The Use of GPS-RTK Techniques through National GPS-GSM Network

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Key words: GPS, GSM, DGPS, RTK, geodetic survey.

SUMMARY

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 GSM phones.
Some correction systems present in Europe are examined, to payment and not; then we introduce the methodology of the GPS measurement through a connection between a reference station and a rover station with GSM modem.
The tests regard some IGM95 vertexes so that to evaluate the accuracy of this transmission system.
This experience requires that the rover GPS must be connected to the reference station of GPS national network through a GSM modem provided of a normal telephone card for data transmission.

RIASSUNTO

Il lavoro descrive alcune sperimentazioni attualmente in corso al Politecnico di Bari sulla trasmissione delle correzioni differenziali GPS, in ambito locale, attraverso l'utilizzo di telefoni cellulari GSM.
Sono esaminati alcuni sistemi di trasmissione delle correzioni presenti in Europa, a pagamento e non; quindi si introduce la metodologia da adottare nelle misurazioni GPS sfruttando la connessione fra una stazione di riferimento e un ricevitore rover munito di modem GSM.
I test riguardano alcuni vertici della rete nazionale italiana IGM 95, al fine di poter valutare la precisione del sistema di trasmissione.
La sperimentazione richiede che il ricevitore GPS rover sia collegato alla stazione di riferimento della rete nazionale GPS attraverso un modem dotato di una normale scheda telefonica (SIM card) abilitata alla trasmissione di dati.
I risultati attesi da questa sperimentazione saranno molto utili per verificare sia l'effettiva funzionalità del sistema TIM "GeoData", sia per certificare l'accuratezza dei risultati da parte di una Istituzione competente, in vista di una normativa ufficiale nazionale per la verifica delle misure tramite GPS.

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1. INTRODUCTION

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 or RTK (Real Time Kinematic).

There are various fields of application of this methodology:
1. terrestrial, maritime and aerial navigation;
2. location of vehicles in real time;
3 fleets management of commercial vehicles;
4 geodetic surveys;
5 data acquisition for Geographic Information Systems (GIS).

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.
In this way it's possible to reduce the intrinsic errors of GPS system, especially those due to the ionosphere, to the troposphere, to the time delay of the satellites clocks, to the orbits, etc.
They can be separate two different methodologies of D-GPS.
The first, more used in the navigation, consists in giving to the GPS "master" the "true" coordinates (fixed and previously note), and in comparising them to the coordinates calculated in every time of acquisition.
Subsequently the corrections are sent to the "rover" receiver which calculates the correct coordinates of its position; in this case it's not necessary the visibility of the same satellites. Nevertheless, the acquisition from one of the two receivers of a new satellite could produce an accuracy variation.
The second method consists in transmitting to the receiver rover the same data received by the master, in this way it's possible to calculate the "baseline" with the Differential Phase method : the position of the "rover" is the difference among the values measured by the "master" and those directly acquired on the point.
In the second methodology there isn't a variation of accuracy in data acquisition due to a change of satellites configuration.
Another advantage, from the economic point of view, it is the possibility to operate in real time for geodetic surveys with one receiver, continuously connected to a fixed receiver.

