# Local Ties Between the Reference Points at the Fundamentalstation Wettzell

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**Summary**. The local ties between reference points of the geodetic space observation systems and the geodetic local network markers have been derived through terrestrial local survey and GPS observations. The local survey consists of direction, distance and levelling observations, which were analysed with the adjustment program PANDA. GPS observations were carried out for the orientation of the local network within the global reference frame. The GPS observations were analysed using the Bernese GPS Software. Both results were combined by making use of the Bernese GPS Software. The results finally were made available in the SINEX format for further application.

## 1 General Information

Local Ties between the reference points of the observing systems co-located at a Fundamentalstation are fundamental for combining the different space techniques. The Fundamentalstation Wettzell, operated by the Bundesamt für Kartographie and Geodäsie in collaboration with the Forschungseinrichtung Satellitengeodäsie of the Technische Universität München, is equipped with

- a 20m Radiotelescope for VLBI
- a Laser Ranging System WLRS for SLR with capabilities for LLR
- various GPS and GLONASS receivers
- a DORIS station

Various local surveys have been carried out since the existing of the station Wettzell in order to determine the local ties, to detect local motions or to demonstrate the local stability.

In the period from 2000 to 2004 various observations have been conducted to control and improve the local ties with highest accuracy through terrestrial survey and local GPS observations for the orientation of the local network. Needs for the new survey came up to include control points for the Ringlaser G, which has started operation in 2002.

## 2 Local Network

The local control network has an extension of 250m x 180m and consists of 50 marked points and 113 levelling points. Figure 1 gives an overview of the entire network. Most of the points are marked as stable survey pillars, Figure 2, with forced centering capabilities or as stable ground markers. Additional levelling points are installed for height control. Levelling technique can easily be employed for regular survey in order to monitor local stability.

As not all the points are of general interest, this report concentrates only to those points used for the combination of the employed space techniques. Table 1 gives the point description with the internal station number, the DOMES number and the approximate longitude, latitude and height.

Table 1: Description of local survey points, relevant for combination of space techniques

| Site ID | DOMES No. | Station Description | APPROX_LON | APPROX_LAT | APP_H |
|---|---|---|---|---|---|
| 1 | M | Pillar 1 | 12 52 39.1 | 49 8 42.8 | 658.9 |
| 100 | M | TIGO VLBI Wettzell | 12 52 39.4 | 49 8 40.2 | 657.5 |
| 200 | M | TIGO SLR Wettzell | 12 52 38.1 | 49 8 39.4 | 657.2 |
| 7224 | 14201S004 | VLBI reference point | 12 52 38.8 | 49 8 42.0 | 669.1 |
| 7595 | M | Platform | 12 52 43.0 | 49 8 40.4 | 658.1 |
| 7596 | 14201M004 | Platform | 12 52 43.3 | 49 8 39.0 | 658.6 |
| 7597 | 14201M005 | Platform; DORIS | 12 52 42.5 | 49 8 38.3 | 660.3 |
| 7598 | M | Platform | 12 52 41.9 | 49 8 39.5 | 660.6 |
| 8834 | 14201S018 | SLR reference point | 12 52 40.8 | 49 8 39.9 | 665.4 |
| 1201 | 14201M011 | WTZT GPS | 12 52 44.2 | 49 8 39.2 | 665.9 |
| 1202 | 14201M010 | WTZR GPS | 12 52 44.1 | 49 8 39.1 | 666.0 |
| 1203 | 14201M012 | WTZJ GPS/GLONASS | 12 52 44.2 | 49 8 39.1 | 665.9 |
| 1204 | 14201M013 | WTZA GPS | 12 52 44.0 | 49 8 39.2 | 665.9 |
| 1205 | 14201M014 | WTZZ GPS | 12 52 44.1 | 49 8 39.2 | 665.9 |
| 1206 | M | WTZL GPS | 12 52 44.1 | 49 8 39.2 | 665.9 |

