20  8.4924
DIR      2        3                          227 51 32.9135
DIR      2        1                          177 20  8.9879
DIR      2        3                          227 51 33.0305
DSET azi
DIR      3        1                           19 59  6.5071
DIR      3        2                          309 18   7.394
DIR      3        1                           19 59  7.4821
DIR      3        2                          309 18  6.8548
DIR      3        1                           19 59  6.3555
DIR      3        2                          309 18  6.8992
DIR      3        1                           19 59  5.8156
DIR      3        2                          309 18  6.7089
DIR      3        1                           19 59  5.2164
DIR      3        2                          309 18  5.5254

DIST dis 1        2                             57.30367334          m
DIST dis 1        3                             46.88884651          m
DIST dis 1        2                             57.30377334          m
DIST dis 1        3                             46.88884651          m
DIST dis 1        2                             57.30387335          m
DIST dis 1        3                             46.88874651          m
DIST dis 1        2                             57.30402335          m
DIST dis 1        3                             46.88884651          m
DIST dis 1        2                             57.30382334          m
DIST dis 1        3                             46.88884651          m
DIST dis 2        1                             57.30381204          m
DIST dis 2        3                             51.93263751          m
DIST dis 2        1                             57.30391205          m
DIST dis 2        3                             51.93258751          m
DIST dis 2        1                             57.30371204          m
DIST dis 2        3                              51.9324375          m
DIST dis 2        1                             57.30381204          m
DIST dis 2        3                             51.93258751          m
DIST dis 2        1                             57.30381204          m
DIST dis 2        3                             51.93253751          m
DIST dis 3        1                             46.88909658          m
DIST dis 3        2                             51.93235057          m
DIST dis 3        1                             46.88889657          m
DIST dis 3        2                             51.93265058          m
DIST dis 3        1                             46.88919658          m
DIST dis 3        2                             51.93250057          m
DIST dis 3        1                             46.88909658          m
DIST dis 3        2                             51.93260058          m
DIST dis 3        1                             46.88904658          m
DIST dis 3        2                             51.93265058          m

HI       1                 0.21873 m
HT       2                  0.2283 m
ZANG ver 1        2                           89  3  0.2992          0.13
HT       3                  0.2286 m
ZANG ver 1        3                           88  7 55.3024          0.13
HT       2                  0.2283 m
ZANG ver 1        2                           89  2 59.7825          0.13
HT       3                  0.2286 m
ZANG ver 1        3                           88  7 53.5356          0.13
HT       2                  0.2283 m
ZANG ver 1        2                           89  2   59.48          0.13
HT       3                  0.2286 m
ZANG ver 1        3                           88  7 54.3227          0.13
HT       2                  0.2283 m
ZANG ver 1        2                           89  3  0.4347          0.13
HT       3                  0.2286 m
ZANG ver 1        3                           88  7 54.8026          0.13
HT       2                  0.2283 m
ZANG ver 1        2                           89  3  0.9439          0.13
HT       3                  0.2286 m
ZANG ver 1        3                           88  7 54.0411          0.13
HI       2                  0.2283 m
HT       1                  0.2187 m
ZANG ver 2        1                           90 57  1.2002          0.13
HT       3                  0.2286 m
ZANG ver 2        3                           89 21  41.661          0.13
HT       1                  0.2187 m
ZANG ver 2        1                           90 57  2.7054          0.13
HT       3                  0.2286 m
ZANG ver 2        3                           89 21 42.8804          0.13
HT       1                  0.2187 m
ZANG ver 2        1                           90 57  2.3893          0.13
HT       3                  0.2286 m
ZANG ver 2        3                           89 21 42.9654          0.13
HT       1                  0.2187 m
ZANG ver 2        1                           90 57  2.5376          0.13
HT       3                  0.2286 m
ZANG ver 2        3                           89 21 43.4468          0.13
HT       1                  0.2187 m
ZANG ver 2        1                           90 57  2.1414          0.13
HT       3                  0.2286 m
ZANG ver 2        3                           89 21 42.5422          0.13
HI       3                  0.2286 m
HT       1                  0.2187 m
ZANG ver 3        1                           91 52 10.2057          0.13
HT       2                  0.2283 m
ZANG ver 3        2                           90 38 19.4561          0.13
HT       1                  0.2187 m
ZANG ver 3        1                           91 52 10.1585          0.13
HT       2                  0.2283 m
ZANG ver 3        2                           90 38   20.54          0.13
HT       1                  0.2187 m
ZANG ver 3        1                           91 52 10.4226          0.13
HT       2                  0.2283 m
ZANG ver 3        2                           90 38 20.0843          0.13
HT       1                  0.2187 m
ZANG ver 3        1                           91 52 10.9219          0.13
HT       2                  0.2283 m
ZANG ver 3        2                           90 38 20.6214          0.13
HT       1                  0.2187 m
ZANG ver 3        1                           91 52 12.1537          0.13
HT       2                  0.2283 m
ZANG ver 3        2                           90 38 21.4436          0.13
```

*VLBI40m Sub-network

```
DSET azi
DIR      10       12                          76 59   41.02
DIR      10       13                         137 14  13.759
DIR      10       12                          76 59  40.307
DIR      10       13                         137 14 13.4229
DIR      10       12                          76 59 40.6513
DIR      10       13                         137 14 13.2352
DIR      10       12                          76 59 40.9645
DIR      10       13                         137 14 12.8842
DIR      10       12                          76 59 40.9494
DIR      10       13                         137 14 13.8054
DSET azi
DIR      12       10                         229  7 52.9733
DIR      12       13                         169 54 58.5118
DIR      12       10                         229  7 53.1988
DIR      12       13                         169 54 58.2355
DIR      12       10                         229  7 52.8117
DIR      12       13                         169 54 58.3114
DIR      12       10                         229  7 52.5148
DIR      12       13                         169 54 58.2637
DIR      12       10                         229  7 52.6607
DIR      12       13                         169 54 58.5103
DSET azi
DIR      13       10                         217  0 33.3303
DIR      13       12                         277 33  5.3336
DIR      13       10                         217  0 33.2297
DIR      13       12                         277 33  5.4752
DIR      13       10                         217  0 32.5357
DIR      13       12                         277 33  5.1699
DIR      13       10                         217  0 32.6879
DIR      13       12                         277 33  5.3282
DIR      13       10                         217  0 32.6692
DIR      13       12                         277 33  5.2666

DIST dis 10       12                            56.03509793          m
DIST dis 10       13                            55.28753195          m
DIST dis 10       12                            56.03524793          m
DIST dis 10       13                            55.28753195          m
DIST dis 10       12                            56.03514793          m
DIST dis 10       13                            55.28753195          m
DIST dis 10       12                            56.03504793          m
DIST dis 10       13                            55.28743194          m
DIST dis 10       12                            56.03514793          m
DIST dis 10       13                            55.28753195          m
DIST dis 12       10                            56.03504757          m
