Installing TIGO in Concepcion

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October 29, 2002

Abstract

During the last year the Transportable Integrated Geodetic Observatory (TIGO), and amongst it the SLR module, was in stand by mode for the shipment to Concepcion, Chile. The negotiations of the previuos years led finally to a diplomatic note exchange aiming at the joint operation of TIGO in Concepcion. Apart from the BKG the chilean side formed a consortium in order to share funding for infrastructure and man power, giving means to host TIGO for at least three years. The Consortium consists of the following institutions:

- The Universidad de Concepcion,
- the Universidad Catolica de la Santisima Concepcion,
- the Universidad Bio Bio and
- the Instituto Geografico Militar.

The present paper describes the final updates in the SLR module, as well as the shipment and setup procedure including first results and local survey data providing a connection between the various employed geodetic space techniques.

1 Introduction

The Transportable Integrated Geodetic Observatory (TIGO) was constructed and set up at the Fundamental Station Wettzell during the 1990's [1]. Aiming at the transfer to a site in the southern hemisphere for reasons of support for the International Terrestrial Reference Frame (ITRF), the principal space geodetic systems contained in TIGO, namely

- a 6m VLBI antenna
- a 50cm aperure SLR telescope
- several GPS receivers

where installed and tested.
Apart from these observing techniques TIGO supports as well the operation of

- a time and frequency laboratory equipped with hydrogen masers and cesium beam frequency standards,
- a PRARE ground station,
- a superconducting gravity meter,
- a broad band seismometer,
- a water vapour radiometer,
- and meteorological sensors.

The selection of the hosting country and the site where TIGO should be set up was based on a trade off between the geodetic requirements with respect to the optimum support of the ITRF and the availability of infrastructure necessary for the operation of the observatory.
After an international invitation to bid for finding hosting countries for TIGO, the application of a consortium in Concepción, Chile was selected, consisting of the following institutions:

- The Universidad de Concepcion,
- the Universidad Catolica de la Santisima Concepcion,
- the Universidad Bio Bio and
- the Instituto Geografico Militar.

The site in Concepción at approximately 36 degree southern latitude offers the optimum conditions to fill in a gap of Fundamental Stations in the southern hemisphere as demonstrated in figure 1.

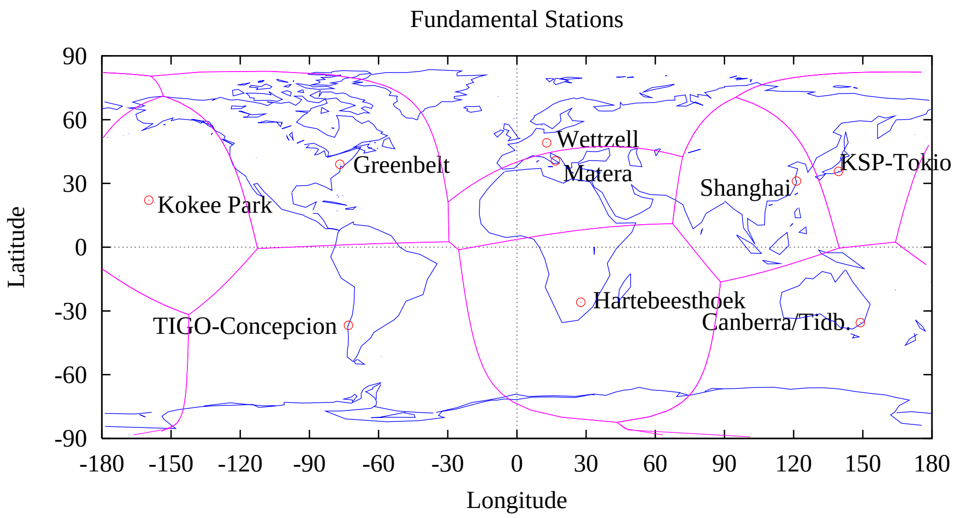

Figure 1: The global distribution of Fundamental Stations after the installation of TIGO in Concepcion, Chile.