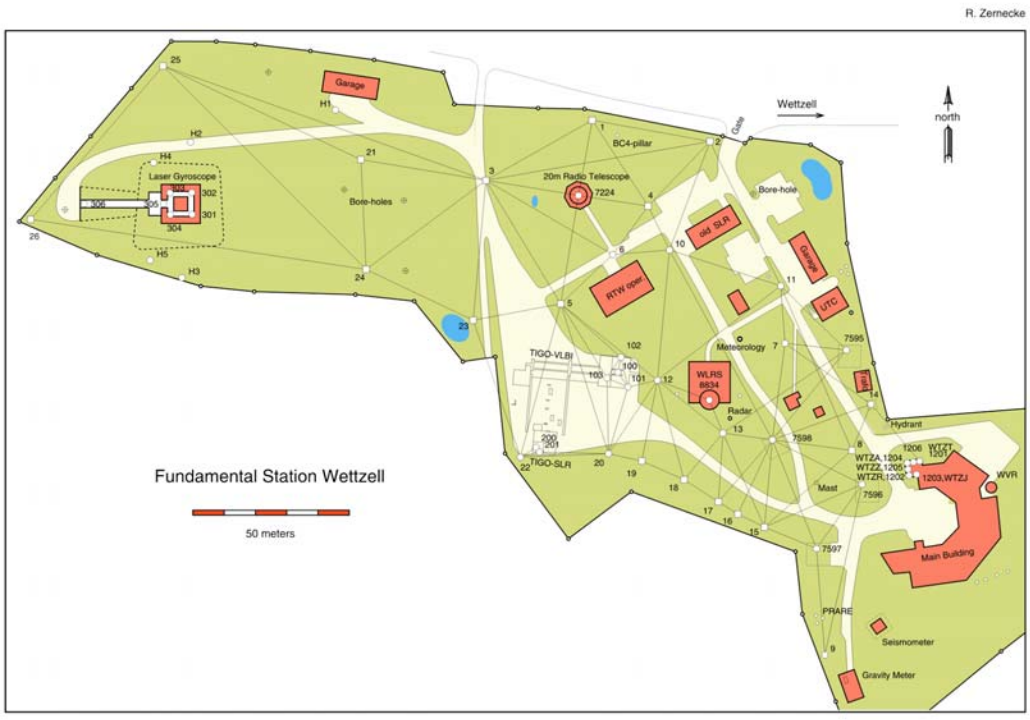


Figure 1: Local Network of the Fundamental Station Wettzell

Figure 2: Survey pillar of the local network, top view of the pillar with survey marker for force centering and marker for levelling

## 3 Local terrestrial survey observations

The analysis of the local terrestrial survey is based on observations performed in the period from 2000 to 2002. Observations carried out in 2000 and 2001 by Rudolf Zernecke placed emphasis to include the reference points of the ring Laser into the local survey network [1], [2], [3]. Control observations covering the entire network including the reference points of the geodetic space systems were carried out by Karin Fischer and Svetlana Becker in the frame of their thesis [4].

For

- distance measurements a Mekometer ME5000 (precision:0.2mm+ 0.2ppm), and Geodimeter 600 (precision 1mm+1ppm)
- direction measurements theodolites and Tachymeters as T3000 and TDA 5005 (precision 0,15mgon) and TCA 2003 (precision 0,3mgon)
- levelling DINI11 and NI2 (precision 0,3mm/km)

were employed.

## 4 3D adjustment of the terrestrial local network

The adjustment of the network has been done with the “PANDA” program [5] . The network specific parameters of the adjustment are summarized in table 2.

