Real Time Monitoring of Cars during European Rally Championships in Poland in 2005

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Abstract

The paper presents the preparations work and experiences gained from realtime GPS car monitoring during the European Rally Championships organized on 10-12 June 2005 in Poland. The developed system is based on GPS and GSM/GPRS technology. Distribution and teletransmission of data are possible using different GSM operators in Poland, which makes the system fully independent. The system's server collects data from rally cars, processing and send data through VPN connections to the SQL server located in main control room. Data can be collected in real time via Internet or GPRS. Some information on GSM/GPRS range during rally championships are also presented in the paper. The study covered many trials and tests of different software and various configurations of the GPRS modems before finally the system started to work. Information coming from 10 Rally Cars were collected to the SQL Server continuously in one second interval. In real time mode these all data were displayed simultaneously in the rally main control room and in the rally press conference room. Paper describes also adopted emergency procedures and remote reconfiguration of GPS/GPRS boxes inside rally cars made during championships. Some problems and method of practical solutions are presented to avoid active jamming dangerous for a driver and his pilot, having system of communication intercoms jammed by teletransmission of GPRS 900/1800 MHz. In cooperation with rally teams special GPS/GPRS safety boxes were designed and made. Monitoring of all 7 rally stages with GPS receivers and method of calibrations of the maps were presented. GSM signal coverage was also checked in all stages. All data transmitted from rally cars were recorded in the computer. Some of our GPS cars had accidents and dispite them information were continuously sent to server. There is possibility to show in post mission mode the position of chosen cars in our rally application. Some information of best rally cars are presented also in the paper.

Keywords: European Rally Championships, GPS, GPRS.

1. Introduction

In the first part of the paper the modern system of teletransmission of data GSM/GPRS for monitoring, satellite positioning and navigation is presented. The system created in University of Warmia and Mazury in Olsztyn is the backbone of the experimental work performed during spring 2005. The GSM/GPRS system was used for transmission of the DGPS/RTK corrections and information of rally cars (such as coordinates, rally ID, velocity and time). First the static GPS positioning trials were examined in detail. However first results were not too much optimistic, but with the help of familiar institutions we managed to make our system working. After successful static trials we put system on a moving vehicle. The RTK technique was used to collect necessary data for efficient and cost-effective generation of precise car positioning. Detailed description of preparation phase as well as experimental work is presented in the paper. Some statistic analyses of different GPS techniques used during car experiment are given. Finally information of best rally cars is presented, followed by the remarks, conclusions and future plans of development of our system.

2. GSM/GPRS System of Data Teletransmission

The project concerning GSM/GPRS transmission was started due to growing need of GPS real-time, precise and reliable applications. Precise navigation, land surveying and vehicle (fleet) monitoring are the subjects where reliable, stable and not expensive wireless connection is essential. Our previous experience gained with classical UHF radio-modems showed very clearly that this type of data teletransmission is not satisfactory in modern positioning/monitoring systems. Especially in urban environment the limitations of radio-modem distribution of DGPS/RTK corrections were very clear. Experiments and practical tests performed by our team showed that the maximum range of the GPS reference station (transmitting with the power of 10 W) reached 10 km in the urban environment. Much shorter range of the station was observed in hilly and wooded areas of the cities. These problems could be overcame and solved by using GPRS transmission. The modern system of GSM/GPRS teletransmission of data for monitoring, satellite positioning and navigation is the project run and coordinated by the Chair of Satellite Geodesy and Navigation, Warmia and Mazury University in Olsztyn, Poland in cooperation with well know Polish companies and institutions, such as: Biatel S.A. in Bialystok, Polkomtel S.A. in Warsaw, Maritime Office in Gdynia and Naval Academy in Gdynia.

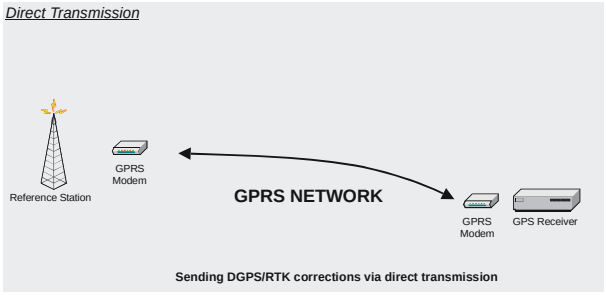

Figure 1. First phase of GPRS project.

