Local Ties Between the Reference Points at the Transportable Integrated Geodetic Observatory (TIGO) in Concepcion/Chile

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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 with the Transportable Integrated Geodetic Observatory (TIGO) in Concepcion/Chile (figure 1) are fundamental for combining the different space techniques. TIGO, operated by the Bundesamt für Kartographie and Geodäsie in collaboration with the Chilean consortium lead by the Universidad de Concepcion, is equipped with

- a 6m Radiotelescope for VLBI (TIGO-VLBI-Module),
- a Laser Ranging System (TIGO-SLR-Module) for SLR,
- a GPS and GLONASS receiver

In the period from March 10 to April 04 observations have been conducted to derive the local ties with highest accuracy through terrestrial survey. Local GPS observations for the orientation of the local network were carried out in the period from July 29 to July 30, 2004.

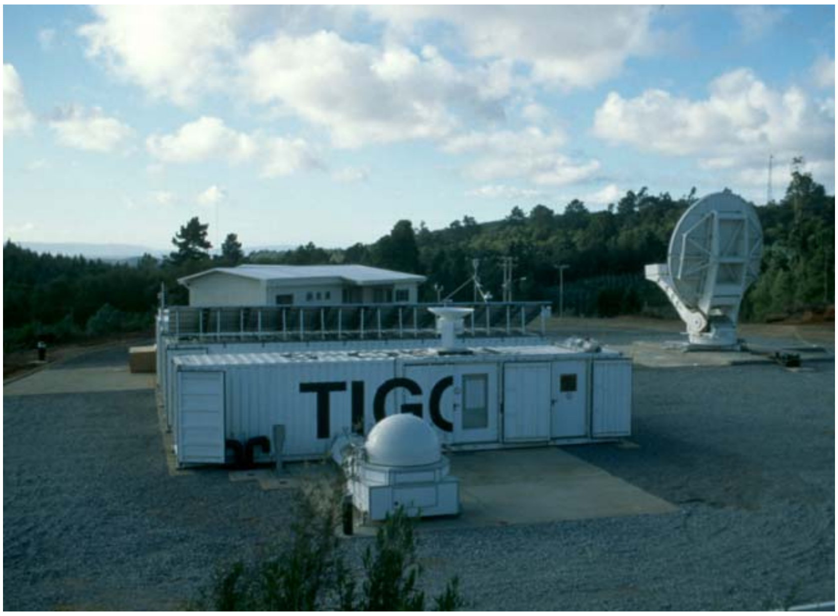

Figure 1: Transportable Integrated Geodetic Observatory TIGO in Concepcion/Chile

2 Local Network

The local control network has an extension of 160mx 50m and consists of 14 marked points for the horizontal location and of 31 levelling markers. Four of the points are marked as stable survey pillars (Figure 2), with forced centring capabilities. Additional levelling points are installed for height control. Levelling technique can easily be employed for regular survey in order to monitor local stability. Figure 3 gives an overview of the entire network.

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

local marker	DOMES No.	Description	approx. Longitude	approx. Latitude	approx. Height
101	M	ground marker VLBI	286 58 29.7	-36 50 33.9	169.3
102	M	ground marker VLBI	286 58 29.4	-36 50 33.9	169.3
103	M	ground marker VLBI	286 58 29.3	-36 50 33.7	169.3
110	M	marker	286 58 28.3	-36 50 34.0	169.3
111	M	marker	286 58 29.7	-36 50 33.7	169.5
112	M	marker	286 58 29.1	-36 50 34.6	169.3
201	M	ground marker SLR	286 58 28.9	-36 50 34.9	169.3
500	M	PRARE reference point	286 58 27.4	-36 50 37.5	180.8
200 / 7405	41719M001	SLR Intersection of axis	286 58 28.8	-36 50 34.8	170.8
100 / 7640	41719S001	VLBI Intersection of axis	286 58 29.5	-36 50 33.8	171.0
300	41719M002	CONZ; GPS/GLONASS	286 58 28.3	-36 50 37.5	180.7
301	M	pillar monument T301	286 58 29.0	-36 50 35.6	175.3
302	M	pillar monument T302	286 58 28.0	-36 50 34.0	171.0
303	M	pillar monument T303	286 58 30.1	-36 50 33.2	171.0