Table 2: Network specific parameters of the PANDA free network solution

| | |
|---|---|
| total number of observations : | 1014 |
| number of directions : | 392 |
| number of distances : | 457 |
| number of height differences : | 165 |
| total networkpoints : | 52 |
| number of datum points : | 27 |
| number of unknowns : | 156 |
| additional parameter estimated : | 1 |
| unknown number for orientation : | 54 |
| free network parameter: | 4 |
| degrees of freedom : | 807 |

The precision obtained for all network points is shown in Figure 3, and demonstrated by the error ellipses for the location and error bars for height. The goal was to derive local ties better than 1 mm, which is achieved for the entire network. Larger values occur for some border points. All ties being relevant for the combination of the space techniques show a precision better than 0.3mm.

# 5 GPS observations and analysis

During two campaigns dedicated GPS observations were carried out in order to connect the local network to the global reference frame ITRF. The first campaign was from May 31 to June 04, 2000 to include the ring Laser reference points into the local survey network. Beside the four permanent observing GPS stations four temporary sites were occupied additionally (Figure 4).

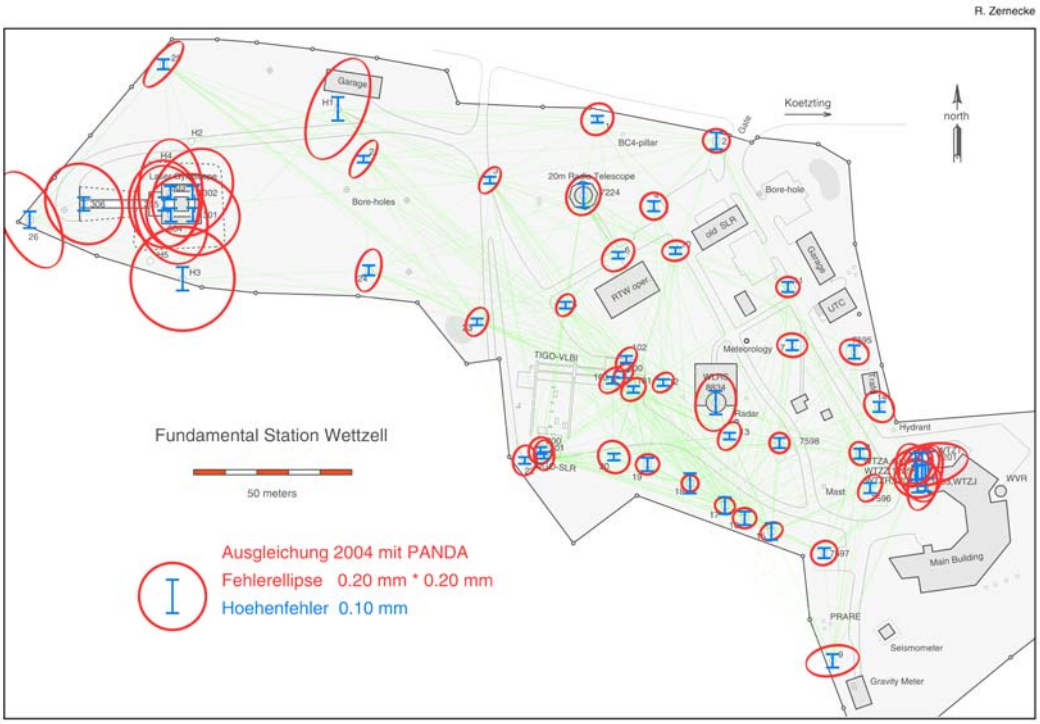


Figure 3: Accuracy obtained after the adjustment, demonstrated by the error ellipses

