THE USE OF DGPS-RTK MEASUREMENTS THROUGH GSM NETWORK FOR GIS ENVIRONMENTS

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Key words: GPS, GSM, DGPS, RTK, geodetic survey, navigation, direct georeferentiation**.**

ABSTRACT

The necessity to get positioning in the most precise way and in the briefest time assumes great importance either in the navigational field or in the geodetic surveys. The GPS system is really the most proper tool to meet such expectations. The purpose of DGPS is, essentially, to transform the absolute positioning of a point (fixed or mobile) in a relative positioning in comparison with another that can be considered fixed and of known coordinates in a determinate reference system. The paper describes some experiments in course at the Polytechnic of Bari on the transmission of D-GPS correction signals in local region by the use of a GSM mobile phone with the Bluetooth wireless connection to the GPS receiver. The rover GPS must be connected to permanent reference station of GPS national network (GeoTIM Network) through the GSM phone, provided of a normal telephone card for data transmission: the correction is directly effected during the survey (RTK) using the standard protocol RTCM. An advantage from the economic point of view, it's the possibility to operate in real time for geodetic surveys only with one "low-cost" receiver, continuously connected to a permanent GPS-station. The results of this experimentation are very useful both to verify the real functionality of the TIM "GeoData" system, and to develope the use of a GPS receiver for GIS data collection with sub-meter accuracy.

1. INTRODUCTION

The technological development of GPS technologies has increased the use of receivers for data collection in Geographic Information Systems (GIS). GPS receivers are conceived to satisfy the needs of GIS applications as well as to survey applications.
At the same time, with second generation sensors, the diffusion of metric and sub-metric satellite data permit better detail and definition of geometric propriety than the past. The acquisition of GCPs (Ground Control Points) by means of GPS-RTK methodology (using Bluetooth wireless connection to receive GSM corrections in real time) allows sub-meter accuracy during the survey. This is necessary to process spatial data with mathematic methods, based on parametric models and not parametric models.
So the necessity to get positioning in the most precise way and in the briefest time assumes great importance either in the navigational field or in the geodetic surveys.
The GPS system is really the most proper tool to meet such expectations.
The present note considers a particular application of GPS, and that is the D-GPS, known also as Differential GPS: the correction is directly effected during the survey (RTK - Real Time Kinematic).
The purpose of DGPS is, essentially, to transform the absolute positioning of a point (fixed or mobile) in a relative positioning in comparison with another that can be considered fixed and of known coordinates in a determinate reference system.
Since the end of 2002 in Italy is operating a TIM Service (Telecom Italia Mobile) called "GeoData". It allows the correction of the topographical measurements using the GeoTIM network (figure n°1), constituted by 34 (23 certified) permanent GPS-stations, uniformly distributed on the whole national territory and inserted in the Italian GPS Reference Network (IGM95).
The corrections, elaborated by the GeoTIM network, for 24 hours a day, are available in RTCM and RINEX data-format.

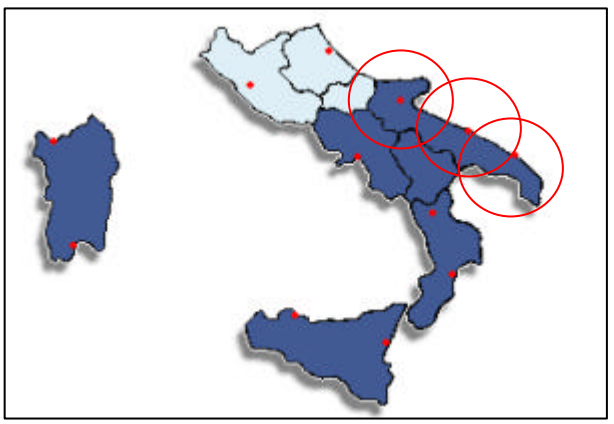

Fig 1. Geo-Data (TIM) Network in South Italy.

