THE ANALYZE OF THE TRANSMISSION POSSIBILITIES OF DIFFERENTIAL DATA CORRECTIONS IN THE GIVEN RADIO INFRASTRUCTURE CONTEXT

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***Abstract**: XXI century means: speed and information. Every decision we take is influenced by the quantity and the quality of the information and the "application" speed of the information. Due to the fact that these factors are influencing many areas, the paper will present only the impact that they have on global positioning systems. The development of GNSS made possible the acquisition of accurate data and allowed the improvement of the position determination speed. This has led to the concept of kinematic measurements and in particular to the RTK mode. In order to obtain high accuracy, this method involves the use of additional information called differential data corrections. Such differential corrections can be obtained by different methods. This paper will present two methods which are used in order to obtain these differential corrections: the Internet and mobile radio transmitters.*

***Keywords:** sensors, GPS, differential data corrections*

1. Introduction

In the last years global positioning technologies and especially those provided by the American NAVSTAR-GPS system and Russian GLONASS system became available in our country. Based on these system have been developed applications in various fields like: navigation (land, sea, river or air), transportation, land measurements (surveying), Geographic Information Systems, Geodynamics, Cartography, tourism etc.

Global positioning systems provide multiple benefits and possibilities that correspond to highest standards demands regarding the navigation. Using such systems the absolute positioning accuracy is about 10 to 15 meters. Most of the time this accuracy is influenced by errors due to the satellite orbit, the satellite and receiver clock errors, errors due to the ionosphere and troposphere. The positioning accuracy may be improved by using relative positioning. This method involves the use of supplementary information called differential data corrections.

As positioning methods based on GNSS navigation are frequently use relative positioning – kinematic (RTK) mode and differential (DGPS) mode.

Taking into account the moment when the results (positioning determination) are obtained, today there are distinguished two types of kinematic positioning: RTK positioning and “post processing” kinematic positioning. The trend is to use methods such RTK, but this solution requires real time data transfer between a fixed receiver (base receiver) and a moving receiver (mobile or rover receiver). The post processing kinematic method is a positioning version where the results are obtained at a certain time after the satellite observations. Differential GPS version may be used if the working area provides signals that contains differential corrections, data that allows kinematic positioning determination with a sufficient accuracy.

The transfer of differential data corrections (DGNSS/RTK) from reference stations network to the users can be done by various ways. The most common are: transfer via radio transmitters, mobile communication systems such as GSM/GPRS/SMS or mobile Internet transmission.

The problem discussed in this paper is how differential corrections data are transmitted from the casters to the users using two ways: radio transmission and mobile Internet transmission.

2. The transmission of differential data corrections

The following part will present two ways of how differential correction are transmitted:

a. Differential data corrections transmitted using radio waves

The most common method of transmitting the differential data corrections is with the help of UHF band and sometimes VHF band with the data bit of 9600 bps. The main advantage of this method is represented by the fact that the radio waves being electromagnetic waves, with the help of radio transmission we can send information on long distances. The frequencies chosen depend on the restriction imposed by the governmental agencies. Especially "the power"restriction is the main subject due to the fact that this restriction has a direct impact to the distances between the rover and transmitter. This distance is a few kilometres between the rover and the radio transmitter.

b. Differential data corrections transmitted using mobile Internet

Due to the available bandwidth of Internet, researchers managed to develop a protocol that allows transmission of differential corrections to GPS receivers via the Internet. This development has started growing, as a result of more and more demands for data transmission over the Internet as the many other problems that radio transmission is "suffering" the transmission of differential corrections through radio signal, the latter, so the signal amplitude and frequency modulation for data transmission is being restricted by government agencies.