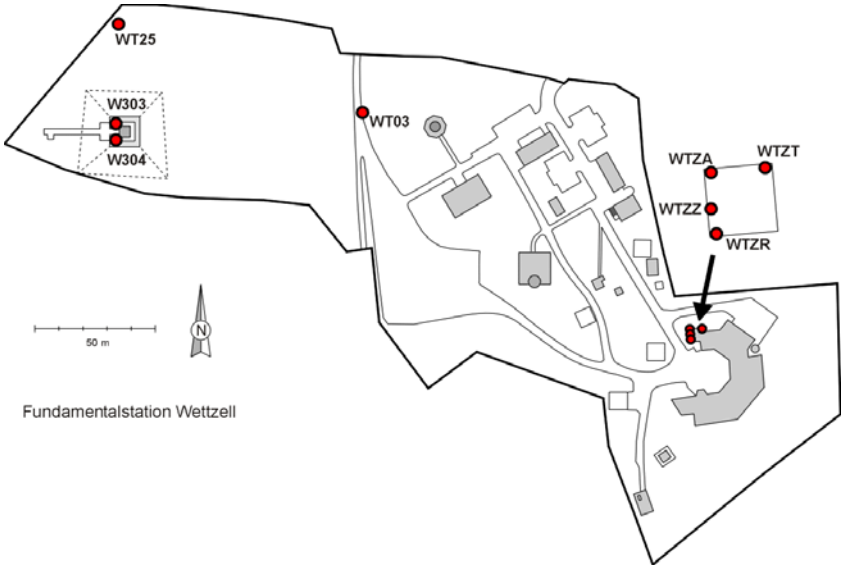


Figure 4: GPS observations during May 31 to June 4, 2000

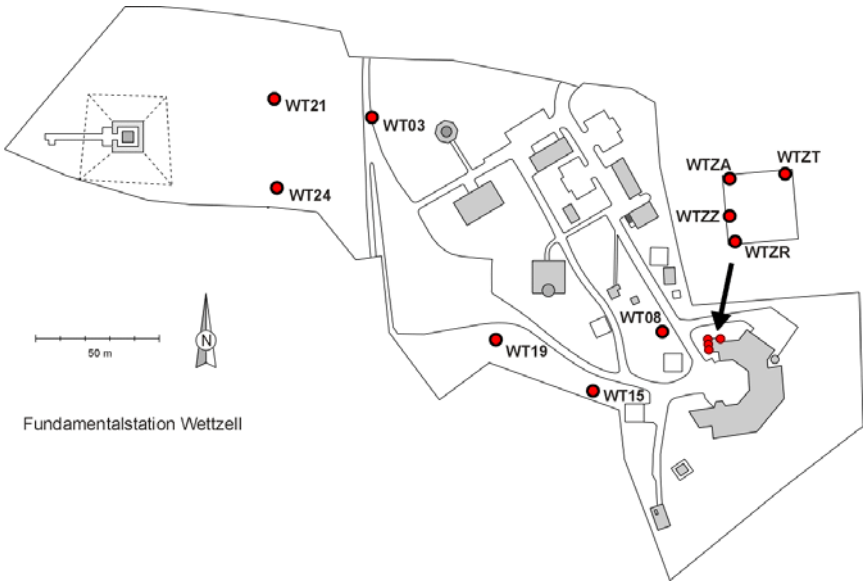


Figure 5: GPS observations during September 27 to October 05, 2003

The second campaign was performed from September 27 to October 5, 2003. The occupied points are shown in the Figure 5. The observations from both periods were combined to one solution employing the Bernese GPS Software, Version 5.0 [6]. The r.m.s values for the coordinates obtained for the daily solutions were better than 1.5mm and for the combined solution between 0,06 and 0,87 mm.

# 6 Combination of terrestrial survey with GPS results

The solutions of the terrestrial survey results and of the GPS observations were combined employing the Bernese GPS Software under consideration of the variance-covariance matrices in order to obtain the best results for the local ties in the frame of ITRF [7]. Table 3 gives the identical points for the combination.

Table 3: Identical points for the combination

| terrestr. survey | GPS |
|---|---|
| 3 | WT03 |
| 8 | WT08 |
| 15 | WT15 |
| 19 | WT19 |
| 21 | WT21 |
| 24 | WT24 |
| 25 | WT25 |
| 303 | W303 |
| 304 | W304 |
| 1201 | WTZT |
| 1202 | WTZR |
| 1204 | WTZA |
| 1205 | WTZZ |

A Helmert transformation considering 7 parameters (scale, 3 translations and 3 rotations) has been conducted in order to transform the local terrestrial results to the ITRF solution derived by GPS. The residuals in average are for the

X-component : 1.09mm,
Y-component : 1.31mm,
Z-component : 3.04 mm.

