Antenna Tests at BEV Vienna 2002-2005

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Abstract

Since 2002 a short baseline at the roof of the Federal Office of Metrology and Surveying was used for antenna tests. The permanent site WIEN was kept fixed, the twin site WIEB was set up with different antennas (Ashtech, Leica, Trimble, Geotracer). This short baseline was included into a network (distances up to 200 km) to test the short and long distance behavior. While the coordinate changes of the surrounding permanent stations are within the range of EPN variations, some antennas caused large jumps of several centimeters for the up-component of WIEB. For two antenna types it can be proved that the NGS phase corrections are incorrect. Up to now for one of those no correct alternative could be found. The other one has be corrected in a pragmatic way.

1. Purpose

The start of the Austrian Positioning Service APOS, which is intended to serve all real time positioning accuracies to the centimeter level, also required knowledge of the characteristics of the antennas used. For that reason antennas are sent to Geo++ (a German company) for calibration, partially including the radoms. Due to copyright restrictions the publication of the calibration values is not allowed. It must also be taken into consideration that users of real time services and post processing data expect that they can use the "official" values of antenna types published by IGS. How the individual antennas and the antenna types behave in combination with those tested by BEV was the subject of investigations. Another concern was how the coordinates produced can vary by changing the equipment in various combinations (receivers, antennas, radoms). A third point of interest was if the influences of a big city with antennas at high buildings and several transmitters in the neighborhood will show some effects on long term stability.

2. Test bed

A steel pillar at the top of BEV (Bundesamt für Eich- und Vermessungswesen) was chosen as monumentation (WIEB, Fig. 1).

Fig. 1. Station WIEB used for antenna tests.

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The building with nine floors is situated almost at the center of Vienna and is surrounded by buildings of similar height. As usual in the city there are many transmitters in the surroundings, mainly used for GSM, but there are also some direct data transmitters. At the same building a GPS permanent station (WIEN) has been running since years. A test network was developed to cover the distances used in APOS, ranging from local neighborhood (WIEN-WIEB 6 m) to about 100 km (MOPI, MTBG, STPO, TRFB). A reference frame was chosen from the set of IGS and EPN stations (GOPE, GRAZ, JOZE, PENC, TUBO). The network is shown in Fig. 2.

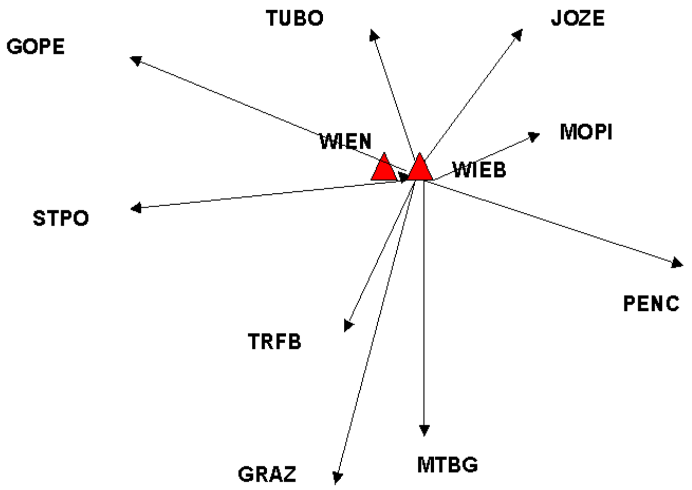

Fig. 2. Net of stations used in the antenna tests 2002-2005.

The tests started in 2002 and are still running. In 2005 WIEB was included in the network AMON that comprises all APOS stations plus some others within and at the borders of Austria. The time span 2002-2005 comprises about 400 days (47 in 2002, 196 in 2003, 140 in 2004, 20 in 2005). The equipment types were of Ashtech, Geotracer, JPS, Leica, Topcon and Trimble, receivers and antennas. Mixed combinations were also frequently used. The radom types used were of type BEV0, BEVA and thoes of commercial firms. BEV0 and BEVA radoms are constructed in the same way, consisting of a cylindrical part with a semi sphere, differing only in the material.

3. Analysis

The network was computed with the Bernese Software 4.2 in a semi-automatic way using the Bernese Processing Engine (BPE). The standards are those of EPN except that the minimum elevation angle was lowered to five degrees. It is not surprising that all permanent stations show the same results at the level of few millimeters as in the EPN or the OLG networks. The results of WIEB were first checked for stability to find a reliable set of coordinates to which the exemptions could be compared. The set consists mainly of results from choke ring antennas of different firms without a radom. The next step was to inspect all differences larger than 10 mm in height. It should be mentioned that all horizontal differences except for one antenna type were well below 10 mm. Therefore the investigations were restricted to the variability of the Up component. All deviations, which most probably originated in observation times less than 12 hours, are not considered. A part of the deviations investigated are discussed in the following.

