Royal Observatory of Belgium
GNSS Research Group

Evaluation of Individual Antenna Calibrations Used in the EPN

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IGS Workshop
July 23 – 27, 2012
Olsztyn, Poland

Introduction

Since April 2011, the igs08.atx antenna calibration model is used in the routine IGS (International GNSS Service) data analysis. The model includes mean robot calibrations to correct for the offset and phase center variations of the GNSS receiver antennas. These so-called "type" calibrations are means of the individual calibrations performed by Geo++ [Wübbena et al., 2006] and are available for a specific antenna/radome combination.

The GNSS data analysis performed within the EUREF Permanent Network (EPN) aims at being as consistent as possible with the IGS analysis. This also applies to the receiver antenna calibrations. However , for historical reason, when available, individual antenna calibrations are used within the EPN analysis (Figure 1) instead of the "type" calibration. When these individual calibrations are unavailable, then the EPN analysis falls back to (type) calibrations identical as the ones used within the IGS (igs08.atx).

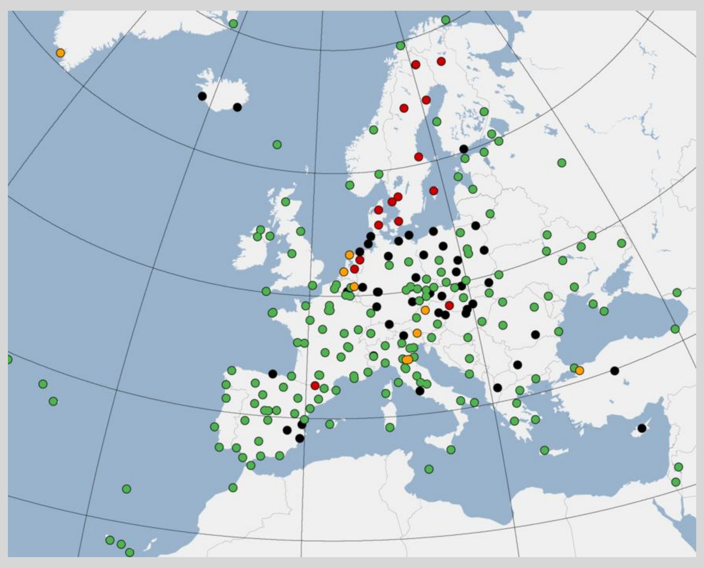

Figure 1. Map of the calibration available at each EPN station at the present date (245 stations).
- *Black dots: antenna/radome pairs with absolute individual calibrations (15.98%)*
- *Green dots: antenna/radome pairs with true absolute type calibrations (69.26%)*
- *Orange dots: antenna/radome pairs with absolute calibrations converted from relative values (6.56%)*
- *Red dots: antenna/radome pairs without absolute calibrations. In this case, the radome is neglected and the calibration values of the antenna with radome 'NONE' is used (8.20%).*

Aim of this study:
- Evaluate the significance of the offset caused by using different receiver antenna calibration models on the station position, using the PPP (Precise Point Positioning) technique.
- Investigate the differences in positioning obtained when switching between:
  1. Individual antenna calibrations and type calibrations.
  2. Individual calibrations from different calibration methods.

Antenna Calibration Methods

Different calibration methods are used. Their usage in the EPN is summarized in Table 1. Each technique is different:
- Robot calibration: the antenna is fixed on a moving robot and observes the signal from the satellites. The robot allows to rotate the antenna in order to determine the azimuth-dependent phase center variation (PCV).
- Chamber calibration: the antenna is in an anechoic chamber and observes a simulated signal. It can also rotate for the determination of the azimuth-dependant PCV.
- Field calibration: the antenna observes the satellites and the differences are made with respect to a calibrated antenna.

Institute	Method	# of antenna calibrated
Geo++ Gmbh	ROBOT	40
SenStadt BERLIN	ROBOT	11
IfE(Hannover university)	ROBOT	1
Lwa (TU-Dresden)	FIELD	1
UniBonn	CHAMBER	0*

Table 1. Known calibration institutes providing individual calibrations for EPN stations, including the calibration method and number of calibrations available within the EPN in April 2011.

