Georeferentiation of the vertexes of a monitoring network trough Differential GPS Real Time Kinematic.

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BIOGRAPHY

Mauro Caprioli is Full Professor in "Topography and Cartography" (ICAR-06) at the Department of Roads and Transportation of the Polytechnic of Bari, in which he is also Responsible for the "Topography and Cartography" Laboratory. He is responsible of conventions of research with public agencies (ASI) and private companies in the field of the land survey also by means of GPS (Global Position System), of Photogrammetry and Remote Sensing aimed to the production of Cartography and GIS projects, of special surveys for environment and territory. He is advisor of Public Administrations for the provision of Standards and Norms in the field of Digital Cartography and Geographic Information Systems, the execution of Cartography and Civil Engineering Great Works' tests and controls. The scientific activity, testified from over 100 publications on national and international conferences and journals, has essentially been turned to the sectors: deformations control and monitoring, geodetic and navigational GPS, geodesy, treatment of the observations, applied photogrammetry, cartography, GIS and remote sensing.

Gianpiero Strisciuglio is a Ph Doctor in "Topography and Cartography" (ICAR-06) at the Department of Roads and Transportation of the Polytechnic of Bari. The scientific activity has essentially been turned to the sectors: deformations control and monitoring, geodetic and navigational GPS, treatment of the observations.

INTRODUCTION

This paper describes some experiments carried out by the Geomatics Laboratory of the Department of Roads and Transportation of the Polytechnic of Bari, finalized to the use of GPS techniques in Differential Real Time Kinematic and in Differential Fast Static, for the determination of 3D coordinates of points belonging to a monitoring network. The aim of the network is to verify the ground water level of subsoil.

The network has been realized in Apulia Region (South East Italy) in the Provinces of Brindisi, Lecce and Taranto in order to monitor the ground water level, because this territory is geographically placed between the Ionian and the Adriatic Seas. This level could be compromise by water infiltrations of the sea (salted water). Therefore it is necessary to determine, with high accuracy, the ground water level in order to make comparison with mean sea level.

EXPERIMENTAL TEST

The network is formed by 9 vertexes (Figure n.1).

Figure n.1

They are constituted by 1 sink each, located in different Municipalities: Oria, S. Isidoro, Nardò (Villaggio Resta), Vernole, Pulsano, Borgagne,

Otranto, Miggiano and Salve They are protected by inspectable sentry-boxes, placed on a concrete base.

The aim of GPS survey is to define the ellipsoidic and then hortometric height (respect the mean sea level) of the roof of each sentry-box (Figure n.2), just because the difference of height (constant for each vertex) between "wellhead" and roof is already know.

Figure n.2

In fact, being H_1 the distance of the antenna of GPS receiver from the base in concrete, H_2 the distance of "wellhead" from the base in concrete and H_3 the distance of the antenna of the receiver from the "wellhead", the determination of the height of the point occupied by the GPS antenna allows to calculate all the values and, particularly, the height of the "wellhead" (Figure n.3). In this way, every measure of the groundwater level carried out by the technical personal during the periodic monitoring can be quickly reported to the height reference surface, the "geoid".

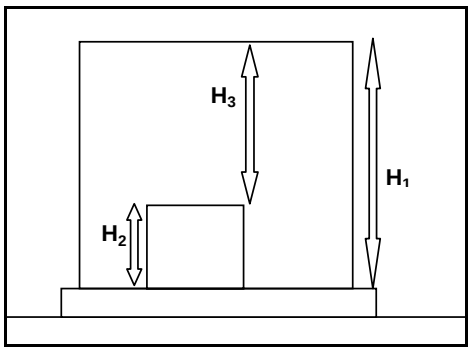

Figure n.3

The first technique employed it has been the Differential Real Time Kinematic. The GPS receiver has been connected with TIM GeoData permanent GPS station of Brindisi through a GSM modem directly connected to the receiver equipped with a business Telecom Italia Mobile SIM card for data transmission (Figure n.4).

GeoTIM Network is constituted by 23 certified permanent GPS stations, uniformly distributed on the whole national territory and inserted in the Italian GPS Reference Network IGM '95. In Apulia region there are the stations of Foggia, Bari and Brindisi. A telephone number of radio mobile network (335 8820 YYY) is associated to each of the 23 permanent GPS stations. In this way, while you are effecting the survey with the GPS rover, you have to start the call in data transmission, through GSM modem. VAS (TIM Service Centre) establishes the virtual connection with the selected permanent GPS station, allowing this last to transmit a flow of D-GPS corrections. The flow of correction D-GPS is transmitted using the standard protocol RTCM. This signal is elaborated in real time from the receiver's software, involving the measurements precision.

