FIRST TEST AND APPLICATION OF GPS PERMANENT STATION INSTALLED BY PISA UNIVERSITY

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1. INTRODUCTION

The Seat of Topography and Photogrammetry of the Civil Engineering Department of Pisa University has been long working on the set up and the utilization of a master permanent station located c/o its structures (Fig. 1), whose recorded data have been made officially available since March 2006.
This GPS master is borne as support in scientific and academic activities and could be a reference point for regional GPS permanent net.
This paper shows the architecture of the permanent station as well as the surveys which led to the determination of its global coordinates. An example of exploitation of permanent station data, aimed at monitoring a master GPS located in the proximity of the VIRGO interferometric antenna for gravitational waves (Cascina, Pisa) is also described.

Fig. 1 – Materialisation of GPS permanent station of Pisa.

2. MATERIALISATION AND COORDINATES COMPUTATION IN THE WGS84

The site in which the antenna was to be installed has been chosen as to maximize visibility, keeping clear of surfaces which could cause interference problems due to multiple paths of the incoming signal. The site which best met these requirements was the piezometric tower of the Civil Engineering Department, seat of Hydraulics, which stands about 20 meters above the field plane, higher than any nearby building.
Besides, data have been checked by means of specific softwares to highlight potential electromagnetic disturbances, which could deteriorate the incoming signal. In this case, too, the chosen site's fit was good.

A concrete pillar has been made, integral with the structure, on the tower's roof pavement, as to raise the antenna above the pavement and higher than the protective metal rail.
On top of the pillar, a metal plate has been rigidly fixed and levelled; in its centre, there is a Wild screw on which the antenna is set, its basis flush with the screw head, which is then the reference point in height (Fig. 2).

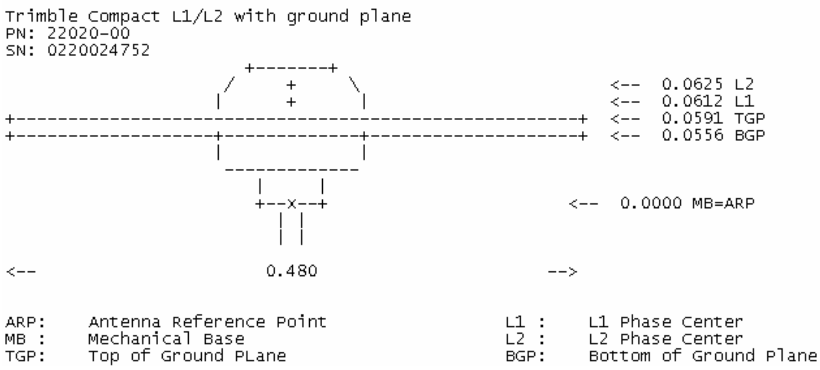

Fig. 2 – Height reference point.

The current hardware configuration of the permanent station includes a Trimble 4000SSI receiver and a Trimble Compact L1/L2 antenna with ground plane on the GPS side, and a desktop station with Internet and phone connectivity for receiver connection and data management. Raw data are stored for post processing by Trimble's TRS (Trimble Reference Station). As the regional network develops, the desktop station will be integrated with a TCP server, which will manage data flow for real-time corrections, in order to forward real-time master data to the centralised data processing server.
Starting March, 2006, raw data (10 seconds) recorde by the permanent station have been made available in rinex format, at the URL http://www2.ing.unipi.it/~o29220/ (fig. 3), managed by the Seat of Topography and Photogrammetry of the Civil Engineering Department.