Figure 2: Survey pillar of the local network , Pillar with GPS/GLONASS antenna and reference point realized by the reflector

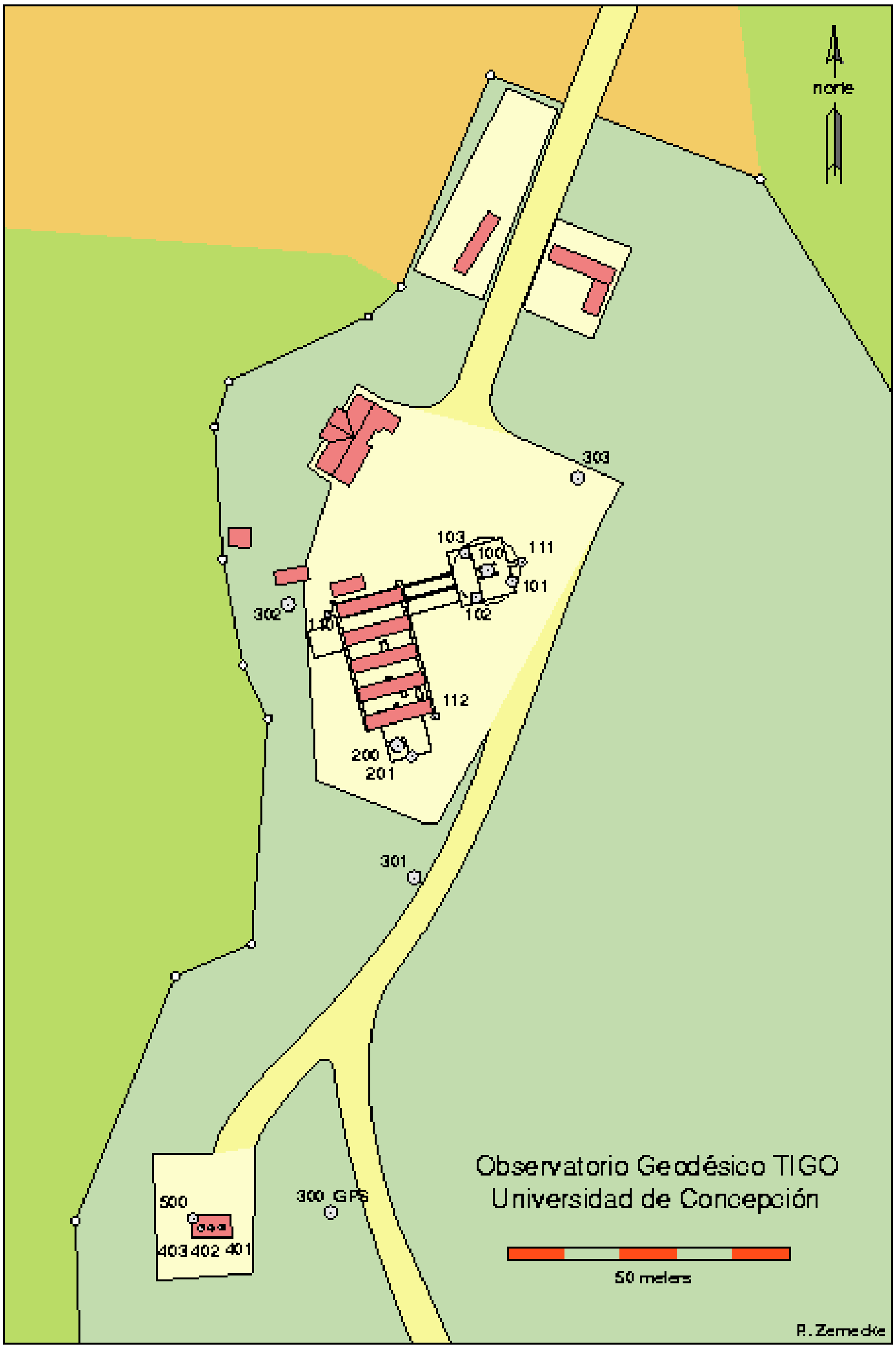

Figure 3: Local Network of TIGO in Concepcion

3 Local terrestrial survey observations

The analysis of the local terrestrial survey is based on observations performed in the period from March 10 to April 04, 2003 by Rudolf Zernecke [1].