2 Preparing the transfer

The purpose of the TIGO operation during it's test phase at Wettzell was to evaluate the principal equipments with respect to their suitability for permanent field operation. Especially the SLR control system was to undergo a complete revision. The primary transputer based control system hardware suffered from temperature problems and was found to be unreliable in operation. The hardware was replaced by a modular setup with a seperate telescope controller and a four channel Pico Event Timer[2] improving the resolution of the system to 1.2 picoseconds. These both main components are steered by a master computer, which handles as well the interface to the laser safety radar, the transmit and receive unit control and the supporting middleware providing range and pointing data. A rough sketch of the new software architecture is shown in figure 2 for illustration.

To improve the daylight and the two colour observation capability, a Photomultiplier (HAMAMATSU HP7422-50) was added to the detector package in the infrared channel. In contrast to the original installed CSPAD, this detector offers approximately equal timing performance at considerable lower dark count level.

Figure 2 gives an indication of the stability of the calibration obtained with the new timing and control system. The blue channel shows a drift of approximately 2ps per hour and a scatter of approximately 10ps rms.

During the collocation campaign the TIGO SLR system was also evaluated in terms of it's two colour ranging capability. Figure2 shows residual histograms

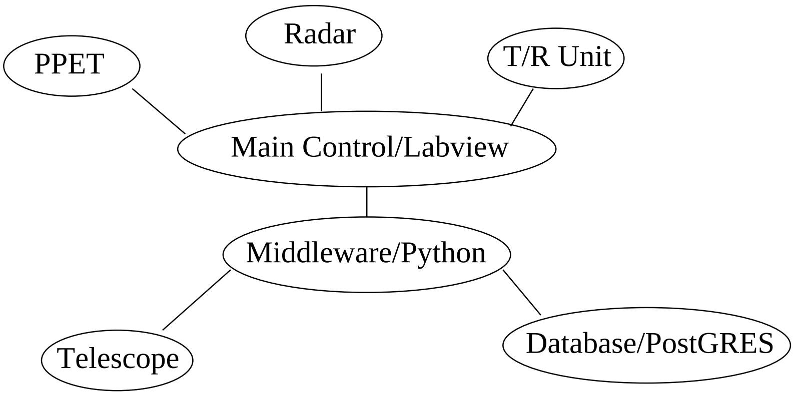

Figure 2: Software architecture of the new SLR control system.

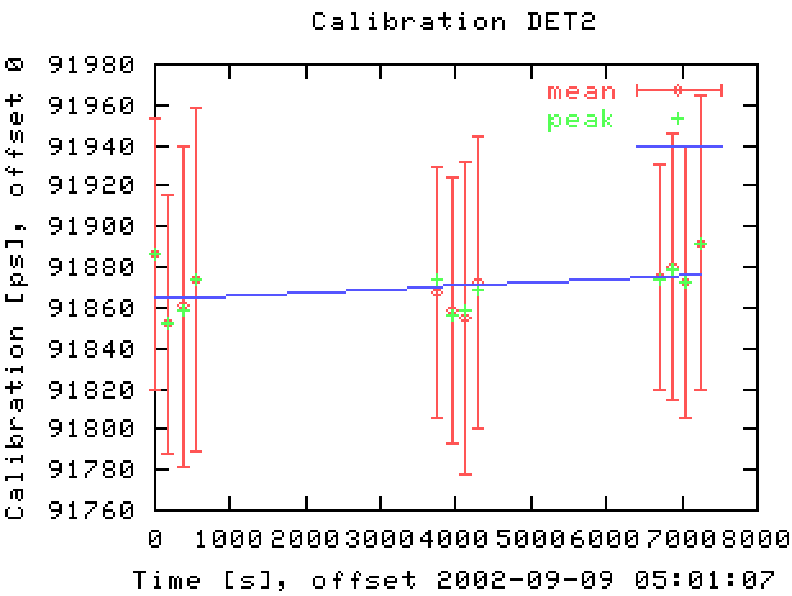

Figure 3: Stability of the calibration in the 423.5nm channel observed over a period of 2 hours. The error bars indicate 2 sigma values of the individual measurements.