**Some calibrations have been added since, like the individual calibration of BRUX performed by UniBonn.*

	GEO++	UniBonn
Technique	robot	anechoic chamber
Source	real observed satellite signals	generated sine wave
Frequencies	only observed frequencies	any (future) frequency
Equipment	GNSS receiver	Vector Network Analyser
Multipath	Not attenuated	Attenuated by absorbers
Environment	variable	stable
Duration	Long (wait for all GNSS signals)	Short (limited by positioner speed)

Table 2. : Comparison of calibration techniques at UniBonn and Geo++.

The differences between robot and chamber calibrations are summarized in Table 2 and the differences between the calibration values for some specific antennas are shown in Figure 4.

Methodology

To evaluate the influence of different receiver antenna calibration models on precise positioning, a similar approach was followed as the one used by Rebischung et al., 2011:
- Two separate PPP runs in which all processing options (satellite antenna calibrations, orbits and clocks, etc…) are identical except for the receiver antenna calibration model.
- For the receiver antenna calibration model, the igs08.atx and individual calibrations were used.
- The difference between the daily positions obtained by the different PPP runs will give us a daily estimate of the position offset caused by the different receiver antenna calibration model.
- **Final position offset** of a station is then obtained by taking the mean of the daily estimates over the considered data set of that station (corresponding to the time frame a specific antenna/radome combination was installed).

Two data sets are analyzed here:
- **The 53 EPN stations with individual calibration**, from the beginning (2003 for the first individual calibration in the EPN) to April 2011. They are compared to the type calibrations from igs08.atx.
- **The six antennas installed at Royal Observatory of Belgium (ROB)**. Each of those antennas have been individually calibrated by both Geo++ and UniBonn. The impact of the calibration method on the positioning is investigated by comparing the two calibrations for each antenna.

Individual vs Type Calibration

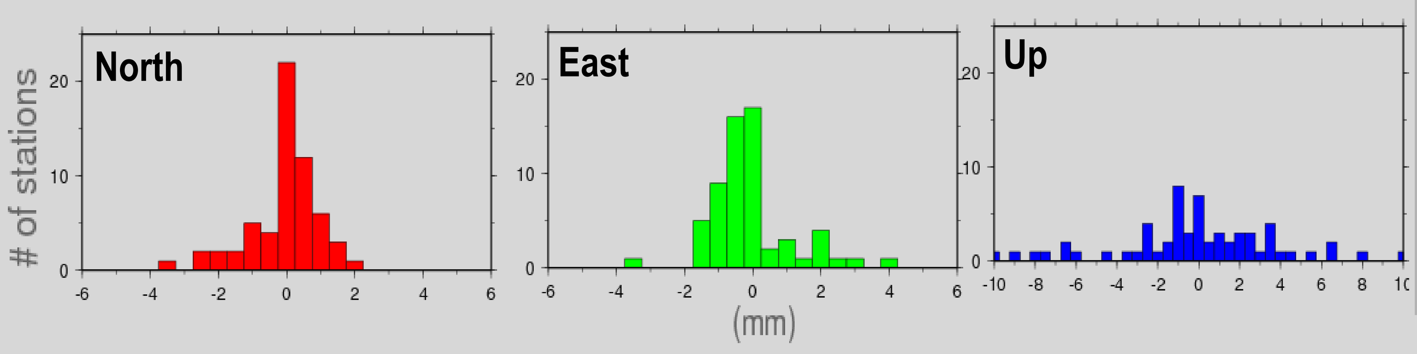

Figure 2. Histograms of position offsets induced by the difference between individual receiver antenna calibrations and igs08.atx calibrations for the 53 station/antenna+radome pairs individually calibrated in the EPN.