Differential data corrections are transmitted to Internet due to the utilization of NTRIP protocol (Network Transport of RTCM via Internet Protocol) which was developed by the Federal Agency for Cartography and Geodesy of Germany. With the help of this protocol there are three classes of objects that are communicating between them:

- GPS station servers that assure differential correction;
- Transmitters that compute differential data corrections and transmitting differential data corrections;
- Users that have access to these differential data corrections

In order to obtain differential data corrections, the client must have an IP address and a password, and in return the caster will transmit the stream of the differential data corrections. The casters are operating in standard model HTTP port 80 and sometimes on port 2101.

At the beginning the data transmitted with the help of the mobile Internet was the GPRS (General Packet Radio Service), and in the following years new ways were developed to transmit the data. These are EDGE (Enhanced Data rates for GSM Evolution), CDMA2000 (also known as IMT Multi-Carrier (IMT-MC) and UMTS (Universal Mobile Telecommunications System) - all of these being the third-generation (3G) mobile telecommunications technologies.

The **GPRS** technology is a technology that transmits data with the help of mobile phone or a modem in a fast and efficient way. The most important characteristics are that the phones that are using GPRS can by permanently connected to the Internet. Transfer rate differs depending on the chosen package, but can reach a speed of 171 kbps with eight access channels at the same time. Lately the development has put increased accent on the EDGE and 3G technologies.

EDGE (Enhanced Data Rates for GSM Evolution) allows access to data, three times faster than GPRS. It works alongside GPRS technology, and is making access to them depending on coverage. One advantage is that it will not show an interruption in the supply of data when moving from an area with EDGE coverage in an area with GPRS coverage and vice versa. Unfortunately, data transmission speed cannot be assured with certainty because the rate is divided between users of the same cell.

3G is the acronym of the "third generation mobile technology". With this technology, you can get a transfer rate up to 3.6 Mbps - which is the network speed. The transfer speed which can be reached up to 2.8 Mbps. Lately developed 3G technology can offer speed up to 21.6 Mbps.

CDMA2000 (also known as IMT Multi-Carrier (IMT-MC)) is a family of 3G mobile technology standards, which use CDMA channel access, to send voice, data, and signalling data between mobile phones and cell sites.

Universal Mobile Telecommunications System (UMTS) is one of the third-generation (3G) mobile telecommunications technologies, which is also being developed into a 4G technology. The first deployment of the UMTS is the release 99 (R99) architecture.

The development of these technologies are trying to obtain higher speeds, but unfortunately, for surveying these three new technologies - 3G, 3G, EDGE - are not offering the desired coverage. It is understood that their development in rural areas was not a priority because of the low demand in these areas.

3. A mobile reference station system prototype

Due to the "coverage" problem of the mobile Internet, there was possible the development of a prototype system in which the radio transmitters and mobile Internet technology are "combined". In countries that are not focus on the transmission of data via Internet, the possibility of accessing the differential corrections becomes increasingly difficult, if not impossible. The transmission problem was solved through software developed by the Federal Agency of Cartography and Geodesy in Germany.

In order to combine these two methods we have to go through following steps:

- will seek an area relatively close to the working place where we have access to the Internet, the distance to be at most the order of kilometres,
- for differential data corrections transmission via radio waves, in first case we will need:

Fig. 1. The equipment used in order to transmit differential data corrections

- a hardware composed by: a dual frequency receiver, a radio modem, a GPRS modem and a user interface,
- a software, specialized software to access the differential corrections and transform them into a format that can be passed down through radio waves. Such software is the GNSS Internet Radio, developed by the Federal Agency for Cartography and Geodesy in Germany.