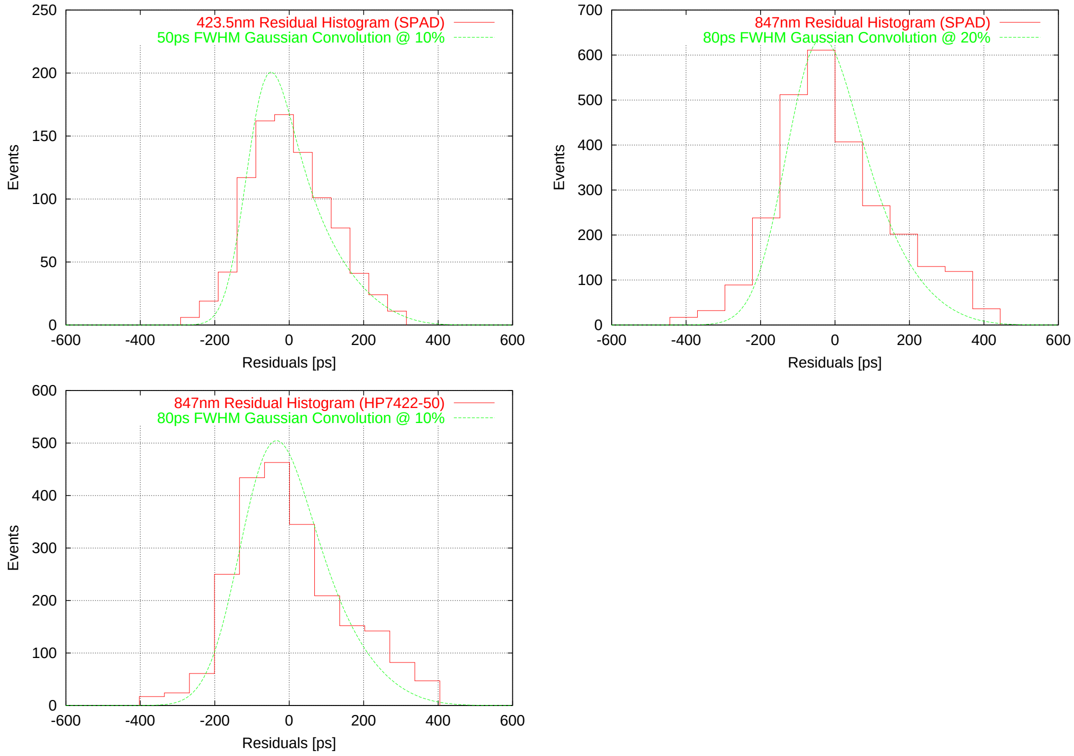

Figure 4: Comparison of measured residual histograms and a model for signatures [3] showing agreement for all three detectrors, two SPAD's for the infrared and blue channel and a photomultiplier (HP-7422) in the infrared channel.

obtained from Lageos-1 measurements. The signatures of the histograms of all three detectors fit well to the model indicated by the green line. The model for the response function was taken from [3] and the indicated distribution was calculated a priori from the satellite parameters, the given laserpulsewidths and return rates.

After a successful calibration campaign, which terminated in September, the system was prepared for the shipment at 27'th of November. Due to the expected environmental conditions and shocks during loading and unloading from the sea vessel, the electronic compartment and the laser were destructed completely and packed tight seprately to avoid any damage during the transport. This effort payed off since the shock recorders, which were installed in the containers and continuously operated during the 2 months of transport, indicated a peak acceleration of 15 G.

3 Setting up TIGO in Concepcion

After the TIGO host platform in Concepción was finished by the end of 2001 (see figure 3), it was ready to conceive the 5 TIGO-containers, which arrived on 13'th of January 2002.