They are possible two ways of access to the service. In "post processing", the data corrections are available on the web (figure n°2). After the survey with a GPS mobile receiver, memorizing data on magnetic support, it' s possible to acces to differential corrections on the web. It' s important to specify: the permanent GPS-station, the date and the hours of interest, the cycle-rate desired (1 second , 5 seconds, 15 seconds, 30 seconds), etc.

The data will be furnished in the RINEX standard data format. At this point with the common elaboration softwares on PC, you can operate the processing of the surveying GPS data.

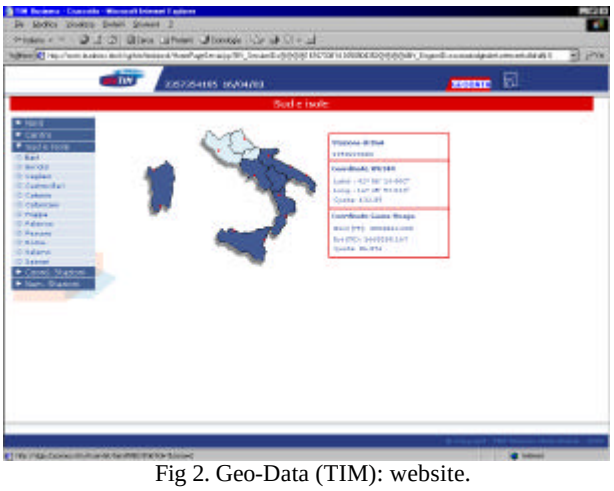

Fig 2. Geo-Data (TIM): website.

In "real time" (DGPS-RTK) the correction is directly effected during the survey. A telephone number of radiomobile 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 mobile GPS, you have to start the call in data transmission, through GSM mobile phone. VAS (TIM Service Center) establishes the virtual connection with the selected permanent GPS-station, allowing this last to transmit a flow of D-GPS corrections. It's used the standard protocol RTCM for data transmission. This signal is elaborated in real time from the receiver's software, envolving the measureaments precision.

2. EXPERIMENTAL TESTS

The receiver adopted as rover has been "Leica GS20 Professional Data Mapper" (figure n° 3). It is a 12- channel L1 code and phase handheld GPS device for professional data mapping with internal antenna. It is a data collector that allows a good integration between GPS and GIS mapping solution.

Fig 3. Leica GS20 and Leica System 500.

The collection of real time sub-meter data is possible with Bluetooth wireless technology. The upgrade of application and receiver firmwares has been realized in the Geomatic Laboratory of the Polytechnic of Bari (figure n°4).
Then, it was estabilished the wireless Bluetooth connection between a mobile phone provided of a SIM card for data transmission.
The use of the wireless Bluetooth system has requested the configuration of a mobile phone (Siemens S55) and above all the upgrading of the GS20 firmwares. The procedure has articulated in two phases: the upgrade of the applications and the upgrade of the receiver.

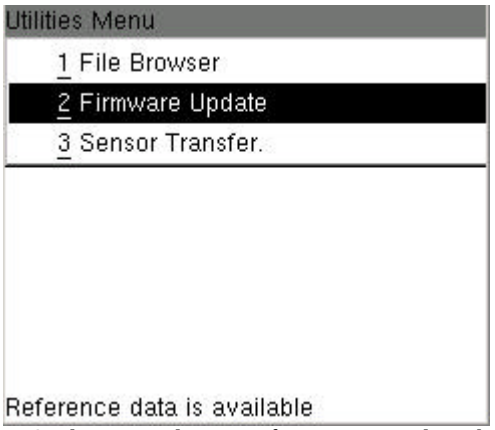

Fig 4. Application and receiver firmware upgrade with the version 1.15.

Firmware updates can only be executed from the compact flash card in the GS20: the files transfer has required more than two hours. The receiver has lost the informations of its initial configuration: it has been necessary to restart the initialization to allow the receiver to adjourn satellites configuration.
The job has been conducted with the geographical coordinates WGS84: the transformation in local coordinates has been effected during the survey.
At each point, it has been started the GSM connection through the call in data transmission to the GeoTIM permanent GPS-station of Bari Modugno (figure n° 5).