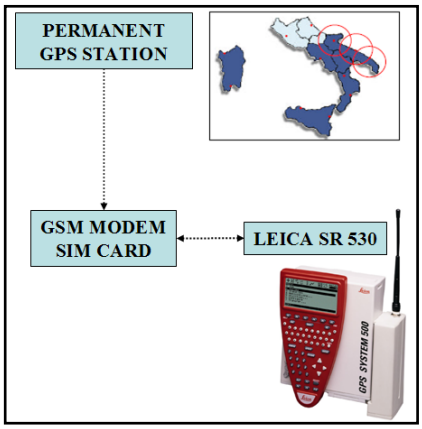

Figure n.4

The vertexes distance from the permanent GPS-Station of Brindisi it is in average about 40÷50 km and oscillates between the minimal value of 23 km (Oria) and the maximum rating of 90 km (Salve). At the moment of the survey there were not available any other permanent GPS station in that zone.

In table n.1 the are the results of D-GPS Real Time Kinematic survey, with particular attention for the ellipsoidic height obtained in this way.

	PUNTO	DISTANZA DA BRINDISI-TIM [km]	h RTK ellips [m]	DEV STANDARD h RTK [m]
1	oria	23,875	170,20	0,051
2	s isidoro	42,467	89,58	0,257
3	vill resta	46,858	67,05	0,204
4	vernole br	48,494	74,77	0,240
5	pulsano	52,623	79,67	0,243
6	borgagne br	57,343	52,05	0,238
7	otranto br	63,710	59,82	0,245
8	miggiano br	79,793	144,16	0,303
9	salve br	90,350	205,57	0,366

Tab n.1

In figure n. 5 there is a graphical representation of the standard deviation of the ellipsoidic height obtained in D-GPS Real Time Kinematic survey in function of the distance of each vertex to the permanent GPS station of Brindisi. The "influence" zone of this station is about 40÷50 km. In fact, in Oria vertex, the standard deviation value is less than 10 cm, while when we exceed this distance (starting from S. Isidoro vertex) it increases quickly, becoming about 40÷50 cm.

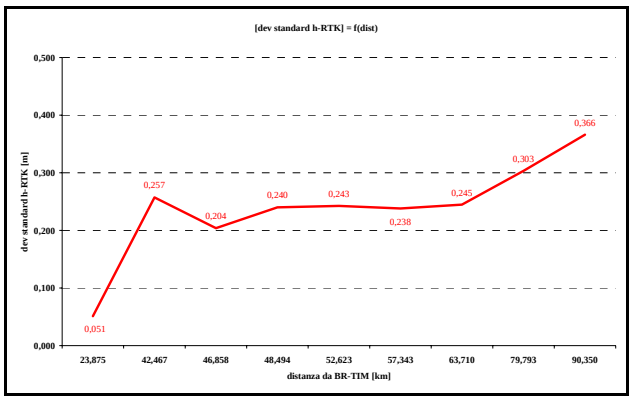

Figure n.5

The second technique of survey it has been the Differential Fast-Static Survey (Figure n.6). Every vertex has been occupied for a short time (about ten minutes) in order to obtain an observation in post-processing.

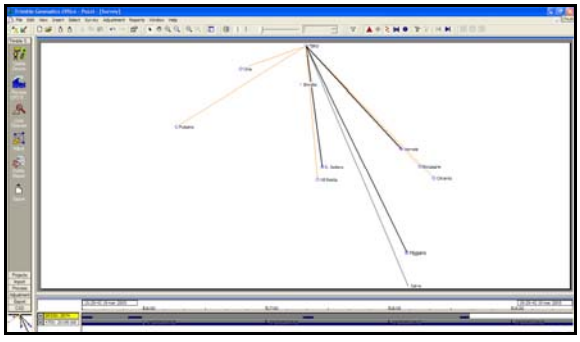

Figure n.6

In the post-processing phase, corresponding GPS data related to the permanent GPS-station of Brindisi, downloaded from the web, have been added to the surveyed data. In this way it has been possible to lead the phase of "Processing GPS Baselines" and to determine the differential corrections. The files are available in RINEX standard format and are related to an hour of survey (rate 10 sec). The treatment of data in laboratory has been carried out using Leica SKI-PRO and TGO software.

In table n.2 the are the results of Differential Fast Static survey, with particular attention for the ellipsoidic height obtained in this way.

	PUNTO	DISTANZA DA BRINDISI-TIM [km]	h STAT ellips [m]	VERT PRECISION h STAT [m]
1	oria	23,875	170,26	0,033
2	s isidoro	42,467	89,65	0,010
3	vill resta	46,858	67,13	0,020
4	vernole br	48,494	74,85	0,011
5	pulsano	52,623	79,75	0,026
6	borgagne br	57,343	52,14	0,034
7	otranto br	63,710	59,91	0,023
8	miggiano br	79,793	144,27	0,130
9	salve br	90,350	205,68	0,487

Tab n.2

In figure n. 7 there is a graphical representation of the vertical precision of the ellipsoidic height obtained in Differential Fast Static survey in function of the distance of each vertex to the permanent GPS-station of Brindisi. The vertical precision value is about 1÷3 cm from Oria vertex to Otranto vertex (distance of 64 km), while it becomes 13 cm in Miggiano vertex (distance of 80 km) and 48 cm in Salve vertex.