For

- distance and direction measurements the Tachymeter "Geodimeter Bergstrand" with a precision of 1mm+ 1ppm for distances and 0,3mgon for directions (Figure 4)
- levelling the Zeiss DINI11 with a precision of 0,3mm/km

were employed.

Figure 4: Tachymeter "Geodimeter Bergstrand" used for distance and direction observations

4 3D adjustment of the terrestrial local network

The adjustment of the network has been done with the "PANDA" program [2] by Karin Fischer [3]. 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 :	467
number of directions :	307
number of distances :	83
number of height differences :	77
total number of network points :	14
number of unknowns :	42
additional parameter estimated :	1
unknown number for orientation :	75
free network parameter:	4
degrees of freedom :	353

The precision obtained for all network points is shown in Figure 5 , and demonstrated by the error ellipses for the horizontal 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 small error ellipses with semi axis up to 0.6mm. The point 500 shows the largest errors as it is located at the border and the PRARE mount has not a clear marker for surveying.

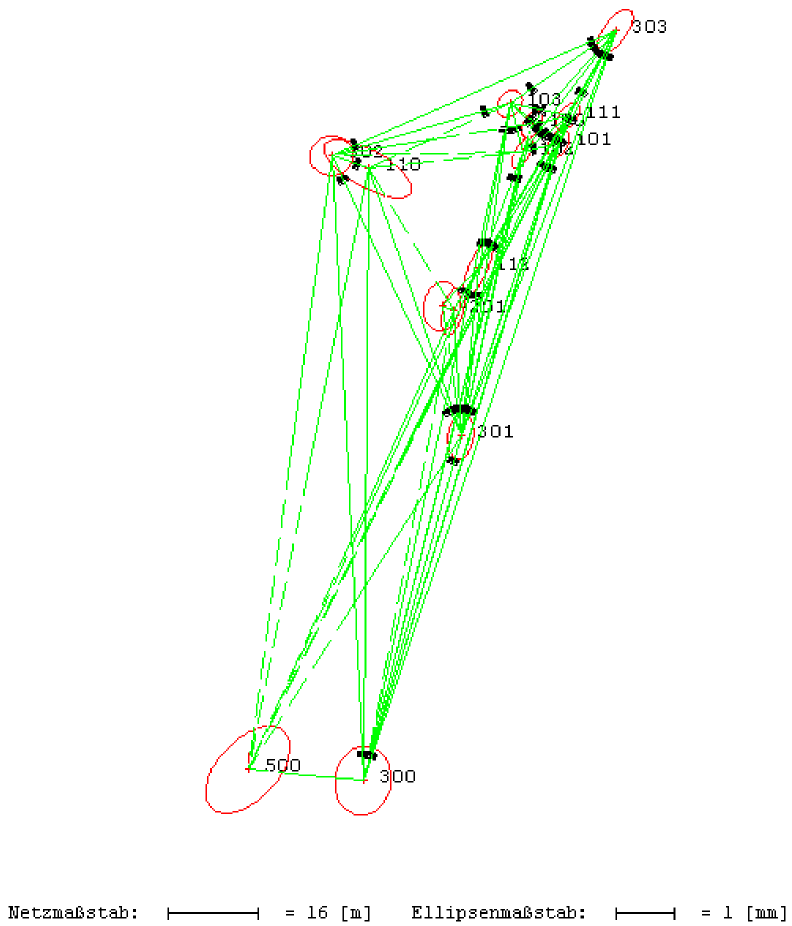

Figure 5: Accuracy obtained after the adjustment, demonstrated by the error ellipses

5 GPS observations and analysis

GPS observations were carried out in the period from July 29 to July 30, 2004 in order to connect the local network to the global reference frame ITRF. Beside the permanent observing GPS station CONZ three temporary sites were occupied additionally (figure 6).

The observations were analysed employing the Bernese GPS Software, Version 5.0 [4]. The r.m.s values for the coordinates obtained for the daily solutions and the combination were better than 1mm.