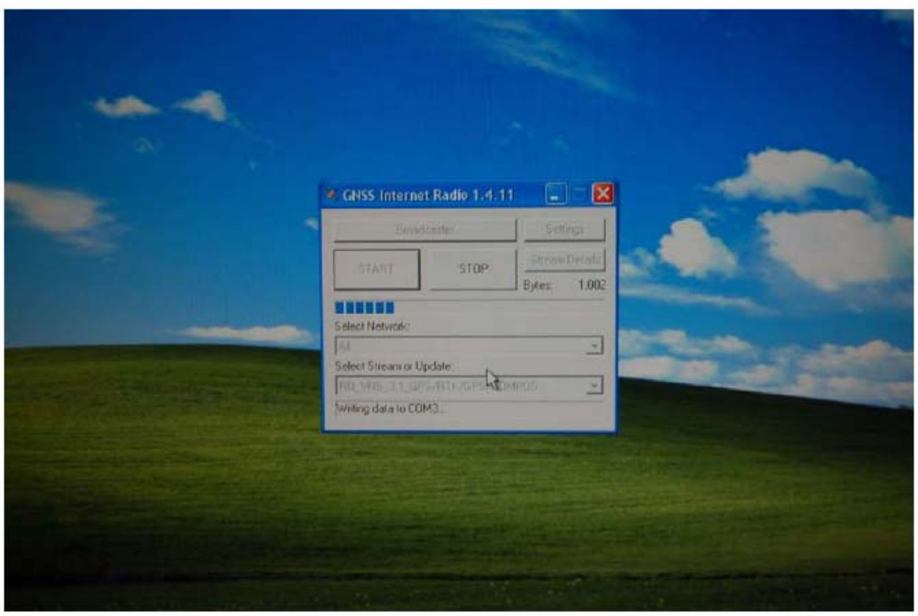

Fig. 2. Differential data transmission

Using GNSS module software, we will use:
- Ntrip Client (Networked Transport of RTCM via Internet Protocol)
- RTCM data transmission by Internet Protocol

Because the work is performed in kinematic method – RTK - this involves a continuous movement. This may cause problems with GPRS signal stability due to inhomogeneous coverage of areas of the GPRS signal transmission relays. The radio signals do not experience such problems, but is recommended to have a special attention to existing barriers and the distance between the radio transmitter and receiver.

This method is possible with devices that allow using the module NTRIP. If it is reaching a distance too large to use the radio transmitter, it will recourse to a second transmitter set to repeater. So the first transmitter will be set only for transmission while the second will receive and then transmit forward differential corrections. If we don't have two radio transmitters, but we have two rovers, one of them can also be set as a repeater with the help of the internal antenna of the rover.

One of the factors that must be taken into account is that this method, in order to be economically efficient, we have to use free radio frequencies.

4. Study case – Measuring an earth road in Halmeu village, Satu Mare county, Romania

This system prototype was tested in an application that regarded the measurement of an earth road in Halmeu village, Satu Mare County in order to carry out topographical plans for road modernisation.

The measurements were made with a Trimble R6 dual frequency receiver. We also used a laptop, a radio transmitter (PLD 450) and a GPRS modem. On the laptop we had installed the GNSS Internet Radio.

At the beginning, we had to examine the possibility of accessing from the site where we were, differential data corrections provided by ROMPOS Romania.

Fig. 3. Covered area

After some tests, we have to go to the location of the interest area. In this moment the receiver will determine a point with a precision of a few meters. This position is to be forwarded to the program.