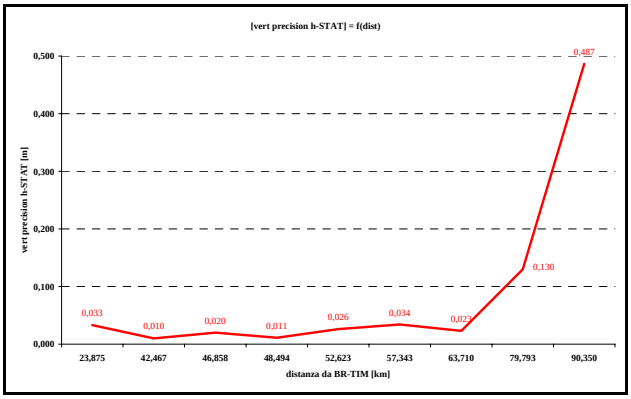

Figure n.7

CONCLUSIONS

The complex of the performed operations has allowed the comparison, in post-processing phase, between the 3D output data in the two different techniques. Both are characterized by short times survey and by centimetric accuracy apt to the aim of this survey and, therefore, to the monitoring activities of this network.

In data comparison, greater attention it has been dedicated to the determination of the height coordinate.

At the end of the post processing phase, the ellipsoidic height coordinate, available in GPS data, has been obviously transformed into hortometric height by employing a dedicated software (IGM VERTO 2.0, by Italian Military Geographic Institute).

In table n.3 the are the results of both techniques of survey. In the last column there is the numerical comparison of ellipsoidic height values. It oscillates between the minimal value of 5,4 cm in Oria vertex and the maximum one of 11,4 cm in Salve vertex.

	PUNTO	DISTANZA DA BRINDISI-TIM [km]	h RTK ellips [m]	h STAT ellips [m]	Δ [m]
1	**oria**	23,875	170,20	170,26	0,054
2	**s isidoro**	42,467	89,58	89,65	0,072
3	**vill resta**	46,858	67,05	67,13	0,079
4	**vernole br**	48,494	74,77	74,85	0,084
5	**pulsano**	52,623	79,67	79,75	0,081
6	**borgagne br**	57,343	52,05	52,14	0,089
7	**otranto br**	63,710	59,82	59,91	0,095
8	**miggiano br**	79,793	144,16	144,27	0,102
9	**salve br**	90,350	205,57	205,68	0,114

Tab n.3

In figure n. 8 there is a graphical representation of the difference between the two values of the ellipsoidic height, obtained in Differential Fast Static and in D-GPS Real Time Kinematic surveys in function of the distance of each vertex to the permanent GPS station of Brindisi.

The values of the difference obtained in correspondence of the height coordinate of every vertex are small and such to justify the use of the Differential Real Time Kinematic technique compared with the Differential Fast-Static one, expecially when the vertex is placed in the influence zone of the permanent GPS station (less than 40÷50 km).

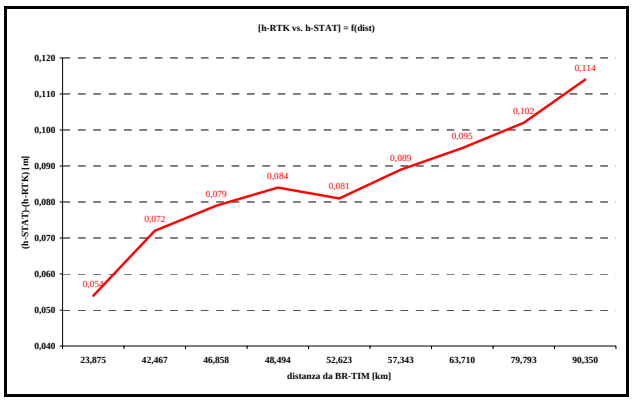

Figure n.8

The comparison has put in evidence the usefullness of GPS in Differential RTK technique for surveying operations having these characteristics, although they are mostly addressed to the determination of the height coordinate.

The necessity to get positioning in the most precise way and in the briefest time assumes great importance both in the navigational field and in the geodetic surveys. The D-GPS Real Time Kinematic system is really the most suitable tool to meet such expectations. In fact, this technique join together both short times of survey operations and centimetric accuracy, near to Fast Static one.

REFERENCES

M. Gatti, F. Negroni: “Experimental test for territorial and geo-topographical survey with TIM GPS network”- Geomedia, 2003.

G. Lachapelle, A. Pugliano “Posizionamento GPS Network RTK: il metodo Multiref”, Bollettino SIFET n.3, 2002.

M. Caprioli, A. Scognamiglio, G. Strisciuglio, “Experimental test of GPS-RTK measurements with GPS-GSM network by T.I.M. (Telecom Italia Mobile)”, ISPRS – WG VI/3 meeting, Geo-Information for practice, Zagreb, Croatia, 15-18 October 2003.

M. Caprioli, A. Scognamiglio, G. Strisciuglio, “The use of DGPS-RTK measurements through GSM network for GIS Environments”, XXth ISPRS Congress, Istanbul, Turkey, 12-23 July 2004.