The difference between individual and type calibrations has a greater impact on the vertical component. The position offsets will be larger on this component:

North:	-0.1 mm mean	and	1.0 mm RMS
East:	-0.1 mm mean	and	1.2 mm RMS
Up:	-0.4 mm mean	and	4.2 mm RMS

There are 4 position offsets equal to 0 mm in all three components. This is explained by the fact that the igs08.atx calibrations for those antenna are made with one individual calibration.

Results 1
- Horizontal position offsets are centered around 0 mm but values up to 4 mm (~ 1 mm RMS).
- Vertical position offsets show values up to 10 mm and a RMS 4 times larger than the horizontal component.

Individual vs Type calibration : the TRM55971.00 TZGD

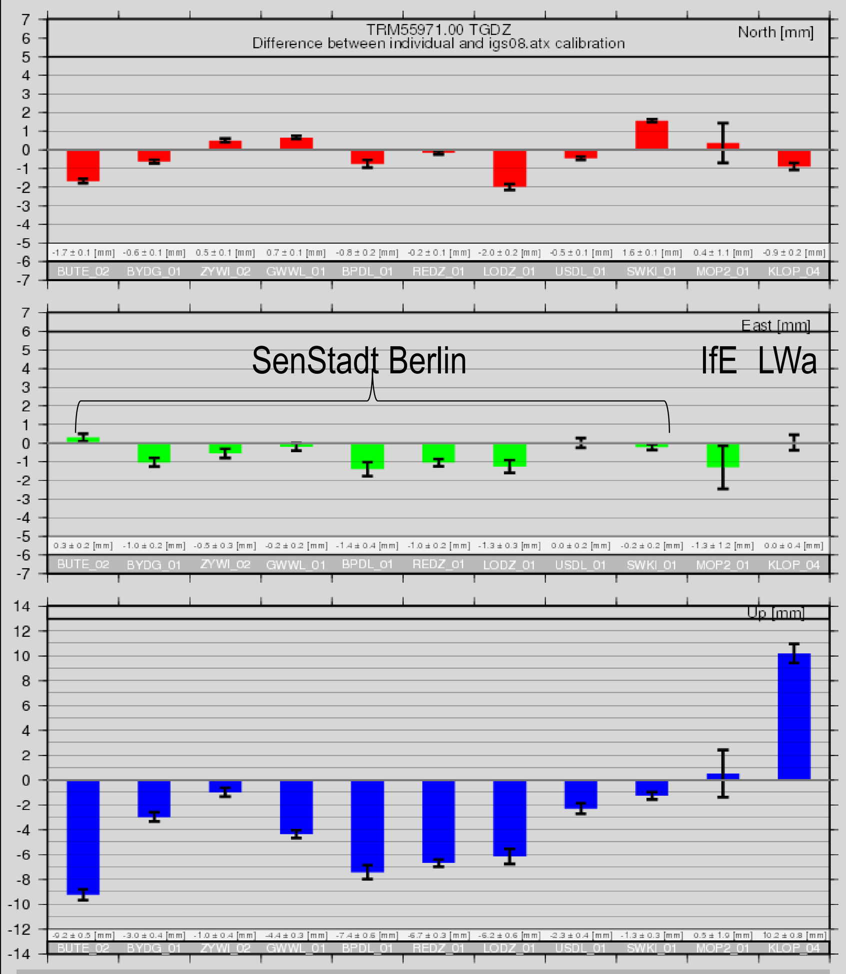

Figure 3. Position offsets between the individual calibrations and the type calibration for 11 different TRM55971.00 TZGD antennas.

Figure 3 presents the position offsets for the TRM55971.00 TZGD:
- Installed in 11 EPN stations and each of these antennas have been individually calibrated
- All the individual calibrations for this antenna have not been performed by the same institute
- The type calibration is the mean of Geo++ calibration of 8 antennas

Horizontal position offsets induced by two different individual calibrations reach 2 mm (for the north).
Vertical position offsets are larger: -9 mm for BUTE and 10 mm for KLOP.
The antenna of KLOP have the only field calibration, and KLOP and BUTE calibration are performed by different institute.