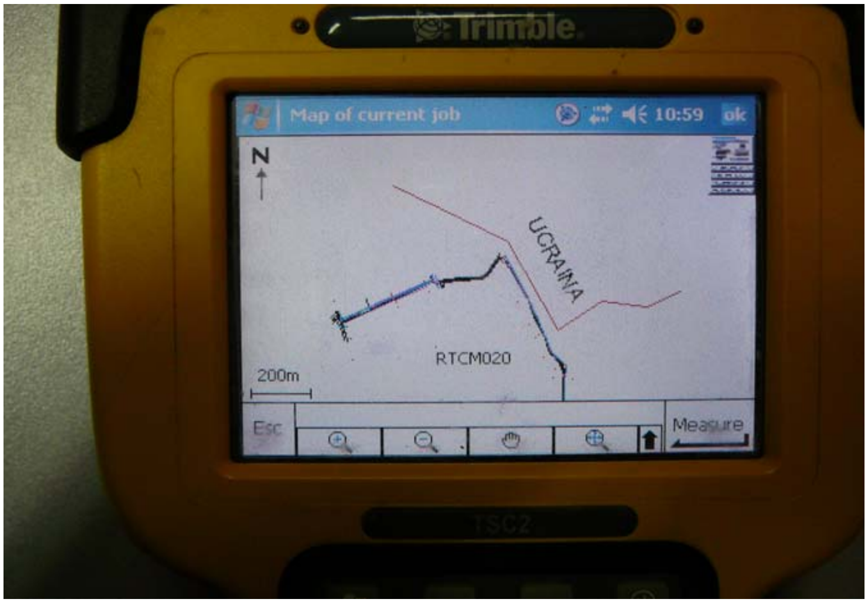

Fig. 4. RTCM position

Taking into account this point we can determine a new position which will be communicated to the program in order to change position. Because of the complexity of the road and distances we created more then one virtual point. Each point was created so that it cover the area as homogeneous possible and not to exceed 2 km.

Fig. 5. Detail of the virtual points created

After we introduce the coordinates of the virtual point, from the list offered by the ROMPOS ROMANIA we chose the transmitting stream correction RTCM 3.0 because:

- Compact and transfer speed;
- Necessity of a bandwidth of 2742 bps/s when the RTCM 2.3 we need 6842 bps/s;

To achieve comparable performance to VRS, these bandwidths are required with an update rate of 1 Hz.

Network format	8 Stations/ 12 satellites	32 Stations/ 12 satellites
VRS RTCM 2.3	6845 bps	6845 bps
VRS RTCM 3.0	2742 bps	2742 bps
SAPOS FKP	6850 bps	6850 bps
RTCM Network Proposal	9961 bps	34712 bps

Fig. 6. Data bandwidth requirements for different network formats

We also could connect direct to a permanent station but we chose the VRS method of obtaining differential correction was chosen for different reason:

- The VRS method allows the correction data stream to by optimized during connection – every second we obtained an update;
- the VRS technique has an advantage that is using the latest model for all error sources;
- is providing additional information on ionospheric and geometric error components in the area near the rover location.

It is necessary to introduced manually the virtual point coordinates because the rover is not using any more a bidirectional link with the ROMPOS server. This bidirectional link is used when we utilize the VRS method using the GPRS connection to transmitted the rover’s position to create the virtual point

Because of the complexity of the road networks and distances that were around 20 km we had to move in different positions with the entire system.

5. Conclusions

Several issues must be considered when choosing the art of communication for the transmission of differential corrections:

- **Technical aspect**: distance and coverage, transmission bandwidth, protocol, trust in the system. More precision offered by RTK method decreases in accuracy if the transmission of differential corrections is the low transfer rate. To obtain values of precision of a few centimetres or millimetres of the transmission of differential corrections must be made in the interval of second or even less. Another issue would be communication dish – the size of the dish must be small enough that it can be integrated into the rover.

- **Economic aspect**: communication costs consist of purchase price of the "senders". If we use such method for obtaining the corrections provided by a national system has to keep account monthly price paid for providing these corrections or direct acquisition of another receiver that will provide differential corrections.

- **Administrative aspects**: bands of radio frequencies may not be used free of restrictions imposed by government agencies. In many countries certain frequencies in the

UHF band can be used free but the transmission of differential correction can be made on distance to several kilometres.

This has led to combining the two methods: using the Internet as the primary method of differential corrections purchase and distribute aid their transmitter radio on a free frequency. The problem created by this method is that the transmission of differential corrections provided by a national system is a way to get anyone with a dual frequency receiver set to the same radio frequency transmitter to obtain these data. To protect them, or rather "sharing" their data not be made without our consent will set different values to "delay" - (delay's) signal to both receiver and radio transmitter.

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