DIST dis 12       13                            55.86564365          m
DIST dis 12       10                            56.03509757          m
DIST dis 12       13                            55.86559364          m
DIST dis 12       10                            56.03509757          m
DIST dis 12       13                            55.86559364          m
DIST dis 12       10                            56.03499757          m
DIST dis 12       13                            55.86564365          m
DIST dis 12       10                            56.03504757          m
DIST dis 12       13                            55.86559364          m
DIST dis 13       10                            55.28740893          m
DIST dis 13       12                            55.86577158          m
DIST dis 13       10                            55.28750893          m
DIST dis 13       12                            55.86577158          m
DIST dis 13       10                            55.28760893          m
DIST dis 13       12                            55.86572157          m
DIST dis 13       10                            55.28765893          m
DIST dis 13       12                            55.86567157          m
DIST dis 13       10                            55.28755893          m
DIST dis 13       12                            55.86567157          m

HI       10                 0.2297 m
HT       12                 0.2283 m
ZANG ver 10       12                          90 36 55.9286          0.13
HT       13                 0.2297 m
ZANG ver 10       13                          90 38  44.333          0.13
HT       12                 0.2283 m
ZANG ver 10       12                          90 36 56.3324          0.13
HT       13                 0.2297 m
ZANG ver 10       13                          90 38 44.6267          0.13
HT       12                 0.2283 m
ZANG ver 10       12                          90 36 56.4088          0.13
HT       13                 0.2297 m
ZANG ver 10       13                          90 38 44.2353          0.13
HT       12                 0.2283 m
ZANG ver 10       12                          90 36 56.2006          0.13
HT       13                 0.2297 m
ZANG ver 10       13                          90 38 44.3357          0.13
HT       12                 0.2283 m
ZANG ver 10       12                          90 36  56.007          0.13
HT       13                 0.2297 m
ZANG ver 10       13                          90 38 44.3878          0.13
HI       12                 0.2283 m
HT       10                 0.2297 m
ZANG ver 12       10                          89 23  8.7095          0.13
HT       13                 0.2297 m
ZANG ver 12       13                          90  1 20.0411          0.13
HT       10                 0.2297 m
ZANG ver 12       10                          89 23  8.6526          0.13
HT       13                 0.2297 m
ZANG ver 12       13                          90  1 19.3881          0.13
HT       10                 0.2297 m
ZANG ver 12       10                          89 23  7.7595          0.13
HT       13                 0.2297 m
ZANG ver 12       13                          90  1 19.6623          0.13
HT       10                 0.2297 m
ZANG ver 12       10                          89 23   8.735          0.13
HT       13                 0.2297 m
ZANG ver 12       13                          90  1 19.6632          0.13
HT       10                 0.2297 m
ZANG ver 12       10                          89 23  8.8369          0.13
HT       13                 0.2297 m
ZANG ver 12       13                          90  1 19.8482          0.13
HI       13                 0.2297 m
HT       10                 0.2297 m
ZANG ver 13       10                          89 21  19.602          0.13
HT       12                 0.2283 m
ZANG ver 13       12                          89 58 42.9536          0.13
HT       10                 0.2297 m
ZANG ver 13       10                          89 21 19.1434          0.13
HT       12                 0.2283 m
ZANG ver 13       12                          89 58 43.4773          0.13
HT       10                 0.2297 m
ZANG ver 13       10                          89 21 20.0654          0.13
HT       12                 0.2283 m
ZANG ver 13       12                          89 58 43.0793          0.13
HT       10                 0.2297 m
ZANG ver 13       10                          89 21 19.8751          0.13
HT       12                 0.2283 m
ZANG ver 13       12                          89 58 44.4774          0.13
HT       10                 0.2297 m
ZANG ver 13       10                          89 21 19.2152          0.13
HT       12                 0.2283 m
ZANG ver 13       12                          89 58 43.8447          0.13
```

Annex 4: Local survey adjustment output file

```
Input file:   C:\Users\Public\Documents\GLSamples\Red Completa Local Tie
Yebes\Observacion_publicar.iob
Output file:  C:\Users\Public\Documents\GLSamples\Red Completa Local Tie
Yebes\Observacion_publicar.lst
Options file: C:\Users\Public\Documents\GLOptions\GLNetOpts.gno

 ------------------------------------------------------------------------
|             PARAMETERS                |              OBSERVATIONS       |
|------------------------------------------------------------------------|
|  Description      |     Number        |  Description      |    Number   |
|------------------------------------------------------------------------|
| No. of Stations   |         23        | Directions        |       683   |
| Coord Parameters  |         68        | Distances         |       663   |
| Free Latitudes    |         23        | Azimuths          |         0   |
| Free Longitudes   |         23        | Vertical Angles   |         0   |
| Free Heights      |         22        | Zenithal Angles   |       663   |
| Fixed Coordinates |          1        | Angles            |         0   |
| Astro. Latitudes  |          0        | Heights           |         0   |
| Astro. Longitudes |          0        | Height Differences|         0   |
| Geoid Records     |          0        | Auxiliary Params. |         0   |
| All Aux. Pars.    |         37        | 2-D Coords.       |         0   |
| Direction Pars.   |         37        | 2-D Coord. Diffs. |         0   |
| Scale Parameters  |          0        | 3-D Coords.       |        60   |
| Constant Pars.    |          0        | 3-D Coord. Diffs. |         0   |
| Rotation Pars.    |          0        |                   |             |
| Translation Pars. |          0        |                   |             |
|                   |                   |                   |             |
|                   |   --------        |                   |  --------   |
| Total Parameters  |        105        | Total Observations|      2069   |
|------------------------------------------------------------------------|
|                      Degrees of Freedom =      1964                     |
 ------------------------------------------------------------------------

-------------------------------------------------------------------------
                      SUMMARY OF SELECTED OPTIONS
-------------------------------------------------------------------------
   OPTION                               |   SELECTION
-------------------------------------------------------------------------
   Computation Mode                     |   Adjustment
   Maximum Iterations                   |   50
   Convergence Criterion                |   0.00010
   Angular Misclosure Limit Factor      |   5.00
   Linear Misclosure Limit Factor       |   5.00
   Residual Rejection Criterion         |   Tau Max
   Confidence Region Types              |   1D 2D Station Relative
   Relative Confidence Regions          |   Connected Only
   Variance Factor (VF) Known           |   Yes
   Scale Covariance Matrix With VF      |   Yes
   Scale Residual Variances With VF     |   Yes
   Force Convergence in Max Iters       |   No
   Distances Contribute To Heights      |   No
   Compute Full Inverse                 |   Yes
   Optimize Band Width                  |   Yes
   Generate Initial Coordinates         |   Yes
   Re-Transform Obs After 1st Pass      |   Yes
   Geoid Interpolation Method           |   Bi-Quadratic
==========================================================================
C:\Users\Public\Documents\GLSamples\Red Completa Local Tie Yebes\Observacion_publicar.iob
GeoLabPX5, V5.1.0.0                        WGS 84      UNITS: m,DMS  Page 0002
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C:\Users\Public\Documents\GLSamples\Red Completa Local Tie Yebes\Observacion_publicar.iob
GeoLabPX5, V5.1.0.0                        WGS 84      UNITS: m,DMS  Page 0003
==========================================================================
Misclosures (pass 1):
NOTE: Observation values shown are reduced to mark-to-mark.