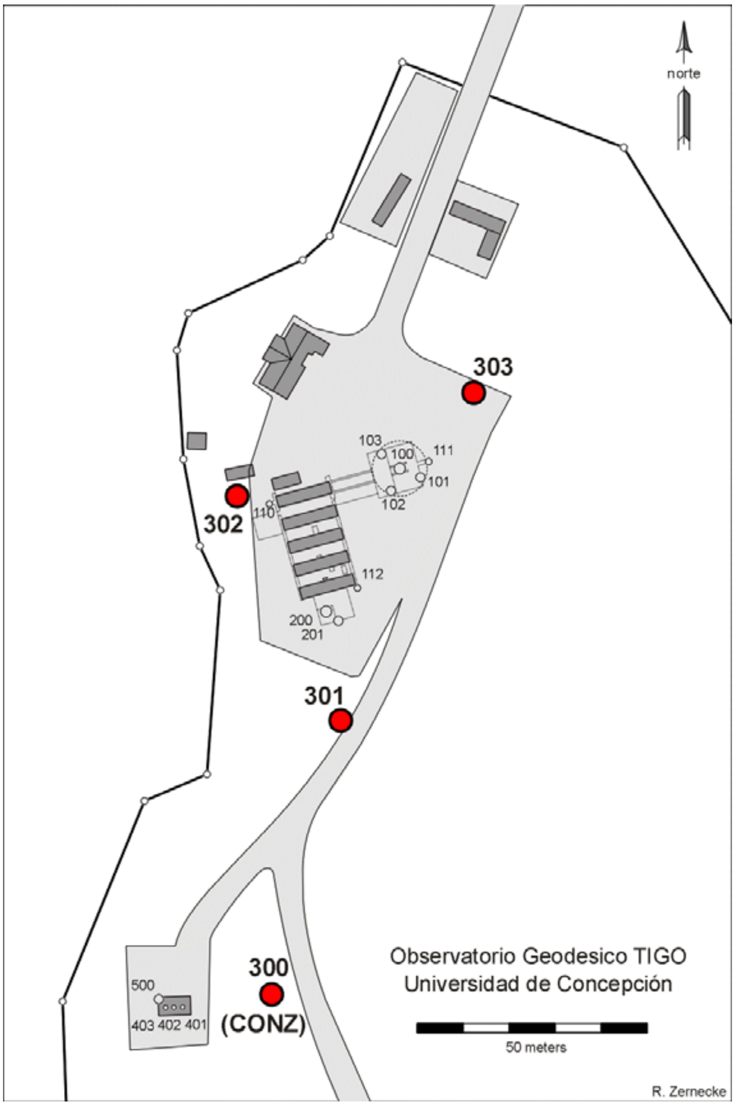

Figure 6: GPS observations during July 29 to July 30, 2004

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 [5]. Table 3 gives the identical points for the combination.

Table 3: Identical points for the combination

local survey	GPS
300	CONZ
301	T301
302	T302
303	T303

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 : 0,45mm,
Y-component : 1,54mm,
Z-component : 0.04 mm.

The combined results are available in SINEX format (TIGO_SNX.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 Nr. 300 (GPS-reference marker)

Table 4: Eccentricities with reference to monument marker No. 300 in dX, dY and dZ in the frame of ITRF

Local point ID.	Difference of the coordinates with respect to reference marker 300		
	ΔX	ΔY	ΔZ
100/VLBI	46,65616	-50,27257	98,61724
101	50,20110	-45,78870	97,03620
102	43,90655	-46,57316	95,64737
103	43,19069	-52,11146	102,44044
110	17,21135	-52,94528	93,30525
111	52,81520	-48,08339	100,66139
112	32,82776	-37,29325	79,37453
200/SLR	25,75611	-36,36005	73,00866
201	27,18456	-34,12821	73,13721
300/GPS-CONZ	0,00000	0,00000	0,00000
301	26,20255	-25,64263	51,91222
302	11,93011	-57,46872	94,21582
303	63,84058	-55,46231	111,85901
500/PRARE	-19,03940	-7,20666	1,58046

References

[1] Zernecke, Rudolf: Lokale Vermessung von TIGO in Concepcion im Frühjahr 2003, interner Bericht, Januar 2004

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