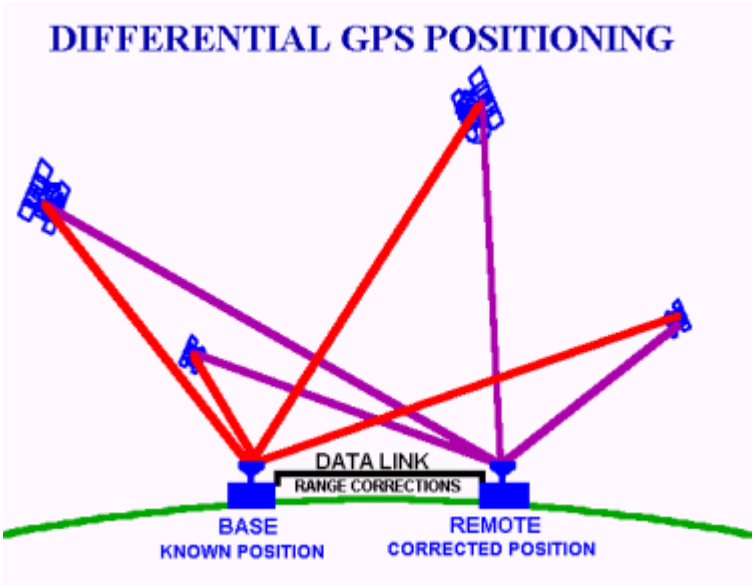

Fig. 1 Differential GPS Positioning

In the last years there was a proliferation of Permanent GPS-Stations: nowadays it's possible to keep data always from different stations in every zone of the territory with distances less than to 100 kms.
It results opportune, therefore, to effect tests "on the field" to verify if this methodology can assure the same accuracies (or at least to verify what) that the system GPS assures for static surveys.
The most important aspect of the technical DGPS is the transmission of the corrections from the master to the rover receiver.
From this point of view, there are some important initiatives in Europe, both in public field and in private one.

In Germany, the SAPOS System (Satellitenpositionierungsdienst) offers four different service areas:

- EPS: broadcasting of DGNSS correction data via audio radio transmitter on UHF/RDS and, in collaboration with Deuche Telekom AG, on LW/RDS. This is for real-time position with an accuracy of 1÷3 m and a cycle rate of 3-5 sec; the user interface is RTCM 2.0;
- HEPS: broadcasting of DGNSS correction data, via the 2m band radio transmitters of the AdV (Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland). In different states, this service will also be additionally provided using GSM mobile telephone. This is for real-time position with an accuracy of 1÷5 cm and a cycle rate of 1 sec; the user interface is RTCM 2.1;
- GPPS: appropriation of original GNSS observation data of reference stations via Internet. This is for a near real-time post-processing with an accuracy less than 1 cm, a cycle rate of 1 sec and the user interface is RINEX 2.0;
- GHPS: appropriation of original GNSS observation data of reference stations via Internet. This is for post-processing with an accuracy of ≤1 cm, a cycle rate of 1 sec and the user interface is RINEX 2.0.

In the last two services the observation data is still mainly provided via mailboxes, which can be addressed with fixed network and radio telephone, or on data carrier.

In Switzerland, the SWIPOS Service offers two positioning service:

- Swipos-NAV: the data corrections from the reference station are turned into a format RDS compatible and, then, transmitted via FM. This service implies that the user has a RDS special decoder that transmits to the GPS mobile receiver: the user interface is RTCM. The accuracy will result dependent from the type of GPS mobile receiver.
- Swipos-GIS/GEO: the correction is in real time with GSM modem. A telephone business number (0900-XXXXXX) is associated to a server that takes data from AGNES network (21 permanent GPS-stations uniformly distributed in Switzerland).

In Italy, it is now present a TIM (Telecom Italia Mobile) Service called "**GeoData**".

It allows the correction of the topographical measurements using the GeoTIM network, constituted by 23 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 formats. The 23 permanent GPS-stations are in the principal Italian towns (Ancona,Bari, Bologna, Milano,Roma,etc.).

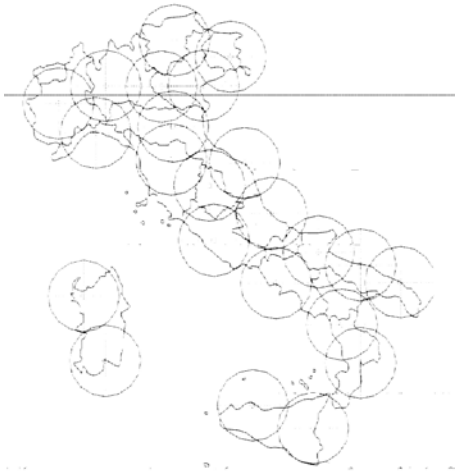

Fig. 2 Geo-Data (TIM) Network in Italy

They are possible two ways of access to the service:
1. Post Processing: the data corrections are available on the Web. After the survey with a GPS mobile receiver, memorizing data on magnetic support, it' s possible to access 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). 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 corrections of the surveying data.

2. Real Time: 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 modem. 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, involving the measurements precision.

2. EXPERIMENTAL TESTS

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 rover.