Immediately after locating the containers on their individual fundaments, power supply cables were pulled through the foreseen channels in order to air condition the containers as soon as possible. The next task was to start unpacking the equipment and to do the local survey by means of GPS (see figure 3).

Meanwhile the laser of the SLR system has been reinstalled and after the local survey was finished the VLBI and the SLR telescope was set up. The initial mount modelling procedures gained from the apparently better seeing conditions in comparison to Wettzell. Typical rms values for post fit residuals of the star pointing are at the level of 3 arcseconds only.

Figure 3 shows the SLR telescope during the determination of the system invariant point excentricity with respect to the SLR marker 7405. The support structure mounted to the elevation axis of the SLR telescope serves for the measurement of the excentricity vector. The support structure houses a HeNe laser which is reflected vertically to the floor. The excentricity of the laser spot with respect to the marker is measured by a ruler mounted to the marker at it's origin. By rotating the telescope the laser spot describes an excentric circle with respect to the SLR marker. The north and east excentricity components, x and y from the system invariant point to the marker respectively, are obtained by fitting a model, namely

$$L_i = \sqrt{(R\sin(\alpha_i) - y)^2 + (R\cos(\alpha_i) - x)^2} \qquad (1)$$

to the measurements L_i obtained at various azimuth angles α_i. The excentricity component with respect to height is obatined by levelling to the telescope elevation axis. The excentricity vector of the system invariant point originating at the SLR marker was obtained by this procedure with an accuracy of better

Figure 5: A GPS antenna located over the VLBI system reference point during the local survey.

Figure 6: The support structure mounted at the elevation axis of the SLR telescope serves for the determination of the excentricity vector of the system invariant point with respect to the SLR marker.

Component	value/m	rms/m
North	-0.193	0.0007
East	-0.001	0.0006
Up	1.465	0.0008

Table 1: Excentricity vector from SLR marker 7405 to the system invariant point as obtained from the procedure described in the text.

Eccentricity Vector from 7405 to	dx/m	dy/m	dz/m
7640	-31.940 +-.02	-15.930 +-.02	-1.644

Table 2: Coordinates derived from positions obtained by the first VLBI experiments [4] and the local survey with an accuracy of $0.7e - 3''$ in Latitude, $0.6e - 3''$ in Longitude and 2cm in Height. The coordinates are determined for the epoch 2002.05.14. The sites correspond to the DOMES numbers `14201M200` and `14201S100`.

than one millimeter, as indicated in table 1.

After the results from the local survey and the first VLBI experiments were available the global coordinates of the TIGO-SLR marker and it's system invariant point have been computed (see table 2). The first Lageos-1 pass has been acquired on 17'th of April 2002. The submission of data started in mid of June.

References

[1] Hase et. al.: *TIGO – Transportable Integrated Geodetic Observatory* VI. Congreso Internacional de Ciencias de la Tierra, Santiago de Chile, August 7-11, (2000)

[2] Hamal et. al.: *Contribution of the Pico Event Timer to satellite laser station performance improvement*, Laser Radar Ranging and Atmospheric Lidar Techniques II, Proc. SPIE Vol. 3865, Florence (1999)

[3] R.Neubert:*On the Effects of Data Clipping and Return Energy on SLR NP Data*, http://www.gfz-potsdam.de/pb1/SLR/tiger/signat.htm

[4] L.Petrov: private communication

Figure 7: The TIGO staff at the formal reception. From left to right: Armin Böer, Wolgang Schlüter, Hayo Hase, Jenny Neumann, Eduardo Carvacho, Roberto Aedo, Cesar Guaitiao, Jorge Bustamante, Emma Chaéz, Raul Escobar, Oscar Cifuentes, David Ramirez, Stefan Riepl, Carlos Bustamante and Rodrigo Reeves.

Figure 8: TIGO SLR in operation.