The 2009 Local ties survey at San Fernando Naval Observatory

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1. Introduction

A local ties survey in the San Fernando Naval Observatory (ROA) was carried out during the summer of 2009. A SLR station (SFEL) contributing to ILRS and a Continuous GPS receiver (SFER), contributing to the IGS are collocated at ROA since 1996. Another CGPS receiver (ROAP) was installed a couple of years ago to contribute to the IGS Time Transfer Experiment.

Goals:

- to verify the old values
- to complete the information linking not only these three reference points together but also linking them with other points to allow reviewing in the future.

Disadvantages that comes from the situation of the main points:

- the SLR station (SFEL) is located inside a closed dome at the top of the Observatory main building while the intermediate reference marks are placed at the main terrace (large height gradients).
- to look for the IVP of the SLR telescope is not an easy task due to the reduced dimensions of the SLR telescope dome.

Real Observatorio de San Fernando

3. Instrumentation

Levels, EDM, Theodolites	
Instruments	**Specifications**
NA2 Wild	σ = 0.3 mm/Km. (double run)
Leica TC2002 Total Station	σ_D= 1mm+1ppm (DIN 18723) σ_A= 0.15 mgon (DIN 18723)
Leica TDA 5005 Total Station	
Wild T3 SN134948	σ_A= 0.2"

GPS units.		
Station	**Receiver**	**Antenna**
ROAP	SEPT POLARX2	SEN67157596+CR NONE
SFER, RONE, RONW, TOAL	TRIMBLE NETRS	TRM29659.00 NONE

Local Code	Local & Global / IERS Designation		
SFR	SFER	13402M004	SAN FERNANDO IGS GNSS
ROP	ROAP	13402M006	SAN FERNANDO IGS GNSS
IVP (SFEL)	ROAP	13402M007	SAN FERNANDO SLR IVP
PNE	RONE		SAN FERNANDO PILAR NE
PNW	RONW		SAN FERNANDO PILAR NW
TAL	TOAL		SAN FERNANDO TORREALTA

Naming points table

2. Site Description

San Fernando Observatory is located in the South of Spain near Strait of Gibraltar. The SLR is co-located with two GNSS observation system stations. There are a number of survey monuments and pillars within the observatory which serve as reference marks for the local tie determination. It is from this network of survey marks and pillars that terrestrial measurements have been made to obtain the 3D coordinates, firstly in a local system, later they were transformed to the Global system.

East view of San Fernando survey

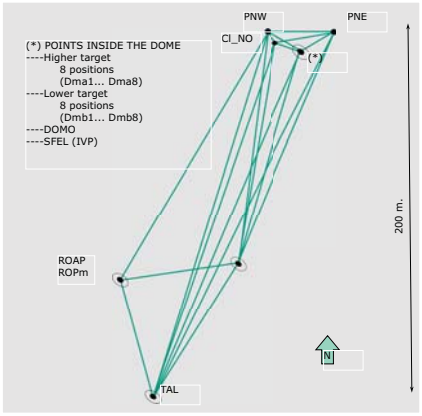
South view of San Fernando survey network.

4. Ground Network and reference points representation

IVP (SFEL): the laser telescope is mounted on the top floor of the central tower that crown the main building of the observatory. The tower structure is independent of the rest of the building. The diameter of the circular plant where it is located is 5 m and it is covered and protected by a swivel metal hemispherical dome. The IVP is the intersection of the azimuth axis with the common perpendicular of azimuth and elevation axis of the San Fernando Satellite Laser Ranging telescope. The elevation axis comes from the knowledge of the height of the IVP from direct levelling observations.

The azimuth axis is materialized by two rotating targets (microprisms) at two different heights well above the SLR.

The determination of the elevation axis was carried out by the next method. They were placed two sheets of paper on both extreme circles, their centres were found (right and left) by different telescope elevation angles using two orthogonal azimuthally positions and finally the heights of these points were measured. The heights obtained from these centers have allowed us to establish that the axis is horizontal (HIVP). The resulting difference between them remains in the order of one to two tenths of a millimetre. Thus, the determination of IVP is the intersection of the azimuthal axis and the horizontal plane HIVP.



SFR (SFER): type GNSS, the antenna is mounted on the end of an iron pole centered in the upper part of the so-called "Meteo tower".

SFER antenna has been intersected from the stations (PNW, PNE and TAL) and, in order to measure the distances from them Retro-tapes Leica 60x60 mm have been attached tangent to the tube. The point SFER (virtual) is still considered to 1.626 m below the bottom of antenna mount.