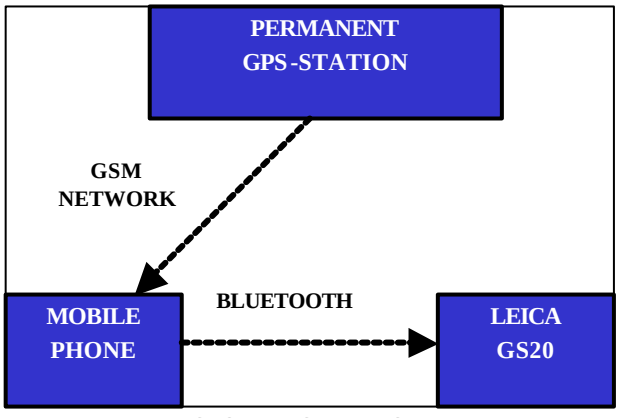

Fig 5. DGPS-RTK GeoTIM System

During GSM connection the corrections are directed from the station to the mobile phone and then to the GPS Leica GS20 receiver through Bluetooth system.

The resolution of the ambiguity effected by the permanent station is very fast.
The following transmissions of the corrections to the rover are not influenced in strong way by the growth of the distance between master and rover.
All the ambiguities have been resolved in very small times with the attainment of the default accuracy of the tool (50 cm or less) after few minutes.
Purpose of the present job it will be to verify the accuracy of use of GSM telephone system in the transmission of corrections from a master to a GPS "low-cost" rover.
The experimental tests will consist in the survey of some "known" points and some Italian GPS Reference Network (IGM 95) vertexes taken with RTK configuration set.
The vertexes IGM95 chosen for the experimental tests, has been: Bari S. Spirito, Palombaio, Palo del Colle, Altamura, Locorotondo; the "known" point is the Polytechnic of Bari permanent GPS-station.
The choice is due to the growth of the vertex distances from permanent GeoTIM GPS-station of Bari (from 7.5 km to 60 km): the purpose it's to verify the possible diluition of precision with the increasing of distance among the receiver and the fixed station.
The tool adopted to transfer GPS raw data has been Leica GIS Data Pro Version 2.1(figure n°6).
This software rapresent a link beetween GPS collected data and Geographic Information System (GIS).

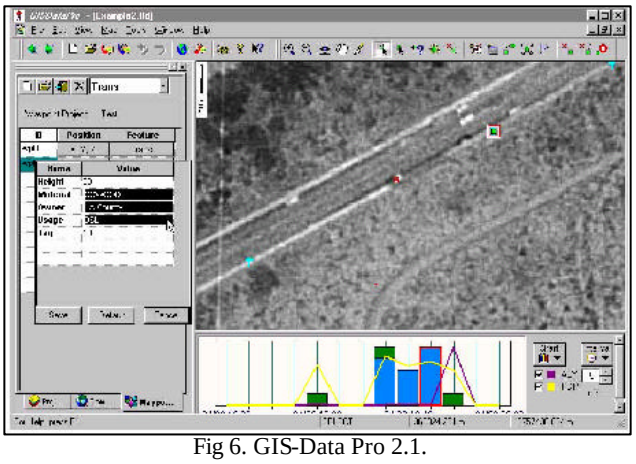

Fig 6. GIS-Data Pro 2.1.

The tool Leica GIS Data Pro software has been used in the phase of data transfer from the GPS receiver (this operation is allowed with a serial cable RS-232 and also in wireless modality).
The software allows the transformation of the coordinates WGS84 into into local coordinate system, opportunely defined or imported.
It's possible to display background files underneath collected GPS data: the imported CAD or ESRI shapefiles can be edited with GIS Data Pro: aside from shapefiles, it can accept data imported from a GIS in different formats.
In the figure n° 6 are displayed the feature browser, the map-view and the GPS summary view: this important characteristics show the attitude of this software to link GPS survey data and GIS informations.