The system will be composed by following components:

- Master Station: permanent GPS-station in the Polytechnic of Bari (Caprioli 1997). The system is realized with a GPS receiver (Chocke Ring antenna) with GSM modem connected to mobile phone network and to PC, that acquires data in continuous with URS software.
- Rover: GPS receiver LEICA system 500- SR530 (tracks the L1 C/A code and L2 P-code), dual frequency antenna AT502, terminal TR500 to set parameters in the receiver and to steer the GPS, PC Card of 16 MB like data storage medium (it's preferred to the Internal Memory), Wavecom GSM module with business SIM card for data transmission, Satelline 3AS/3ASd Radio modem.

Fig. 3 Leica System 500 - main hardware components

The experimental tests will consist in the survey of some IGM 95 Network vertexes taken with a GPS mobile receiver connected with GSM modem. In this way it's possible to take data corrections in real time from GeoTIM network and to make a comparison with two kinds of post processing data:

- those from the permanent GPS-station of Polythenic of Bari;

- those from GeoTIM network (available on the Web).

Another comparison it is possible with Real Time data acquired with two radio modems: one connected to GPS reference station and one connected to the rover.

The vertexes IGM95 chosen for the experimental tests, has been:

1. 177801 (Bari Dogana)
2. 177701 (Bari S. Spirito)
3. 177901 (Palombaio)
4. 177702 (Palo del Colle)
5. 189701 (Altamura)
6. 178701 (Mola di Bari)
7. 190702 (Locorotondo).

As underlined by the scheme of the figure n. 4, the distances from permanent GPS-station of Polythenic of Bari increase: the purpose it's to verify the possible diluition of precision with the increasing of distance among the two receivers.

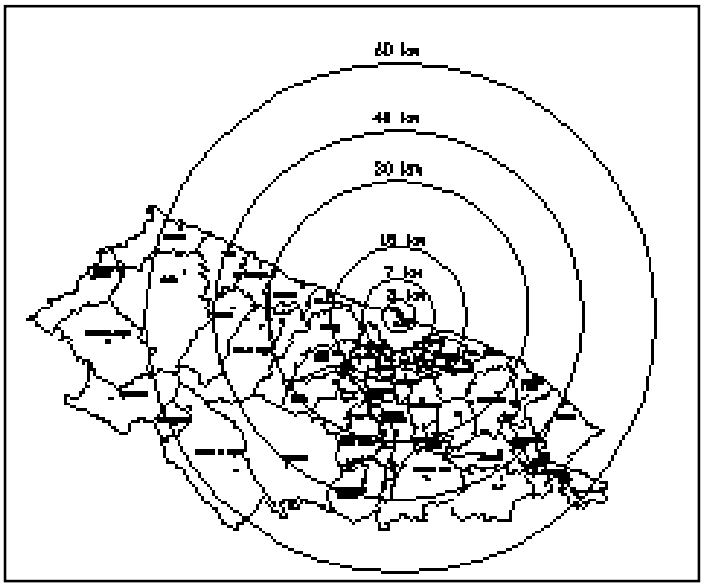

Fig. 4 Vertexes IGM95 chosen

The interval of the distances from the reference station results among ≈4 Kms. (IGM95 177801) and ≈65 Kms (IGM95 190702).

3. CONCLUSIONS

The results obtainable by this experimentation will be very useful both to verify the real accuracy of TIM GeoData System, and for certification of the results accuracy by a competent institution, in sight of national standards for the verification of the measuraments through GPS.

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BIOGRAPHICAL NOTES

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.

From 1997 Mr. Caprioli is President of the Degree Course in Engineering of Infrastructures, Polytechnic of Bari.

Since 1985 coordinator of the researches carried out from the local unit of “Topography and Cartography” of the Polytechnic of Bari.

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.

Advisor of Public Administrations (Regioni, Province, Comuni, etc.) 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.

President of Bari Section of S.I.F.E.T. - Italian Society of Photogrammetry and Topography, of which he is fellow of the National Directive.

Member of A.I.T. - Italian Association of Remote Sensing.

Member of the editorial board of the national scientific review “Bollettino SIFET”.

Reference referee on behalf of the review ”Terra Nova - Blackwell Science”.

The scientific activity, testified from over 70 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.

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