ROP (ROAP): type GNSS, the antenna is mounted on the top of an iron pipe attached to the west facade of the "time department" building, and it stands out at the level of the terrace. The permanent mark is a eccentric bronze plate, located on the edge of the terrace.

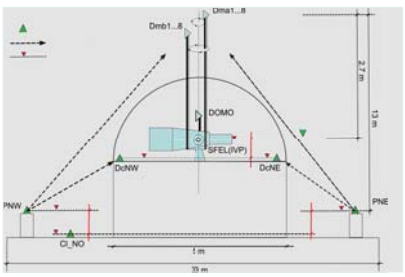
ROAP (antenna) and its eccentric mark on a bronze plate (ROPm) cannot be occupied, therefore, they are obtained by measurements from other points of the network.

PNE (RONE), PNW (RONW), TAL (TOAL): Concrete pillar protruding 1.5 m above ROA main building terrace and the mark consist of three brass centering devices.

ASF: Stainless steel plate with three brass centering devices. The mark refers to the centre of the three centering devices.

5. Observations

The "local network" consists of the so-called "external network" and the "internal network". The second one, for the determination of the station SFEL IVP (ILRS), comprising sequences DMan and DMbn (n = 1, 2, ... ,8) and the altimetric points in the dome.

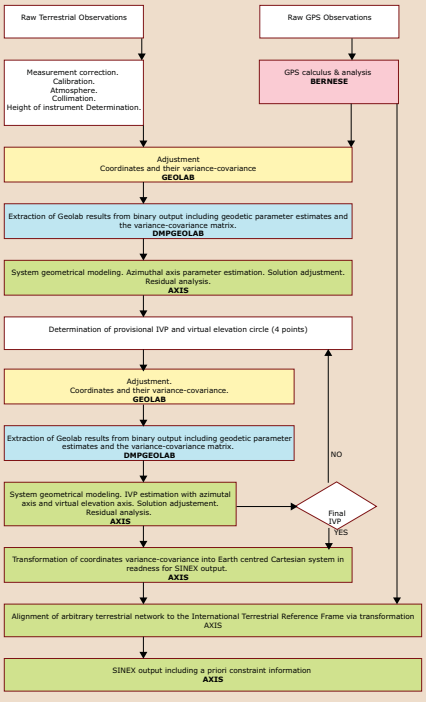


Network Survey
Horizontal and vertical angles were observed as well as slope distances.

Levelling
High precision levelling was conducted among the survey points, using on one hand the elevation angle and slope distances with EDM and on the other hand height differences with Leica precision levels and invar rod. Levelling loops covering all monuments were completed in both directions.

SLR
Two posts fixed to the telescope were deployed on their tops. Coordinates were obtained at eight azimuthal positions of the telescope measuring directions and distances from PNW, PNE and TAL. Thus the radius of the circle described by the lowest prism DMb was ~ 26 mm and the uppest prism DMa was ~ 266 mm.

GPS
GPS survey has been made in order to give results within ITRF geocentric frame and also to align the local system. PNE, PNO, TAL and of course ROAP and SFER IGS stations were observed.



6. Data Analysis

The flow chart of the analysis processes is detailed in the figure on the left. First, classical and GPS raw data were processed and then a geodetic adjustment was made using GEOLAB. Second, the results were used as input of the AXIS 1.0.7 software to get the first azimuthal axis estimation. Third, a provisional IVP was calculated as intersection of this axis and the horizontal plane (HIVP), then a virtual elevation circle was estimated. Fourth, this new data was added and processed again using AXIS to get a quasi final IVP, and we go back to second step to get the IVP and axis values. Finally, rotation and translation of the `geometrically modified` solution onto the required global reference frame was

7. Results

The last process provides the final azimuthal axis parameters and the local ties in ITRF2005. The results were sent to IERS for the new ITRF2008 in SINEX format.The results are summarize below.

Dma target radius	0.2609 m	σ_R=0.1 mm
Dmb target radius	0.0266 m	σ_R=0.1 mm
Azimuth/Deflection	235º 26' 26.3"	

Local Tie	ΔX (m)	ΔY (m)	ΔZ (m)	Distance (m)
OLD	-45.0950	35.2995	89.5475	106.2938
NEW	-45.1017	35.2780	89.5560	106.2966
Precision	0.0017	0.0009	0.0020	0.0027
Difference	-0.0067	0.0215	-0.0085	

References: http://www.iers.org/nn_10900/IERS/EN/Organization/Working
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