TYPE AT          FROM         TO                OBSERVATION STD.DEV.     MISC
---- ----------- ------------ ----------- ---------------- -------- --------
DIR              21           20               233 25     52.7 3.3      -28.4
DIR              21           20               233 25     52.1 3.3      -27.8
DIR              21           20               233 25     51.9 3.3      -27.6
DIR              21           20               233 25     52.2 3.3      -27.9
DIR              21           20               233 25     52.0 3.3      -27.8
DIR              18           22               169 35     47.6 3.7      -32.4
```

[illegible]

```
6            ELON   W  3 05 21.884524      0  0  0.000014   W  3 05 21.884510
6            EHYT              970.1820             -0.0035             970.1784
7            ELAT   N 40 31 27.722744      0  0 -0.000060   N 40 31 27.722685
7            ELON   W  3 05 16.714483      0  0 -0.000138   W  3 05 16.714620
7            EHYT              970.0836              0.0034             970.0871
8            ELAT   N 40 31 29.407644      0  0 -0.000080   N 40 31 29.407564
8            ELON   W  3 05 16.411369      0  0  0.000054   W  3 05 16.411315
8            EHYT              968.0438             -0.0085             968.0353
9            ELAT   N 40 31 30.506667      0  0  0.000022   N 40 31 30.506689
9            ELON   W  3 05 16.552586      0  0  0.000063   W  3 05 16.552524
9            EHYT              966.6903             -0.0057             966.6846
YEB1         ELAT   N 40 31 25.594508      0  0  0.006380   N 40 31 25.600889
YEB1         ELON   W  3 05 24.706267      0  0 -0.004465   W  3 05 24.710733
YEB1         EHYT              975.4244              0.0760             975.5004
```

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================================================================================
C:\Users\Public\Documents\GLSamples\Red Completa Local Tie Yebes\Observacion_pub
GeoLabPX5, V5.1.0.0                          WGS 84      UNITS: m,DMS   Page 0021
================================================================================
Adjusted NEO Coordinates:
                                    NORTHING         EASTING    O-HEIGHT
 CODE FFF STATION                    STD DEV         STD DEV     STD DEV MAPPROJ
 ---- --- ----------- --------------- --------------- --------- -------
 NEO      1                  4487635.5231      492479.4756   967.7174 UTM 30  m       0
                                   0.0004           0.0004     0.0006
 NEO      10                 4487783.3741      492607.5322   968.5537 UTM 30  m       0
                                   0.0006           0.0004     0.0006
 NEO      11                 4487757.4783      492605.2799   969.5915 UTM 30  m       0
                                   0.0006           0.0003     0.0006
 NEO      12                 4487821.5791      492648.5084   967.9538 UTM 30  m       0
                                   0.0007           0.0005     0.0006
 NEO      13                 4487766.9852      492660.3222   967.9309 UTM 30  m       0
                                   0.0008           0.0004     0.0006
 NEO  001 15                 4487817.2794      492489.8846   969.3791 UTM 30  m       0
                                   0.0005           0.0006     0.0000
 NEO      16                 4487658.7827      492497.9633   977.6469 UTM 30  m       0
                                   0.0004           0.0004     0.0006
 NEO      17                 4487697.2083      492572.5633   970.1479 UTM 30  m       0
                                   0.0005           0.0003     0.0006
 NEO      18                 4487733.0722      492387.1539   970.8888 UTM 30  m       0
                                   0.0005           0.0003     0.0006
 NEO      19                 4487672.0639      492396.8813   970.6162 UTM 30  m       0
                                   0.0005           0.0004     0.0006
 NEO      2                  4487666.4832      492527.6756   968.6584 UTM 30  m       0
                                   0.0004           0.0004     0.0006
 NEO      20                 4487665.3973      492326.8211   969.6754 UTM 30  m       0
                                   0.0007           0.0004     0.0006
 NEO      21                 4487726.9129      492338.2674   970.5053 UTM 30  m       0
                                   0.0006           0.0003     0.0006
 NEO      22                 4487771.7278      492347.6193   970.3210 UTM 30  m       0
                                   0.0006           0.0004     0.0006
 NEO      23                 4487698.7820      492436.5246   970.4586 UTM 30  m       0
                                   0.0004           0.0003     0.0006
 NEO      3                  4487682.3635      492478.2423   969.2368 UTM 30  m       0
                                   0.0004           0.0003     0.0006
 NEO      4                  4487706.1923      492516.4230   969.7972 UTM 30  m       0
                                   0.0004           0.0003     0.0006
 NEO      5                  4487730.0947      492476.1112   970.4555 UTM 30  m       0
                                   0.0004           0.0003     0.0006
 NEO      6                  4487772.0994      492423.4710   970.1789 UTM 30  m       0
                                   0.0004           0.0003     0.0006
 NEO      7                  4487758.3374      492545.1463   970.0898 UTM 30  m       0
                                   0.0004           0.0003     0.0006
 NEO      8                  4487810.3012      492552.3371   968.0385 UTM 30  m       0
                                   0.0005           0.0004     0.0006
 NEO      9                  4487844.2079      492549.0472   966.6877 UTM 30  m       0
                                   0.0004           0.0005     0.0006
 NEO      YEB1               4487693.0770      492356.8665   975.4967 UTM 30  m       0
                                   0.0006           0.0004     0.0006
```

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C:\Users\Public\Documents\GLSamples\Red Completa Local Tie Yebes\Observacion_pub
GeoLabPX5, V5.1.0.0                          WGS 84      UNITS: m,DMS   Page 0022
================================================================================
Adjusted PLH Coordinates:
                                   LATITUDE          LONGITUDE  ELIP-HEIGHT
 CODE FFF STATION                   STD DEV            STD DEV      STD DEV
 ---- --- ----------- ----------------- ----------------- ------------
 PLH      1           N 40 31 23.739004 W  3  5 19.499321     967.7174 m       0
                                 0.0004            0.0004       0.0006
 PLH      10          N 40 31 28.536377 W  3  5 14.065228     968.5537 m       0
                                 0.0006            0.0004       0.0006
 PLH      11          N 40 31 27.696780 W  3  5 14.159829     969.5915 m       0
                                 0.0006            0.0003       0.0006
 PLH      12          N 40 31 29.776269 W  3  5 12.325975     967.9538 m       0
                                 0.0007            0.0005       0.0006
 PLH      13          N 40 31 28.006749 W  3  5 11.821788     967.9309 m       0
                                 0.0008            0.0004       0.0006
 PLH  001 15          N 40 31 29.631763 W  3  5 19.064866     969.3791 m       0
                                 0.0005            0.0006       0.0000