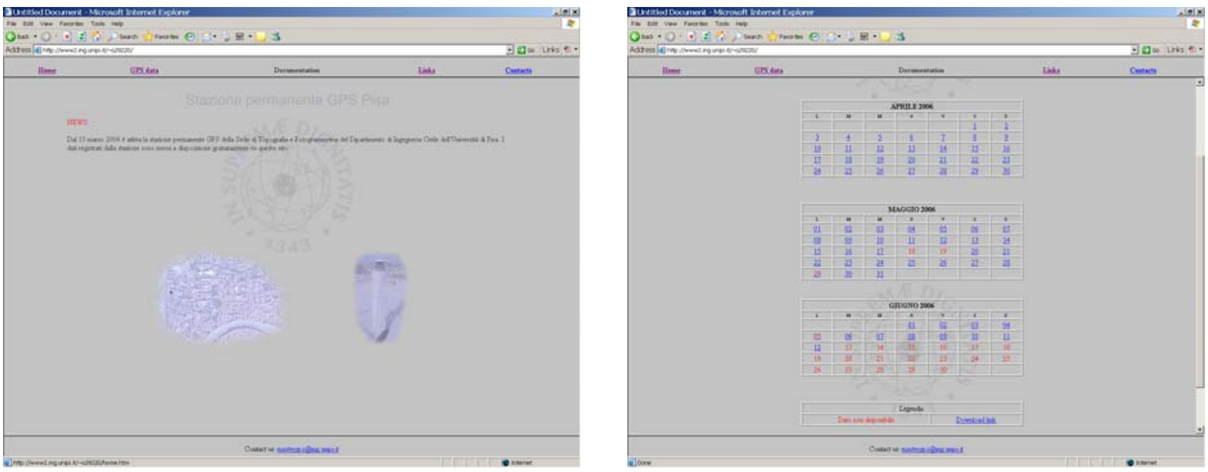

Fig. 3 – WEB site of GPS permanent station.

The coordinates of the master point in the WGS84 reference frame have been computed by means of several surveys, carried out throughout recent years to check time consistency of the structure.

Due to the absence of obvious structural or terrain failures, for the mainly cartographical aims of this permanent station, it is possible to ignore the dynamics of the Earth's crust and to provide a position check every 2-3 years.
The last determination of the global master coordinates has been based on a six points network, including four datum points of the IGM95 network, the Hydraulics tower master and the one located in the proximity of the VIRGO interferometric antenna for gravitational waves (Cascina) (Fig. 4).
Including this last point has allowed for a check of its WGS84 framing computed in the previous years, for an increase of the number of independent concurring bases in the points needed to the framing of the Pisa master, and for the achievement of a protected GPS point, close to the master and with checked stability, by means of which short-period baseline monitoring is possible.
IGM95 points included in the network are as follows:

- IGM 104702 Pontasserchio	43°46'51.471''	10°23'54.519''	60.79m
- IGM 105703 Cascina	43°40'29.524''	10°34'01.239''	62.04m
- IGM 112904 Crespina	43°34'04.218''	10°33'40.642''	160.79m
- IGM 111901 Tirrenia	43°37'32.131''	10°17'45.849''	86.14m

VIRGO's master point is as follows:

- Master VIRGO	43°37'50.645''	10°30'13.911''	60.98m

Surveys have been planned in order to have independent baselines, computed via two-hours observations. Field operations have been carried out by means of two Leica SR530 receivers, three Leica SR520 receivers and three Trimble 4000SSE, each equipped with geodetic antennas.