Differences between individual calibration and the type calibration on L_3 can exceed 6 mm. It depends on the elevation and the azimuth of the satellite over the station.

Comparison and Impact of Different Individual Calibration Methods

To study the impact of the calibration method on geodetic positioning 6 antennas have been installed at ROB. 5 of the 6 antennas are TRM59800.00 NONE, the other one is a LEIAR25.R3 NONE. All those antennas have been calibrated by Geo++ and UniBonn.

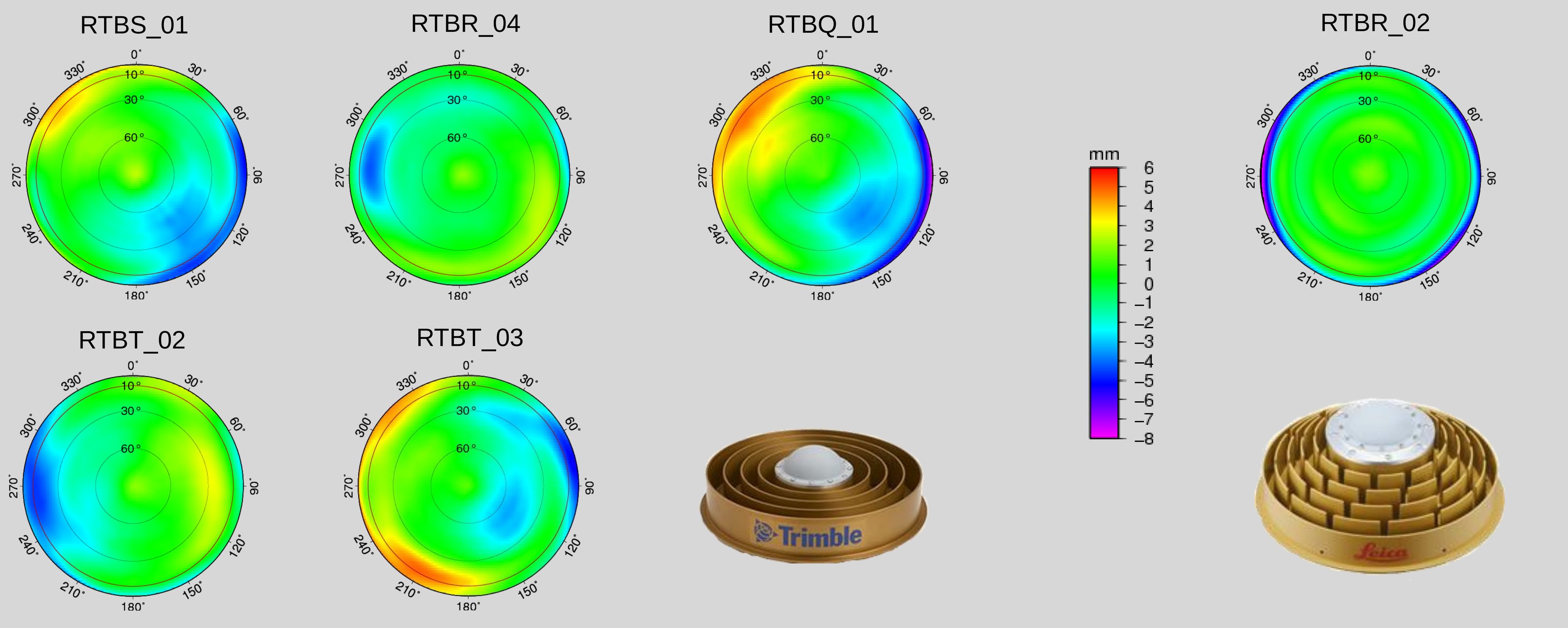

Figure 4. Differences between GEO++ and Bonn calibration (PCO+PCV) on L3 frequency for 5 Trimble antennas (TRM59800.00 NONE on the left hand side) and one Leica antenna (LEIR25.R3 NONE on the right hand side). All the plots have the same scale and antennas are installed at different location at ROB.