 PLH      16          N 40 31 24.493667 W  3  5 18.714888     977.6469 m       0
                                 0.0004            0.0004       0.0006
 PLH      17          N 40 31 25.741817 W  3  5 15.547223     970.1479 m       0
                                 0.0005            0.0003       0.0006
 PLH      18          N 40 31 26.898451 W  3  5 23.425700     970.8888 m       0
                                 0.0005            0.0003       0.0006
 PLH      19          N 40 31 24.920922 W  3  5 23.009801     970.6162 m       0
                                 0.0005            0.0004       0.0006
 PLH      2           N 40 31 24.744277 W  3  5 17.452926     968.6584 m       0
                                 0.0004            0.0004       0.0006
 PLH      20          N 40 31 24.702474 W  3  5 25.985935     969.6754 m       0
                                 0.0007            0.0004       0.0006
 PLH      21          N 40 31 26.697151 W  3  5 25.502331     970.5053 m       0
                                 0.0006            0.0003       0.0006
 PLH      22          N 40 31 28.150331 W  3  5 25.106974     970.3210 m       0
                                 0.0006            0.0004       0.0006
 PLH      23          N 40 31 25.788410 W  3  5 21.326754     970.4586 m       0
                                 0.0004            0.0003       0.0006
 PLH      3           N 40 31 25.257499 W  3  5 19.553717     969.2368 m       0
                                 0.0004            0.0003       0.0006
 PLH      4           N 40 31 26.031256 W  3  5 17.932668     969.7972 m       0
                                 0.0004            0.0003       0.0006
 PLH      5           N 40 31 26.804843 W  3  5 19.646295     970.4555 m       0
                                 0.0004            0.0003       0.0006
 PLH      6           N 40 31 28.164884 W  3  5 21.884479     970.1789 m       0
                                 0.0004            0.0003       0.0006
 PLH      7           N 40 31 27.722694 W  3  5 16.714598     970.0898 m       0
                                 0.0004            0.0003       0.0006
 PLH      8           N 40 31 29.407559 W  3  5 16.411301     968.0385 m       0
                                 0.0005            0.0004       0.0006
 PLH      9           N 40 31 30.506686 W  3  5 16.552510     966.6877 m       0
                                 0.0004            0.0005       0.0006
 PLH      YEB1        N 40 31 25.600830 W  3  5 24.710694     975.4967 m       0
                                 0.0006            0.0004       0.0006
```

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GeoLabPX5, V5.1.0.0                          WGS 84      UNITS: m,DMS   Page 0023
================================================================================
Adjusted XYZ Coordinates:
                                X-COORDINATE       Y-COORDINATE       Z-COORDINATE
 CODE FFF STATION                    STD DEV            STD DEV            STD DEV
 ---- --- ----------- ------------------ ------------------ ------------------
 XYZ      1                 4848838.4733       -261648.8392       4122952.4484 m       0
                                  0.0005             0.0004             0.0004
 XYZ      10                4848749.9732       -261515.9505       4123065.4926 m       0
                                  0.0006             0.0004             0.0006
 XYZ      11                4848767.4469       -261519.1232       4123046.4781 m       0
                                  0.0006             0.0003             0.0006
 XYZ      12                4848726.9041       -261473.7022       4123094.1785 m       0
                                  0.0007             0.0005             0.0006
 XYZ      13                4848762.9460       -261463.7592       4123052.6680 m       0
                                  0.0007             0.0004             0.0007
 XYZ  001 15                4848722.3333       -261632.3296       4123091.7159 m       0
                                  0.0003             0.0006             0.0004
 XYZ      16                4848831.8998       -261629.9905       4122976.5976 m       0
                                  0.0006             0.0004             0.0005
 XYZ      17                4848805.2416       -261553.8709       4123000.9949 m       0
                                  0.0006             0.0004             0.0005
 XYZ      18                4848772.6585       -261737.8560       4123028.5999 m       0
                                  0.0006             0.0003             0.0005
 XYZ      19                4848812.5623       -261730.2047       4122982.0487 m       0
                                  0.0006             0.0004             0.0005
 XYZ      2                 4848821.6614       -261599.6858       4122976.6342 m       0
                                  0.0006             0.0004             0.0005
 XYZ      20                4848812.4438       -261800.3643       4122976.3147 m       0
                                  0.0007             0.0004             0.0006
 XYZ      21                4848773.7613       -261786.8743       4123023.6302 m       0
                                  0.0006             0.0003             0.0006
 XYZ      22                4848745.0355       -261776.0025       4123057.5880 m       0
                                  0.0006             0.0004             0.0006
 XYZ      23                4848797.2142       -261689.6966       4123002.2894 m       0
                                  0.0006             0.0003             0.0004
 XYZ      3                 4848809.1630       -261648.5400       4122989.0454 m       0
                                  0.0005             0.0003             0.0004
 XYZ      4                 4848796.1568       -261609.6202       4123007.5545 m       0
                                  0.0005             0.0003             0.0004
 XYZ      5                 4848778.9983       -261649.0949       4123026.1233 m       0
                                  0.0005             0.0003             0.0004
 XYZ      6                 4848748.7255       -261700.2285       4123057.8370 m       0
                                  0.0006             0.0004             0.0005
 XYZ      7                 4848764.0669       -261579.1718       4123047.4096 m       0
                                  0.0006             0.0003             0.0005
 XYZ      8                 4848729.1690       -261570.1387       4123085.5872 m       0
                                  0.0006             0.0004             0.0005
 XYZ      9                 4848705.9636       -261572.2159       4123110.4842 m       0
                                  0.0006             0.0005             0.0005
 XYZ      YEB1              4848800.4991       -261769.6541       4123001.1641 m       0
                                  0.0007             0.0004             0.0006
```

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================================================================================
C:\Users\Public\Documents\GLSamples\Red Completa Local Tie Yebes\Observacion_pub/
GeoLabPX5, V5.1.0.0                          WGS 84      UNITS: m,DMS   Page 0024
================================================================================
Residuals (critical value = 4.367):
NOTE: Observation values shown are reduced to mark-to-mark.
