Surveying the GPS – VLBI eccentricity at Medicina: methodological aspects and practicalities

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Goals

• Monitor the stability of ground control network
• Test a rigorous methodology for local ties based on terrestrial local survey
• Focus on VLBI reference point (geometrical and implicit definition)
• Full covariance matrix and SINEX production
• **Instrumentation:**
  – TDA5005 (0.15 mgon; 1 mm + 2 ppm) with ATR
  – TCA2003 (0.15 mgon; 1 mm + 1 ppm) with ATR (survey 2000)
  – TC2003 (0.15 mgon; 1 mm + 1 ppm)
  – All provided by a biaxial compensator

• **Surveying approach:**
  – Three strata (position I-II) with distances and angles

• **Set-up of all tribrachs:** using biaxial compensator of total stations

• **Equal height between tribrach-prisms centre and tribrach-total station reference point**

• **One three-dimensional benchmark was fixed as origin of elevations and instrumental heights were direct measured on auto-centring devices**

• **10 retro-reflecting prisms were installed on the VLBI antenna, with prism constants equal to EDM internal calibration path (approximate zero constant)**
Instrumental heights measurement
Reflector types for measurement of distances

- Reflective tape

  \[ 1 \sigma_{EDM} = 1-2 \text{ mm} \quad (d < 120 \text{ m}) \]

- Prism reflector

  \[ 1 \sigma_{EDM} = 0.5-1 \text{ mm} \quad (d < 120 \text{ m}) \]

- Corner cube reflector

  \[ 1 \sigma_{EDM} = 0.5-1 \text{ mm} \quad (d < 120 \text{ m}) \]

- 360° prism reflector

  \[ 1 \sigma_{EDM} = 2 \text{ mm} \quad (d < 120 \text{ m}) \]
Targets for angular measurements

Manual target collimation

Aut. Target Recognition

- Reflectometer within field of view?
- Spiral search
  - Measure HzVD
Angles and distances: reciprocal weights

The European Synchrotron Radiation Facility (ESRF)

EDM_{ESRF} = D_1 + D_2 - D_{EDM}

Calibration Results (Mean = -0.09 mm; Standard Deviation = 0.14 mm) and Best Model

standard deviation from 0.18 mm to 0.10
Classical network processing

- Using STAR*NET (Starplus software Inc.) least square adjustment software
- Planimetric origin on pillar P3
- Height reference on 3D benchmark G7
- Fixed bearing from P3 to pillar P1
Total ground control network 2002
\[ c^j : \begin{cases} P^j : a^j x_i^j + b^j y_i^j + c^j z_i^j + d^j = 0 \\ S^j : \left( x_i^j \right)^2 + \left( y_i^j \right)^2 + \left( z_i^j \right)^2 - 2 \cdot \left( \alpha^j x_i^j + \beta^j y_i^j + \gamma^j z_i^j \right) + o^j = 0 \end{cases} \]
Tilted azimuth (fixed) axis

Elevation axis

Tilt direction

Plane containing the tilted elevation (moving) axis
GPS antenna survey approach

Horizontal angles

Vertical angles

$90^\circ$  $90^\circ$

$90^\circ$  $90^\circ$

* = Points of view

Symmetry axis fictitious points
VLBI reference point estimated with terrestrial measurements

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<th>Survey Year</th>
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The DOMES are correct
Variance factor equal to 1.00

+SITE/ID
*CODE PT__DOMES__ T__STATION_DESCRIPTION__ APPROX_LON__ APPROX_LAT__ APP_H__
VLBR A 12711S001
GPSR A 12711M003

+SOLUTION/ESTIMATE
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2  STAY   VLBR A    1 0:000:00000 m    2 9.19596254768435E+05 7.98877E-004
3  STAZ   VLBR A    1 0:000:00000 m    2 4.449559199128945E+06 3.98169E-004
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+SOLUTION/MATRIX_ESTIMATE L COVA
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2   1 1.070616748207442E-09 6.382049648848917E-07
3   1 -3.45893878519546E-08 1.28617721140089E-07 1.58536126962561E-07
4   1 1.450773449662466E-08 6.619023700247679E-08 8.041846065194363E-09
4   4 1.478387343400914E-06
5   1 8.872940924006697E-09 2.818508001119155E-07 6.581914984641E-08
5   4 3.293477064931050E-09 7.140361834719233E-07
6   1 -3.79540049408266E-08 6.583918267119025E-08 3.962229159026654E-08
6   4 -4.50003259709083E-08 1.296042716134309E-09 7.19559638398684E-07

+SOLUTION/MATRIX_ESTIMATE L COVA

%ENDSNX
The DOMES are correct
Variance factor equal to 1.00

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Conclusions

• Two high precision total stations are advisable: in order to reduce time of antenna inactivity, and to supply a calibration check of EDM on common distances.

• In our survey scheme, distances between points have to be contained in 100-120 m in order to maintain accurate, angular collimation at prisms centre, and distance measurements.

• Constants of reflectors have to be evaluated before in laboratory, and high accuracy accessories are required.

• Local survey has met high precision requirements.

• Full covariance and SINEX were produced.