4. Problems

4.1 Radom effects

Fig. 3 shows the differences of several LEIAT504 antennas by using no radom, the radom of BEVA before 2000 (BEV0) and the one of BEVA type manufactured afterwards. For this test several individual antennas were used. The diagram shows that on average the BEV0 radom does not differ from the results with no radom, but the results given by BEVA differe by about 10 mm. The same effect can be seen in Fig. 4 where Ashtech antennas with BEVA are compared to LEIAT504 ones with no radom. The difference is about 7 mm. The differences for Trimble antennas seem to be lower than Fig. 5 indicates. The individual differences seem to be at about 5 mm.

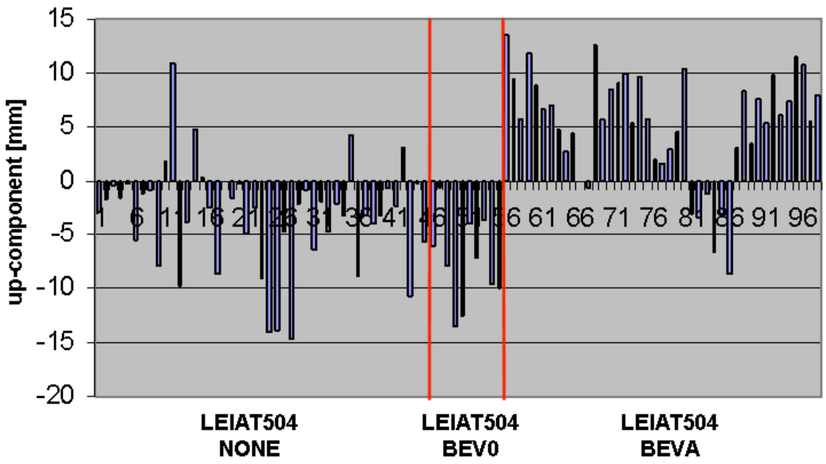

Fig. 3. Differences of LEIAT504 antennas with different radoms.

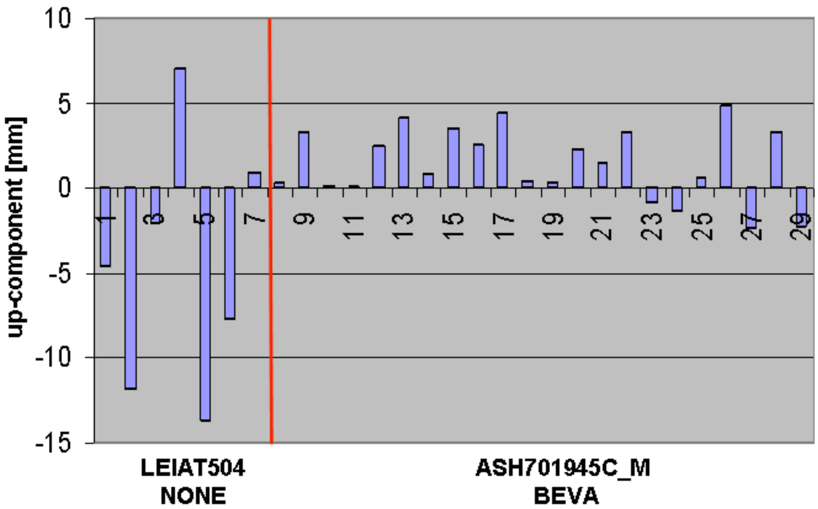

Fig. 4. Differences of ASH701945C_M with radom BEVA to LEIAT504 antennas.

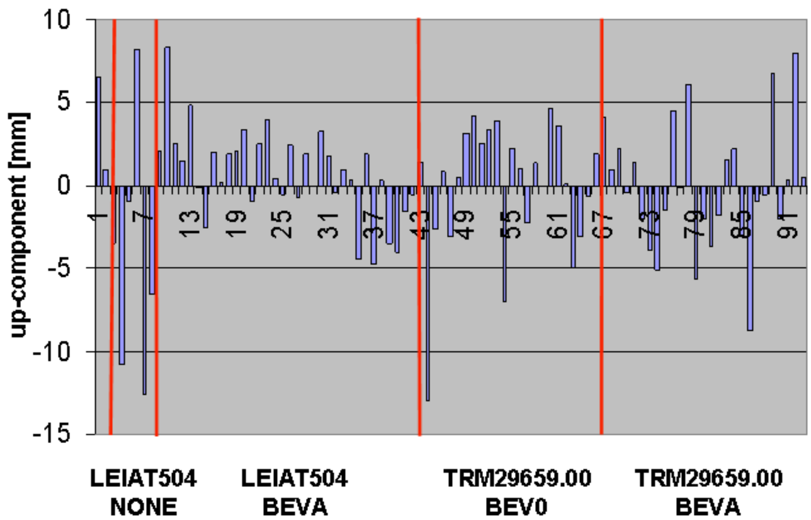

Fig. 5. Differences between TRM29659.00 with radoms BEVA/BEV0 and LEIAT504 antennas.