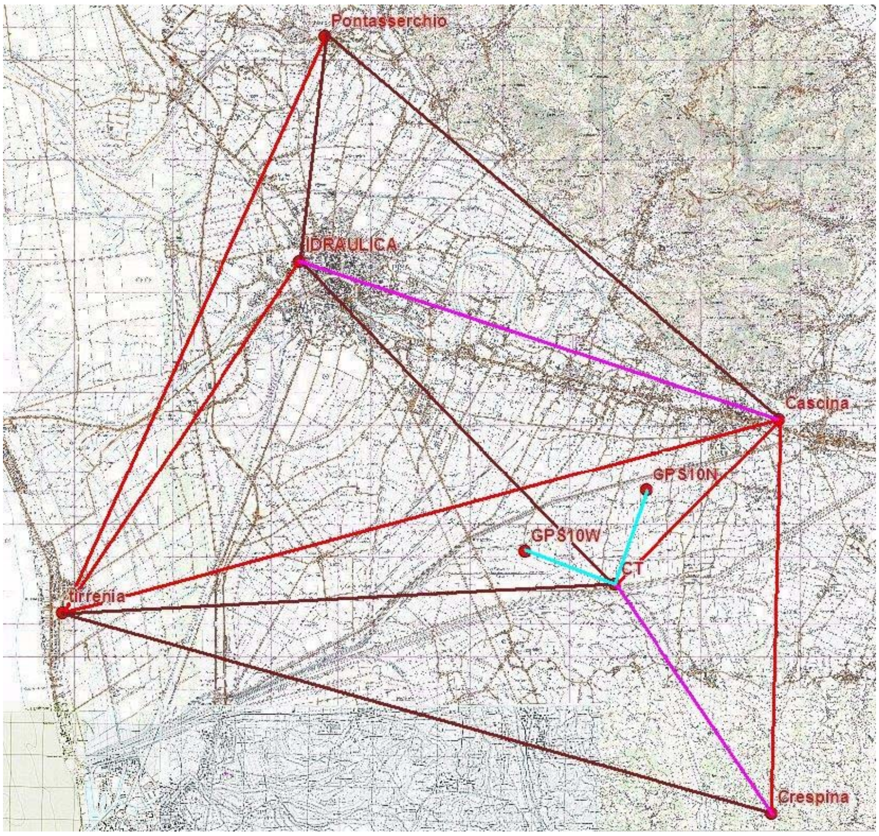

Fig. 4 – GPS net for WGS84 coordinates computation.

The survey results have been satisfactory; during the compensation process, the network has been bound to three of the IGM95 points, namely Tirrenia, Pontasserchio and Cascina (Fig. 5). Single-baseline processing and network compensation have been carried out by means of the Leica SkiPro 2.5 commercial software.

The orthometric height of the point has been computed on a IGM bench mark, combining geometric levelling to the Hydraulics tower's surroundings and trigonometric levelling up to the top of the tower, thus also achieving the geodic undulation datum for the given point.

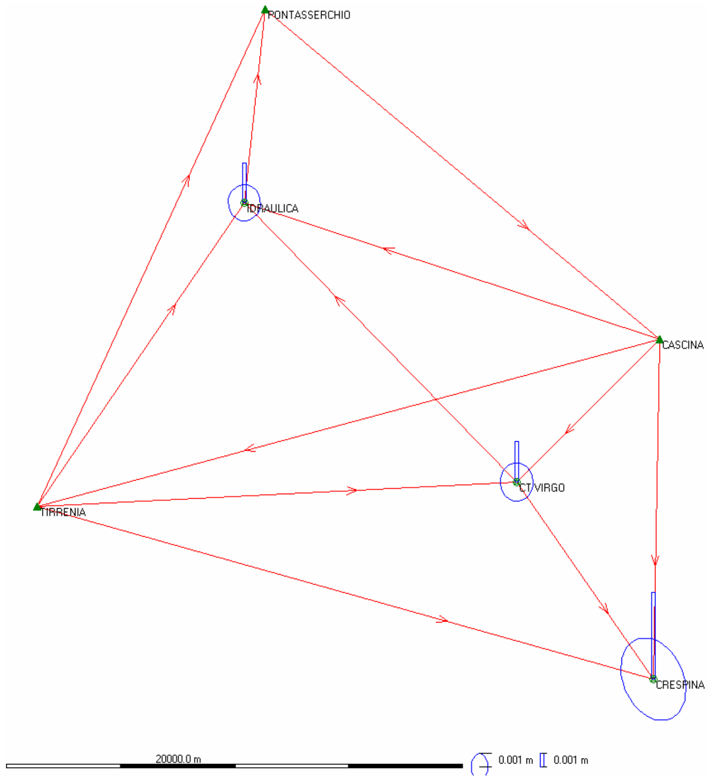

Fig. 5 – Compensation with three IGM fixed points.

Pisa permanent station's coordinates are therefore the following:

WGS84	Gauss Boaga
43° 43' 12.54633" N	4841743.404m N
10° 23' 16.20714" E	1611819.220m E
68.954m	22.558m s.l.m.

As previously outlined, the IGM95 framing of the Pisa master yielded the side effect of checking the previously performed framing of the master located on the roof of the VIRGO complex (Fig. 6).