The combined results are available in SINEX format (WTZ_SNX1.SNX) at the IERS Central Bureau for further applications.

The local eccentricities in dX, dY and dZ with reference to ITRF are summarized in Table 4. They are referred to the survey monument No. 1.

Table 4: Eccentricities with reference to monument marker No. 1 in dX, dY and dZ

| Internal point ID | ΔX | rms ΔX | ΔY | rms ΔY | ΔZ | rms ΔZ |
|---|---|---|---|---|---|---|
| | [m] | [m] | [m] | [m] | [m] | [m] |
| 1 | 0,00000 | 0,00151 | 0,00000 | 0,00061 | 0,00000 | 0,00183 |
| 100 (TIGO VLBI) | 57,27253 | 0,00086 | 20,61512 | 0,00039 | -54,09384 | 0,00088 |
| 200 (TIGO SLR) | 80,52671 | 0,00145 | -1,35079 | 0,00041 | -69,82686 | 0,00154 |
| 1201 (WTZT) | 63,09859 | 0,00040 | 120,97928 | 0,00039 | -67,18717 | 0,00040 |
| 1202 (WTZR) | 66,16981 | 0,00037 | 119,35753 | 0,00037 | -69,34447 | 0,00037 |
| 1203 (WTZJ) | 65,50397 | 0,00039 | 120,92659 | 0,00039 | -69,21625 | 0,00039 |
| 1204 (WTZA) | 63,97892 | 0,00039 | 118,35597 | 0,00038 | -67,45288 | 0,00039 |
| 1205 (WTZZ) | 65,04648 | 0,00039 | 118,67096 | 0,00038 | -68,43863 | 0,00039 |
| 1206 (WTZL) | 63,52703 | 0,00040 | 119,66441 | 0,00038 | -67,31879 | 0,00040 |
| 7224=VLBI | 25,37253 | 0,00130 | 0,96110 | 0,00052 | -8,02375 | 0,00119 |
| 7595 | 36,70871 | 0,00059 | 91,23808 | 0,00044 | -49,53325 | 0,00094 |
| 7596 | 67,92918 | 0,00059 | 103,02342 | 0,00039 | -77,43646 | 0,00043 |
| 7597 (DORIS) | 87,38736 | 0,00103 | 92,23954 | 0,00041 | -89,59820 | 0,00098 |
| 7598 | 64,75638 | 0,00059 | 72,93692 | 0,00038 | -66,39097 | 0,00056 |
| 8834 (SLR) | 62,34602 | 0,00061 | 51,15581 | 0,0004 | -53,82678 | 0,0007 |

## References

[1] Zernecke, Rudolf: Auswertung der Laserkreiselmessung im Jahr 2000, interner Bericht

[2] Zernecke, Rudolf: Auswertung der Laserkreiselmessung vom Herbst 2001, interner Bericht

[3] Zernecke, Rudolf: Einmessung des Laserkreisels im Oktober 2001, interner Bericht

[4] Fischer, Karin, Svetlana Becker: Wiederholungsmessungen im lokalen Vermessungsnetz der Fundamentalstation Wettzell, Diplomarbeit 2003

[5] GeoTech GmbH: PANDA für Windows, Laatzen, Version 3.08, Januar 2002

[6] Klügel, Thomas: Auswertung lokaler GPS-Kampagnen in Wettzell und Concepcion, interner Bericht, Januar 2005

[7] Thaller, Daniela, Peter Steigenberger, Markus Rothacher: Kombination von terrestrischer Messung mit GPS für die lokalen Netze in Wettzell und Concepcion, interner Bericht, Januar 2005