4.2 The TRM41249.00 problem

Testing the "Zephyr" Trimble antenna TRM41249.00 resulted in a jump of about 20 mm, similar to the one that was already detected when the antenna was changed in PENC. The real surprise was the effect of the BEVA radom (Fig. 6). The position of the antenna within the radom turned out to be crucial. Originally the phase center was placed at the equatorial plane of the hemisphere which gives almost the same effects as without radom. Shifting the antenna up in steps resulted in non-linear effects concerning the Up component. Shifting the antenna down was not at all successful as it increased the difference considerably. The first idea was to put the antenna up so that the bottom was within the equatorial plane. As can be seen in Fig. 6 the effect was a strong overshooting by several centimeters. This continued until there was a sharp turn toward the correct values near a shift of +20 mm. Beyond the value of +15 mm the difference increased quickly to the negative side. This means that the compensation of the wrong phase corrections can be achieved under the BEVA radom by shifting the phase center into the hemisphere by 15-20 mm. However, there is only a limited range of shifting, otherwise values sharply tend to become wrong. Later this was corroborated by chance at the site KRBG that was shifted +25 mm and experienced a jump of about 20 mm. For antennas without radom or with other radoms the differences remain or may have other values. Therefore the trick is insufficient to solve the problem. The Swiss colleagues from LPT have constructed phase corrections of that antenna and helped with the derived values. The effect can be seen in Fig. 7. The LPT values reproduce the correct coordinates best in contrast to the NGS values while the shift differs by some millimeters.

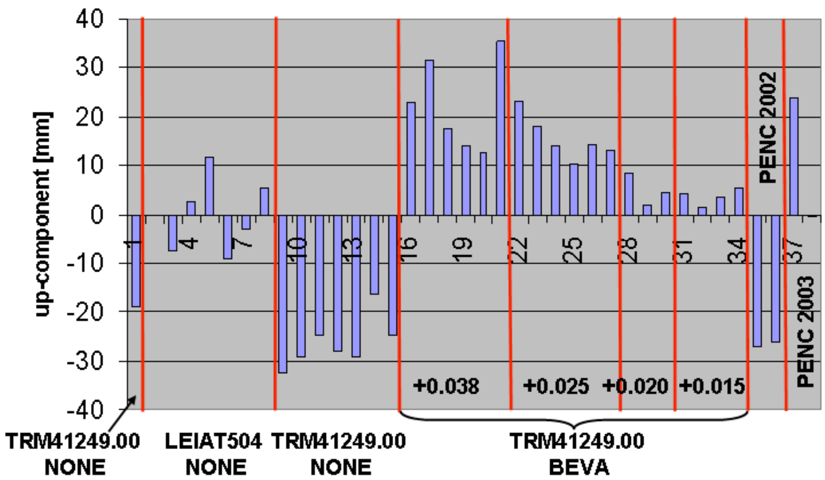

Fig. 6. Differences between TRM41249.00 antennas with radom BEVA and without to LEIAT504 antennas. Variations when the antenna height within the BEVA radom changes. Changes of PENC-WIEB after the jump of PENC (2003). Always phase corrections IGS/NGS used.

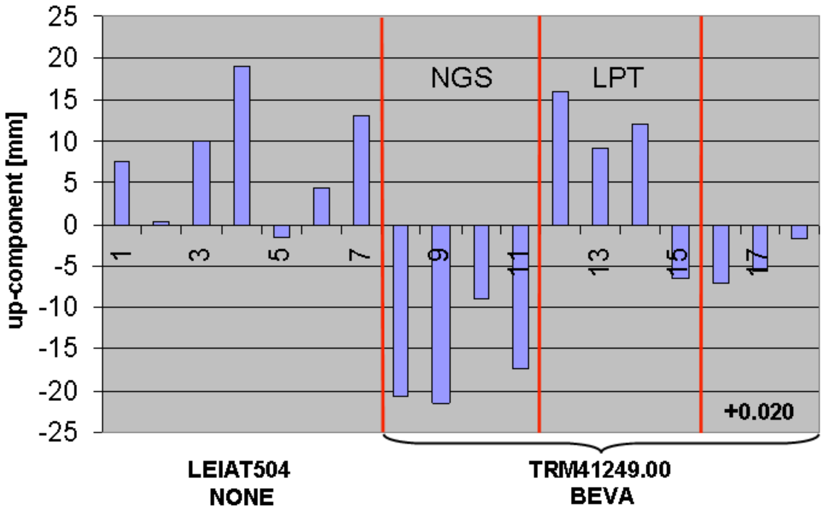

Fig. 7. Differences between TRM41249.00 antennas with radom BEVA and different phase corrections and LEIAT504 antennas.