This master is used by VIRGO's Ing, Paoli, in charge of topographical surveying, to supplement with satellite measurements the periodic check, performed by means of classic instruments, of planoaltimetric movements of the bench marks within the complex.

Fig. 6 – VIRGO master and GPS control points.

The two big vacuum pipes which make for the arms of the VIRGO interferometer have been carried out with their axes lying nominally on two coplanar, mutually orthogonal straight lines.

The geometric configuration needs to be kept within the design tolerance limits, in order to ensure proper functioning of the interferometer. This leads to the need for periodic checking surveys of the position of the pipes by means either of the survey of the position of the structure they lie on, or new surveys of reference points used for the deployments of the modules.

For the kind of foundations used for the tunnels' beams, failures are unavoidable and therefore predictable, so that these surveys' aim is to measure them rather than checking their presence, thus allowing for a timely correction of the modules' position by adjusting the supports. Such procedure has been foreseen by the designers and the supports of the modules are adjustable.

Failure measurements are performed via high precision levelling and total station surveys, stationing on the datum points in the two tunnels, materialised every 15 meters. In order to provide datum points with an absolute reference, and to check measurements, VIRGO engineers have set up a control GPS point network, positioned along the axes at a nominal distance of 300 meters, as close as possible to foundation beams (Fig. 7).

The forecast of a future continuous monitoring of the VIRGO master – Hydraulics tower master baseline will single out possible changes of the reference coordinates, which could affect the measurements of the relative shifts between the master point of the complex and the datum points in the tunnels.

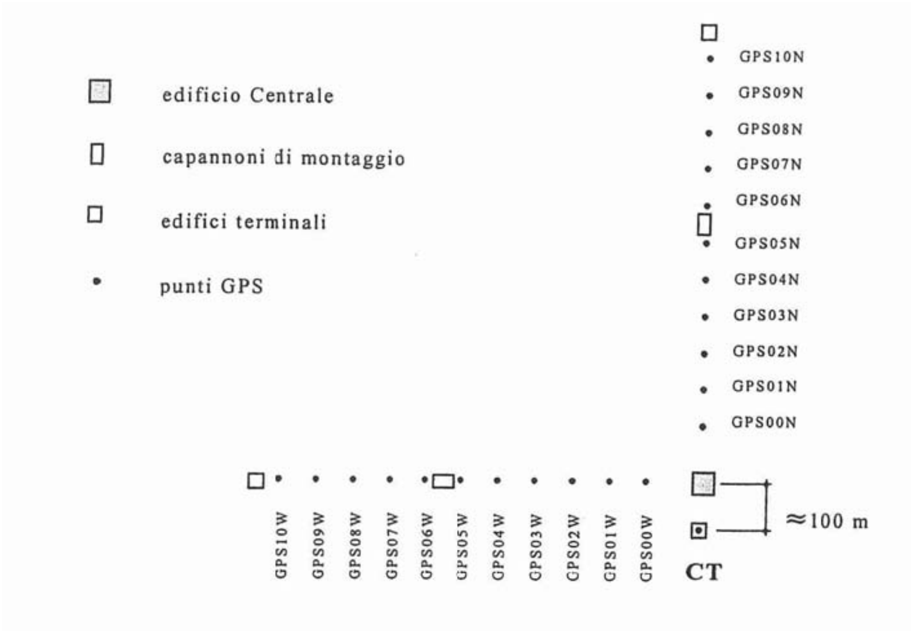

Fig. 7 – GPS control points position in the two tunnels.

3. CONCLUSIONS

Setting up the permanent station c/o the Pisa University is crucial both for the immediate effects on the utilisation by GPS operators in Western Tuscany, and for scientific achievements as both a single station and a node of the regional network.
In particular, to check the fitness of the network configuration, tests will be carried out by means of well-established technologies, such as GSM and GPRS.
Subsequently, new technologies such as WI-FI and WI-MAX, available for Internet connectivity, will be tested for precision and latency.
High precision satellite positioning techniques will be exploited for the collection of laser scanning data and the achievement of 3-D models and Geographical Information Systems.
The MMS VINCI'S vehicle will then be exploited for the survey of road geometry, for safety checks of road routes and the generation of geographical databases for road cadastre.

REFERENCES

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