                                                     OBSERVATION RESIDUAL  STD RES
TYPE AT           FROM        TO                         STD DEV  STD DEV      PPM
---- ------------ ----------- ------------ ----------------- -------- --------
XCT  1                                          4848838.46749   0.0058   3.0057
                                                       0.0020   0.0019
YCT  1                                          -261648.83914  -0.0001  -0.0572
                                                       0.0011   0.0011
ZCT  1                                          4122952.44144   0.0070   5.1124
                                                       0.0014   0.0014
                                                ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
ZANG              3           18               89  5     42.1      8.2      4.6
                                                          1.8      1.8
                                                ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
ZANG              6           7                90  2     38.8      6.8      4.4
                                                          1.6      1.5
                                                ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
```

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GeoLabPX5, V5.1.0.0                          WGS 84      UNITS: m,DMS   Page 0025
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|                                                                               |
|                 S T A T I S T I C S     S U M M A R Y                         |
|                                                                               |
 -------------------------------------------------------------------------------
|                                     |                                         |
|     Residual Critical Value Type    |             Tau Max                     |
|     Residual Critical Value         |             4.3671                      |
|     Number of Flagged Residuals     |                  3                      |
|     Convergence Criterion           |             0.0001                      |
|     Final Iteration Counter Value   |                  5                      |
|     Confidence Level Used           |            95.0000                      |
|     Estimated Variance Factor       |             0.8413                      |
|     Number of Degrees of Freedom    |               1964                      |
|                                     |                                         |
 -------------------------------------------------------------------------------

 -------------------------------------------------------------------------------
|                                                                               |
| NOTE:  All confidence regions were computed using the following factors:     |
|        ----------------------------------------------------------------      |
|        Variance factor used      =         0.8413                            |
|        1-D expansion factor      =         1.9600                            |
|        2-D expansion factor      =         2.4477                            |
|                                                                               |
|        Note that, for relative confidence regions, precisions are            |
|        computed from the ratio of the major semi-axis and the spatial        |
|        distance between the two stations.                                    |
|                                                                               |
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C:\Users\Public\Documents\GLSamples\Red Completa Local Tie Yebes\Observacion_pub/
GeoLabPX5, V5.1.0.0                          WGS 84      UNITS: m,DMS   Page 0026
================================================================================
2-D and 1-D Station Confidence Regions (95.000 and 95.000 percent):
STATION            MAJOR SEMI-AXIS  AZ     MINOR SEMI-AXIS           VERTICAL
------------ ------------------- ---  ------------------ ------------------
1                         0.0011  69              0.0009             0.0012
10                        0.0015 163              0.0008             0.0012
11                        0.0014 172              0.0008             0.0012
12                        0.0019 154              0.0009             0.0012
13                        0.0019 173              0.0009             0.0012
15                        0.0015  87              0.0012             0.0000
16                        0.0012  44              0.0010             0.0012
17                        0.0013  16              0.0008             0.0012
18                        0.0012   8              0.0008             0.0012
19                        0.0012 159              0.0008             0.0012
2                         0.0011  31              0.0008             0.0012
20                        0.0017 160              0.0009             0.0012
21                        0.0015   4              0.0008             0.0012
22                        0.0015  20              0.0009             0.0012
23                        0.0010   3              0.0008             0.0012
3                         0.0009  24              0.0008             0.0011
4                         0.0010  16              0.0007             0.0011
5                         0.0009  12              0.0007             0.0011
6                         0.0011  27              0.0008             0.0012
7                         0.0011 171              0.0008             0.0011
8                         0.0012 142              0.0009             0.0012
9                         0.0014 124              0.0009             0.0012
YEB1                      0.0015 170              0.0010             0.0012
```

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C:\Users\Public\Documents\GLSamples\Red Completa Local Tie Yebes\Observacion_pub/
GeoLabPX5, V5.1.0.0                          WGS 84      UNITS: m,DMS   Page 0027
================================================================================
2-D and 1-D Relative Station Confidence Regions (95.000 and 95.000 percent):
FROM         TO            MAJ-SEMI  AZ MIN-SEMI  VERTICAL     DISTANCE      PPM
------------ ------------ -------- --- -------- --------- ------------ --------
1            10             0.0017 131   0.0007    0.0005     195.6289     8.53
1            11             0.0015 136   0.0007    0.0005     175.2501     8.68
1            12             0.0022 134   0.0007    0.0005     251.4122     8.60
1            13             0.0019 148   0.0009    0.0005     223.6134     8.70
1            16             0.0006 115   0.0006    0.0005      31.3316    20.61
1            17             0.0011 145   0.0006    0.0004     111.7143     9.58
1            18             0.0012  46   0.0005    0.0004     134.3676     9.25
1            19             0.0009  22   0.0005    0.0003      90.3765    10.00