4.3 The LEIAT502 problem

The Leica antenna LEIAT502 is not used for international permanent stations but appears sometimes in campaigns and is frequently used for small-scale surveys. The deviations from correct values appeared to be very large (50 mm and more). Even the horizontal deviations exceeded 10 mm when using the NGS phase corrections (Fig. 8). In order to find alternative phase corrections the type corrections of Leica and Geo++ were compared. As this type of antenna was obviously not designed for low elevation tracking the minimum elevation angle was enlarged in steps of five degrees up to 20 degrees. Fig. 9 shows that there is an elevation cut-off influence by some centimeters which keeps growing at higher elevations. However, none of the three tested phase correction sets reached the correct values. A crude measure would be to add simply 80-100 mm to each height to reach an acceptable range.

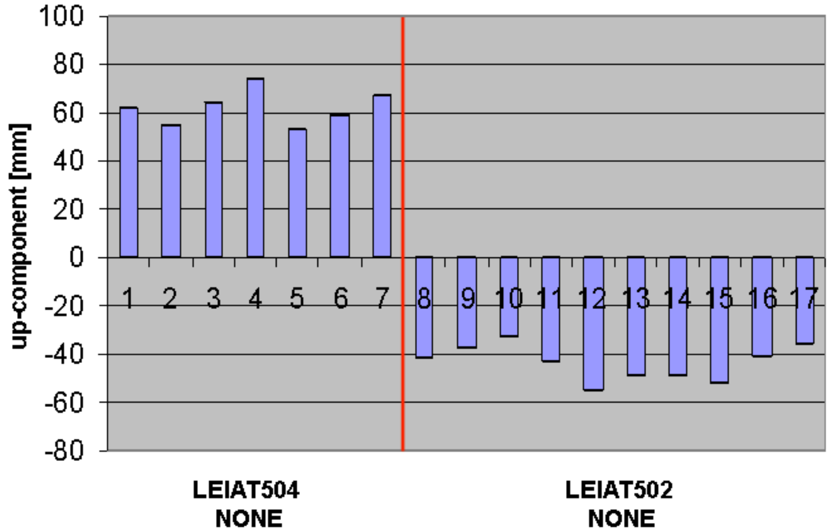

Fig. 8. Differences between LEIAT502 antennas and LEIAT504 antennas.

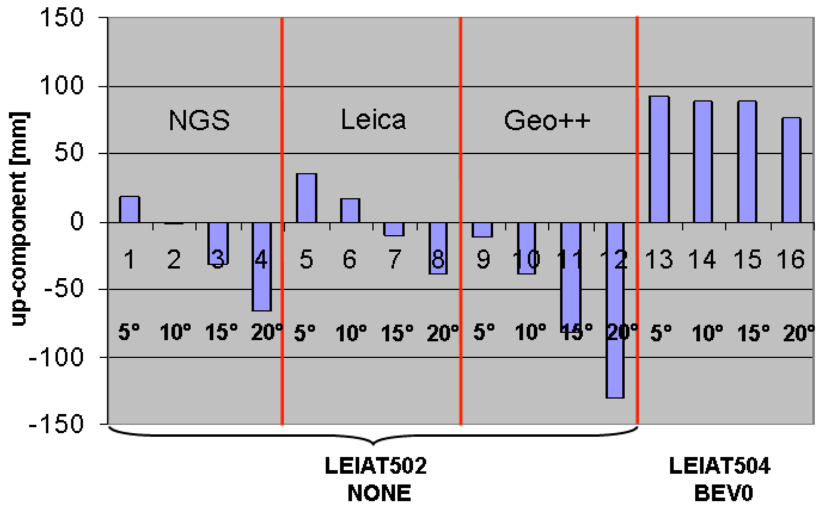

Fig. 9. Differences between LEIAT502 antennas and LEIAT504 antennas. Different phase correction sets of NGS, Leica and Geo++ are used.

5. Conclusions

Most of the used antennas with and without the radoms of BEV0 and BEVA are compatible down to a level of 5 mm, below however individual deviations seem to be predominant, but also the change in manufacturing may have changed the geometry of the rays passing through. Although choke ring antennas of different type show some significant deviations they are usable for RTK practice, which requires one-centimeter stability of the permanent stations. Two antenna types suffer from phase corrections, which do not give correct results when used in the Bernese Software. As in Austria the TRM41249.00 antenna is frequently used for permanent stations a solution had to be found. Consequently further calibrations will be necessary.