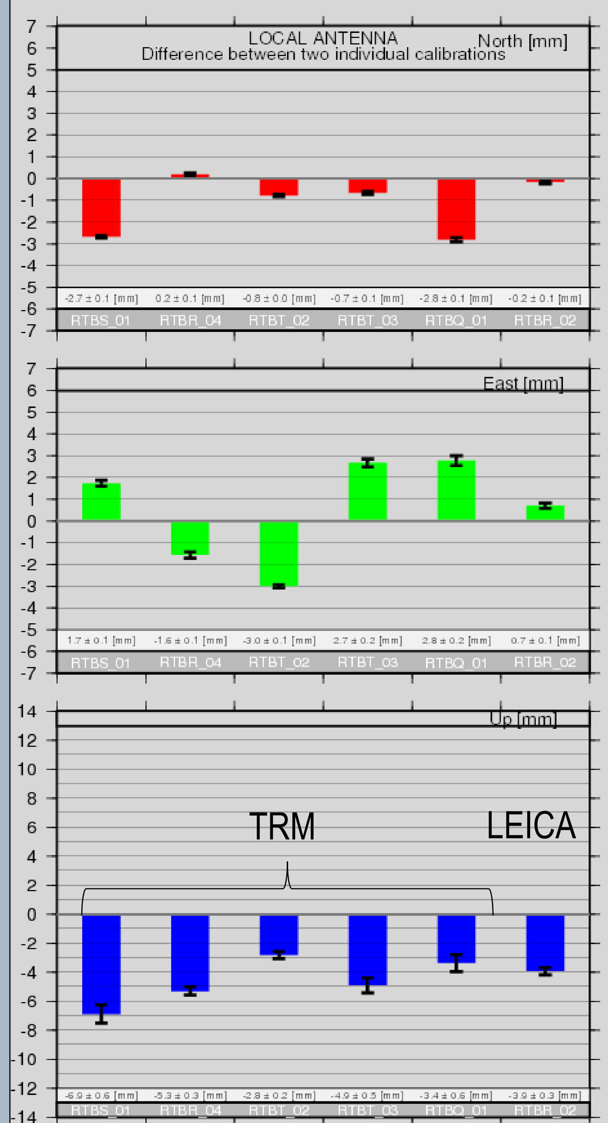

Figure 5. Position offsets for the antennas installed at ROB, resulting from the differences between GEO++ and UniBonn calibrations.

The impact is not straight forward: the impact on the position depend on the convolution of the differences between the calibration (Figure 4) and the skyplot of the station.

Differences between PCO+PCV from Geo++ and Bonn has a maximal value of -8 mm (Figure 4). This is only present below 10°. As the PPP solution is computed with a 10° elevation cutoff, those values are not taken into account to asses the impact on positioning here.

Results 2
- There is no systematic effect on the horizontal component.
- The position offsets can reach 3 mm in the horizontal component.
- There are not enough values to conclude to a negative bias in the vertical component induced by the different calibration methods.
- The vertical component is affected by position offsets up to 7 mm.
- The position offsets are equal or larger than those observed between individual and igs08.atx calibrations.

Summary

Comparisons between station positions computed with:
- Individual and igs08.atx receiver antenna calibrations show that *(results for Europe)*:
  - The position offsets can reach 4 mm in horizontal components and 10 mm in the vertical component.
  - The position offsets have a greater impact on the vertical component.
  - For the same antenna model, the position offsets induced by different individual calibrations with respect to igs08.atx calibrations can reach 2 mm in the horizontal components and 10 mm in the vertical component.
- Individual receiver antenna calibrations from Geo++ and UniBonn show that *(results for 6 antennas in Brussels)*:
  - The position offsets can reach 3 mm in the horizontal components and 7 mm in the vertical component.

This work gives no clue on a possible improvement of the repeatability or on the accuracy of positioning when using an individual calibration instead of the type mean one. But individual calibrations ensure continuity in the time series (no jumps in the time series when the type mean calibrations are updated, e.g. week 1632).

References

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