3. CONCLUSIONS

Some results gotten in the surveys are brought in following table n. 1. It is showed the comparison between GS20 PDM data, in DGPS-RTK configuration set, and the known coordinates.

Vertice IGM95	distance [km]	DN [± m]	DE [± m]
PALO DEL COLLE	7,5	0,25	0,04
BARI S. SPIRITO	7,7	0,32	0,05
POLYTECHNIC	9,5	0,40	0,06
PALOMBAIO	14	0,15	0,25
ALTAMURA	36	0,18	0,28
LOCOROTONDO	60	0,53	0,30

Table n.1: Comparison beetween RTK "GS20 PDM" data and known coordinates

The results show the increasing of the differences with the growth of the distance from the permanent GeoTIM GPS-station of Bari Modugno.
The accuracy is sub-metric, coherently with how anticipated in the planning session.
It is possible to hypothesize that the values gotten in this first phase are confirmed by the following survey measurements, for the other different vertexes of the IGM95 Network.
In the following phases of the research, still in course of execution at the Polytechnic of Bari, we propose ourselves to complete the planimetric surveys and also to investigate the orthometric height in all the points.

The wireless Bluetooth system, after the firmware upgrading and the initial configuration, effected in the laboratory, is very simple to use: it is an easy solution for the collection of submeter GPS/GIS data, while during the survey some correlated problem to the use of the batteries is manifested.
The GSM connection to the reference station is fast and it has been maintained during the survey without problems.
The data in the table n°1 have been gotten using the internal GS20 antenna: it has expected that the accuracy of the measures can increase using the external antenna (AT501 – tracks L1 only).
The survey has also been conducted using different kinds of devices [Caprioli et alii,2003].
In the prevoius tests, the same survey has been conducted with LEICA system 500- SR530" (tracks the L1 C/A code and L2 P-code, Wavecom GSM module with business SIM card for data transmission) in order to realize many kinds of data comparison.
The DGPS RTK results brought in table 2 have been gotten with higher accuracy obtained, obviously, with an "high cost" receiver.

Vertice IGM95	distance [km]	DN [± m]	DE [± m]
PALO DEL COLLE	7,5	0,047	0,035
BARI S. SPIRITO	7,7	0,014	0,046
POLYTECHNIC	9,5	0,016	0,041
PALOMBAIO	14	0,014	0,047
ALTAMURA	36	0,005	0,029
LOCOROTONDO	60	0,125	0,048

Table n.2: Comparison beetween RTK "SR530" data and known coordinates

The graph of the figure n. 7 shows the differences among the values of known coordinates and the GPS-Leica SR530 survey data.

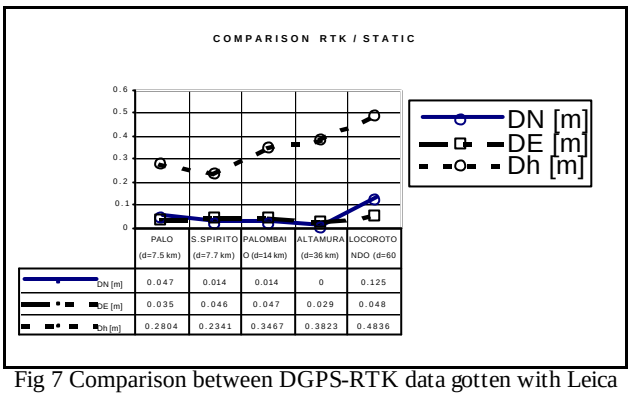

Fig 7 Comparison between DGPS-RTK data gotten with Leica SR530 and known coordinates.

The analysis of the gotten data encourage the development of the experimental tests both to verify the constancy (linearity) of the accuracy at the increasing of distances and to evaluate the altimetric problems.
The results obtained by this experimentation will be very useful to verify the real accuracy of TIM GeoData System, to develope the use of a GPS "low-cost" receiver for GIS data collection with sub-meter accuracy and for certification of the results accuracy by a competent institution, in sight of standards for the verification of the measuraments through GPS.

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