1            2              0.0007 146   0.0004    0.0003      57.3031    11.63
1            20             0.0015   5   0.0007    0.0004     155.5860     9.77
1            21             0.0016  31   0.0006    0.0004     168.2503     9.38
1            22             0.0018  45   0.0007    0.0005     189.6192     9.23
1            23             0.0008  59   0.0005    0.0004      76.5230    11.02
1            3              0.0006  88   0.0004    0.0003      46.8884    12.24
1            4              0.0008 115   0.0004    0.0003      79.7841    10.20
1            5              0.0009  88   0.0005    0.0003      94.6854     9.83
1            6              0.0013  67   0.0006    0.0004     147.6559     8.98
1            7              0.0012 117   0.0005    0.0004     139.3108     8.80
1            8              0.0016 112   0.0006    0.0005     189.3862     8.52
1            9              0.0019 107   0.0006    0.0005     220.0120     8.43
10           11             0.0005  99   0.0004    0.0003      26.0182    18.06
10           12             0.0007 138   0.0004    0.0003      56.0355    12.95
10           13             0.0008  18   0.0004    0.0003      55.2874    13.79
10           17             0.0010 114   0.0006    0.0004      93.0189    10.35
10           18             0.0019 168   0.0006    0.0005     226.0924     8.45
10           19             0.0020 153   0.0006    0.0005     238.2964     8.40
10           2              0.0013 128   0.0007    0.0005     141.5862     9.07
10           20             0.0026 157   0.0007    0.0005     304.5431     8.50
10           21             0.0023 169   0.0007    0.0005     275.1691     8.45
10           22             0.0022 179   0.0008    0.0005     260.2190     8.57
10           23             0.0016 155   0.0007    0.0005     190.8247     8.64
10           3              0.0014 144   0.0006    0.0004     164.0964     8.74
10           4              0.0011 143   0.0006    0.0004     119.4310     9.51
10           5              0.0013 159   0.0005    0.0004     141.8445     9.08
10           6              0.0016 177   0.0006    0.0004     184.4412     8.79
10           7              0.0007 160   0.0004    0.0003      67.2500    10.93
10           8              0.0007  24   0.0004    0.0003      61.4245    12.01
10           9              0.0009  45   0.0004    0.0003      84.4209    10.97
11           12             0.0009 128   0.0004    0.0003      77.3441    11.78
11           13             0.0008   0   0.0005    0.0003      55.8905    14.16
11           17             0.0008 118   0.0006    0.0004      68.5899    11.29
11           18             0.0019 175   0.0006    0.0005     219.5241     8.50
11           19             0.0019 158   0.0007    0.0005     225.2598     8.47
11           2              0.0011 134   0.0007    0.0004     119.6149     9.45
11           20             0.0025 161   0.0008    0.0005     293.3329     8.56
11           21             0.0023 175   0.0007    0.0005     268.7983     8.51
11           22             0.0022   5   0.0008    0.0005     258.0943     8.61
11           23             0.0016 162   0.0007    0.0005     178.7009     8.74
11           3              0.0013 152   0.0006    0.0004     147.6058     8.91
11           4              0.0010 154   0.0006    0.0004     102.6110     9.91
11           5              0.0012 169   0.0006    0.0004     132.0622     9.20
11           6              0.0016   5   0.0006    0.0004     182.4243     8.81
11           7              0.0007   3   0.0004    0.0003      60.1509    11.50
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GeoLabPX5, V5.1.0.0                          WGS 84      UNITS: m,DMS   Page 0028
================================================================================
2-D and 1-D Relative Station Confidence Regions (95.000 and 95.000 percent):
FROM         TO            MAJ-SEMI  AZ MIN-SEMI  VERTICAL     DISTANCE      PPM
------------ ------------ -------- --- -------- --------- ------------ --------
11           8              0.0009  42   0.0005    0.0004      74.8151    11.38
11           9              0.0011  56   0.0005    0.0004     103.4206    10.50
12           13             0.0008  75   0.0004    0.0003      55.8659    13.52
12           17             0.0015 127   0.0007    0.0004     145.7635     9.96
12           18             0.0024 161   0.0007    0.0005     275.9914     8.53
12           19             0.0025 150   0.0007    0.0005     292.7524     8.47
12           2              0.0018 133   0.0007    0.0005     196.6405     9.09
12           20             0.0030 154   0.0008    0.0005     357.6550     8.47
12           21             0.0027 163   0.0008    0.0005     324.4217     8.45
12           22             0.0026 170   0.0009    0.0005     305.0460     8.55
12           23             0.0021 150   0.0007    0.0005     245.0320     8.72
12           3              0.0019 143   0.0006    0.0005     219.9722     8.84
12           4              0.0017 142   0.0006    0.0004     175.4234     9.43
12           5              0.0018 152   0.0006    0.0004     195.2126     9.17
12           6              0.0021 166   0.0006    0.0004     230.4583     8.90
12           7              0.0013 149   0.0004    0.0003     121.2116    10.43
12           8              0.0011 171   0.0004    0.0003      96.8449    11.38
12           9              0.0011   9   0.0005    0.0003     102.0262    11.08
13           17             0.0012 156   0.0008    0.0005     112.1569    10.93
13           18             0.0024 175   0.0007    0.0005     275.3229     8.59
13           19             0.0024 162   0.0008    0.0005     280.0752     8.52
13           2              0.0016 153   0.0009    0.0005     166.4473     9.47
13           20             0.0030 164   0.0009    0.0006     348.6874     8.49
13           21             0.0028 174   0.0008    0.0006     324.5975     8.51
13           22             0.0027   2   0.0008    0.0006     312.7953     8.61
13           23             0.0021 166   0.0008    0.0005     234.0086     8.81
13           3              0.0018 161   0.0008    0.0005     200.8179     9.01
13           4              0.0015 164   0.0007    0.0005     156.2486     9.80
13           5              0.0017 172   0.0007    0.0005     187.9139     9.31
13           6              0.0021   2   0.0007    0.0005     236.9529     8.95
13           7              0.0013   0   0.0005    0.0004     115.5378    10.86
13           8              0.0013  21   0.0005    0.0004     116.3665    11.28
13           9              0.0015  33   0.0005    0.0004     135.4717    10.86
15           6              0.0012 100   0.0010    0.0012      80.3405    15.39
15           7              0.0013  70   0.0008    0.0011      80.8115    16.06
15           8              0.0012  83   0.0010    0.0012      62.8649    18.97
15           9              0.0013  96   0.0009    0.0012      65.0681    19.38
16           2              0.0006 163   0.0006    0.0005      31.9875    19.93
16           3              0.0007  56   0.0006    0.0005      31.8746    20.86
17           18             0.0016  11   0.0006    0.0004     188.8762     8.71
17           19             0.0016 171   0.0006    0.0004     177.4997     8.81
17           2              0.0007 154   0.0006    0.0004      54.4248    12.19
17           20             0.0022 171   0.0007    0.0005     247.8305     8.84
17           21             0.0021   8   0.0007    0.0005     236.2074     8.74
17           22             0.0021  19   0.0007    0.0005     237.0020     8.79
17           23             0.0013   2   0.0006    0.0005     136.0688     9.23
17           3              0.0009 174   0.0005    0.0004      95.5008     9.82
17           4              0.0007  14   0.0005    0.0004      56.8643    12.06
17           5              0.0010  20   0.0005    0.0004     101.9203     9.67
17           6              0.0015  27   0.0006    0.0004     166.8701     8.86
17           7              0.0008  65   0.0005    0.0003      67.0061    11.31
17           8              0.0011  79   0.0006    0.0004     114.9241     9.73
17           9              0.0014  80   0.0006    0.0004     148.9315     9.35
```

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C:\Users\Public\Documents\GLSamples\Red Completa Local Tie Yebes\Observacion_pub/
GeoLabPX5, V5.1.0.0                          WGS 84      UNITS: m,DMS   Page 0029
================================================================================
2-D and 1-D Relative Station Confidence Regions (95.000 and 95.000 percent):
FROM         TO            MAJ-SEMI  AZ MIN-SEMI  VERTICAL     DISTANCE      PPM
------------ ------------ -------- --- -------- --------- ------------ --------
18           19             0.0007  82   0.0004    0.0003      61.7889    10.95
18           2              0.0014  24   0.0005    0.0004     155.5401     9.08
18           20             0.0011 133   0.0005    0.0004      90.6858    11.81
18           21             0.0006 176   0.0004    0.0003      49.2819    13.08
18           22             0.0007  42   0.0005    0.0004      55.3036    13.41
18           23             0.0007  35   0.0005    0.0003      60.1212    11.58
18           3              0.0010  28   0.0004    0.0003     104.2808     9.55
18           4              0.0012  12   0.0005    0.0004     132.0587     9.19
18           5              0.0009   3   0.0004    0.0003      89.0217     9.82
18           6              0.0006 138   0.0005    0.0003      53.3238    11.74
18           7              0.0014 172   0.0005    0.0004     160.0259     8.66
18           8              0.0016 156   0.0007    0.0005     182.3951     8.61
18           9              0.0017 145   0.0008    0.0005     196.4431     8.48
19           2              0.0012   1   0.0005    0.0004     130.9477     9.43
19           20             0.0009 168   0.0005    0.0003      70.3936    12.35
19           21             0.0009  42   0.0005    0.0003      80.2868    11.31
19           22             0.0012  62   0.0006    0.0004     111.1912    10.48
19           23             0.0006 145   0.0004    0.0003      47.8138    12.94
19           3              0.0008 171   0.0004    0.0003      82.0343    10.13
19           4              0.0012 163   0.0005    0.0004     124.3395     9.35
19           5              0.0009 144   0.0004    0.0003      98.2237     9.64
19           6              0.0010 106   0.0005    0.0003     103.5257     9.62
19           7              0.0015 150   0.0005    0.0004     171.5657     8.59
19           8              0.0018 139   0.0006    0.0005     208.0764     8.47
19           9              0.0019 131   0.0007    0.0005     229.8248     8.37
19           YEB1           0.0008  28   0.0007    0.0005      45.4662    18.12
2            20             0.0019 176   0.0007    0.0005     200.8903     9.32
2            21             0.0018  17   0.0006    0.0004     198.8531     9.13
2            22             0.0019  30   0.0007    0.0005     208.5968     9.09
2            23             0.0010  19   0.0005    0.0004      96.7357    10.18
2            3              0.0006  18   0.0004    0.0003      51.9325    11.77
2            4              0.0006  67   0.0004    0.0003      41.2947    13.32
2            5              0.0008  48   0.0005    0.0003      81.9181    10.22
2            6              0.0013  43   0.0006    0.0004     148.3993     9.01
2            7              0.0009  98   0.0005    0.0004      93.5260     9.57
2            8              0.0013  99   0.0007    0.0005     145.9406     8.89
2            9              0.0016  96   0.0007    0.0005     179.0431     8.73
20           21             0.0008 104   0.0005    0.0003      62.5865    12.98
20           22             0.0012 106   0.0007    0.0005     108.3639    11.37
20           23             0.0013 160   0.0006    0.0004     114.6908    10.99
20           3              0.0015 170   0.0006    0.0004     152.3924     9.90
20           4              0.0018 166   0.0006    0.0005     193.9704     9.35
20           5              0.0016 155   0.0006    0.0004     162.7327     9.73
20           6              0.0015 135   0.0006    0.0004     143.9899    10.12
20           7              0.0021 157   0.0006    0.0005     237.3203     8.82
20           8              0.0023 148   0.0007    0.0005     268.1026     8.65
20           9              0.0024 142   0.0008    0.0005     285.2914     8.53
20           YEB1           0.0008 137   0.0007    0.0005      41.2709    20.35
21           22             0.0007  95   0.0006    0.0004      45.7876    14.79
21           23             0.0011  16   0.0006    0.0004     102.2202    10.77
21           3              0.0014  17   0.0005    0.0004     146.9209     9.62
21           4              0.0016   7   0.0006    0.0004     179.3850     9.19
21           5              0.0013   0   0.0006    0.0004     137.9014     9.63
```

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C:\Users\Public\Documents\GLSamples\Red Completa Local Tie Yebes\Observacion_pub/
GeoLabPX5, V5.1.0.0                          WGS 84      UNITS: m,DMS   Page 0030
================================================================================
2-D and 1-D Relative Station Confidence Regions (95.000 and 95.000 percent):
FROM         TO            MAJ-SEMI  AZ MIN-SEMI  VERTICAL     DISTANCE      PPM
------------ ------------ -------- --- -------- --------- ------------ --------
21           6              0.0010 159   0.0006    0.0004      96.4593    10.64
21           7              0.0018 173   0.0006    0.0004     209.2839     8.73
21           8              0.0020 161   0.0008    0.0005     229.7857     8.62
21           9              0.0020 153   0.0009    0.0005     241.2848     8.48
21           YEB1           0.0008  58   0.0007    0.0005      38.9380    20.60
22           23             0.0012  39   0.0006    0.0005     115.0185    10.61
22           3              0.0015  34   0.0006    0.0004     158.2944     9.56
22           4              0.0017  22   0.0007    0.0005     181.1071     9.24
22           5              0.0013  20   0.0006    0.0004     135.0890     9.82
22           6              0.0009   9   0.0006    0.0004      75.8642    11.93
22           7              0.0018   6   0.0007    0.0005     198.0104     8.90
22           8              0.0018 173   0.0008    0.0005     208.3641     8.84
22           9              0.0019 163   0.0010    0.0005     214.1345     8.69
23           3              0.0006  22   0.0004    0.0003      44.8558    12.98
23           4              0.0008 174   0.0005    0.0004      80.2562    10.48
23           5              0.0006 140   0.0005    0.0003      50.4813    12.08
23           6              0.0008  77   0.0005    0.0004      74.4822    10.86
23           7              0.0011 152   0.0005    0.0004     123.8963     8.95
23           8              0.0014 136   0.0007    0.0005     160.8190     8.76
23           9              0.0016 126   0.0007    0.0005     183.9415     8.62
3            4              0.0005 148   0.0004    0.0003      45.0167    11.93
3            5              0.0006  85   0.0004    0.0003      47.8015    11.71
3            6              0.0010  56   0.0005    0.0003     105.1507     9.42
3            7              0.0009 131   0.0005    0.0003     101.2521     9.02
3            8              0.0013 120   0.0006    0.0004     147.8721     8.74
3            9              0.0015 112   0.0006    0.0004     176.7000     8.61
4            5              0.0006  30   0.0004    0.0003      46.8771    11.98
4            6              0.0011  34   0.0005    0.0004     113.9645     9.33
4            7              0.0006 118   0.0004    0.0003      59.5424    10.82
4            8              0.0010 109   0.0006    0.0004     110.1601     9.45
4            9              0.0013 102   0.0006    0.0004     141.8746     9.14
5            6              0.0007  38   0.0004    0.0003      67.3561    10.23
5            7              0.0007 159   0.0004    0.0003      74.6009     9.45
5            8              0.0010 133   0.0005    0.0004     110.6933     9.34
5            9              0.0012 119   0.0006    0.0004     135.5036     9.13
6            7              0.0011   8   0.0004    0.0003     122.4696     8.98
6            8              0.0012 165   0.0006    0.0004     134.4466     9.12
6            9              0.0013 149   0.0007    0.0004     144.8707     8.96
7            8              0.0006  96   0.0004    0.0003      52.5071    11.31
7            9              0.0009  90   0.0004    0.0003      86.0394    10.26
8            9              0.0005  81   0.0004    0.0003      34.0979    14.79
```

Annex 3: SINEX file

```
%=SNX 2.02 IGN 18:338:38900 IGN 16:063:00000 16:313:00000 C 00012 2 X
*-------------------------------------------------------------------------------
+FILE/COMMENT
* File created by software tosinex (J.López-Ramasco)*
* Matrix scalling Factor used   1.0000000
-FILE/COMMENT
*-------------------------------------------------------------------------------
+SITE/ID
*CODE PT __DOMES__ T _STATION DESCRIPTION__ APPROX_LON_ APPROX_LAT_ _APP_H_
 YEB1  A 13420M002   13420M002                -3   5 24.7  40 31 25.6   975.4
 7389  A 13420S003   13420S003                -3   5 18.7  40 31 24.5   977.1
 7386  A 13420S002   13420S002                -3   5 12.7  40 31 28.8   987.7
 YEBE  A 13420M001   13420M001                -3   5 19.1  40 31 29.6   972.8
-SITE/ID
*-------------------------------------------------------------------------------
+SOLUTION/EPOCHS
*Code PT SOLN T Data_start__ Data_end____ Mean_epoch__
-SOLUTION/EPOCHS
*-------------------------------------------------------------------------------
+SOLUTION/ESTIMATE
*INDEX TYPE__ CODE PT SOLN _REF_EPOCH__ UNIT S __ESTIMATED VALUE____ _STD_DEV___
     1 STAX   YEB1  A    1 16:313:00000 m    2 0.484880012006000E+07 0.60000E-03
     2 STAY   YEB1  A    1 16:313:00000 m    2 -.261769158390000E+06 0.40000E-03
     3 STAZ   YEB1  A    1 16:313:00000 m    2 0.412300148813000E+07 0.50000E-03
     4 STAX   7389  A    1 16:313:00000 m    2 0.484883106750900E+07 0.60000E-03
     5 STAY   7389  A    1 16:313:00000 m    2 -.261629454480000E+06 0.40000E-03
     6 STAZ   7389  A    1 16:313:00000 m    2 0.412297653236000E+07 0.50000E-03
     7 STAX   7386  A    1 16:313:00000 m    2 0.484876177517000E+07 0.14000E-02
     8 STAY   7386  A    1 16:313:00000 m    2 -.261484111180000E+06 0.12000E-02
     9 STAZ   7386  A    1 16:313:00000 m    2 0.412308509127400E+07 0.18000E-02
    10 STAX   YEBE  A    1 16:313:00000 m    2 0.484872459568000E+07 0.60000E-03
    11 STAY   YEBE  A    1 16:313:00000 m    2 -.261631978730000E+06 0.40000E-03
    12 STAZ   YEBE  A    1 16:313:00000 m    2 0.412309430430000E+07 0.50000E-03
-SOLUTION/ESTIMATE
*-------------------------------------------------------------------------------
+SOLUTION/MATRIX_ESTIMATE L COVA
*PARA1 PARA2 ____PARA2+0__________ ____PARA2+1__________ ____PARA2+2__________
     1      1 0.399349803703331E-06
     2      1 -.949745450350327E-08 0.171168170090582E-06
     3      1 0.417274350354161E-07 -.215689230528934E-07 0.305024243443326E-06
     4      1 0.266887877232670E-06 0.874849816854087E-08 0.111828279764368E-06
     4      4 0.352588594421265E-06
     5      1 -.289275289064266E-07 0.898853392886134E-07 0.815333859514687E-09
     5      4 -.343912345618522E-07 0.180212059664241E-06
     6      1 0.106790441831226E-06 -.419993973828026E-07 0.154677227003315E-06
     6      4 0.937010342333650E-07 0.988469098495230E-08 0.246837283639591E-06
     7      1 0.232786619031969E-06 -.387992217881363E-07 0.136757568192243E-06
     7      4 0.273575979860889E-06 -.574103490237298E-07 0.883326262985326E-07
     7      7 0.198506463052522E-05
     8      1 -.457573175913036E-07 0.629717610499311E-07 0.180065474574056E-07
     8      4 -.220263602003546E-07 0.516251025170187E-07 -.102653756262653E-07
     8      7 -.858595548644221E-09 0.153879265490230E-05
     9      1 0.142023651941708E-06 0.111923977407388E-07 0.116522002164866E-06
     9      4 0.929094731006245E-07 0.337932727295365E-07 0.175798348891874E-06
     9      7 0.464825752863313E-07 -.328514736743445E-07 0.328146191189655E-05
    10      1 0.257017792179926E-06 -.297280680062906E-07 0.112077779211696E-06
    10      4 0.271561991649125E-06 -.369267612678623E-07 0.935458769524691E-07
    10      7 0.292852800646143E-06 0.814346611391874E-08 0.849979398535071E-07
    10     10 0.319196156852729E-06
    11      1 -.548103469417231E-07 0.617559283912244E-07 0.261190530388072E-07
    11      4 -.220432503257474E-07 0.455196841376532E-07 -.129138875313923E-07
    11      7 -.158550613047934E-07 0.105625024440226E-06 -.156295458436014E-07
    11     10 -.149309820927718E-07 0.188564478045174E-06
    12      1 0.115284012107174E-06 0.759156045327023E-10 0.148450759593621E-06
    12      4 0.960318570406963E-07 0.908491678571333E-08 0.170664154757817E-06
    12      7 0.845968459108923E-07 -.458397437212257E-07 0.194557187140205E-06
    12     10 0.931798768480302E-07 -.186254396564993E-07 0.237715781523039E-06
-SOLUTION/MATRIX_ESTIMATE L COVA
%ENDSNX
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