In the first phase of the project (P2P connection between GPS reference station and rover GPS receiver) a classical UHF radio-modem wireless connection was simply replaced by the GPRS connection (Fig. 1). This concept was used for the first, initial tests of GPRS teletransmission.
A special, dedicated to our purposes GPRS modem was designed and built in cooperation with Biatel Company. A GPRS modem is compact in size, not heavy and operated by just one switch (Fig. 2). The possibility of remote upgrading the modem's software is essential for the project. After many trials and tests of different software and configurations of the GPRS modem finally the system started to work. First the DGPS corrections in RTCM format were successfully sent. Next modifications to the GPRS modem's software contributed to first fixed solution in RTK mode of surveying. The success of fixed RTK solution (real time kinematic centimeter accuracy measurements) was followed by undeniable limitation of the solution presented in the phase 1 of our project.

Figure 2. Rally GPS-GPRS components designed by Biatel S.A.

In presented P2P solution only one user could use the corrections from the reference station, what of course was unacceptable in modern teletransmission system.
In the second phase of designing of the system a server of corrections was introduced (Fig. 3). The server gathers information from multiple reference stations, manages data and redistributes corrections to multiple users of the network. In this solution there can be practically unlimited number of GPS reference stations as well as users. Distribution of corrections from the reference station to the server and from the server to the user was assured by the GSM/GPRS network.

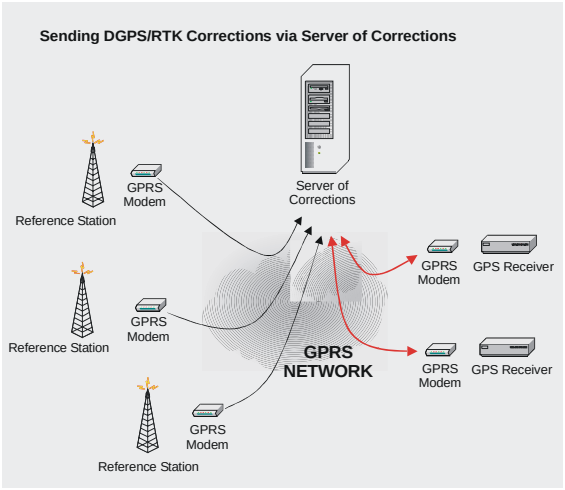

Figure 3. Second phase of GPRS project.

Such a solution gave quite promising results and gave great possibilities of development and introduction new features to the system. The limitation was not the number of the users any more. The problem introduced in this phase of the project was the delay of transmission. The delay of GPRS transmission caused problems in continuous real time solution. Especially RTK method suffered the effect of delay.
In the third phase of the project the server of corrections also called "replicator" was connected to GPS reference stations using secure internet connection (Fig. 4). Such a system built on existing infrastructure significantly improved the speed of transmission making our system more reliable and more accessible for different kind of users.

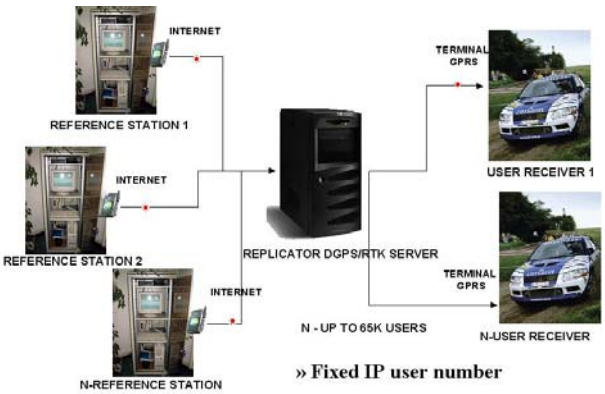

Figure 4. Third (existing) phase of GPRS project.

Created system which is still in the testing phase (Initial Operational Capability Status) consists of a network of GPS reference stations (4 stations at the moment) connected to the system's main server using IPSEC tunnels (Fig. 5). The system's server collects data from all existing GPS reference stations, manages data and distributes data to mobile users in real time.

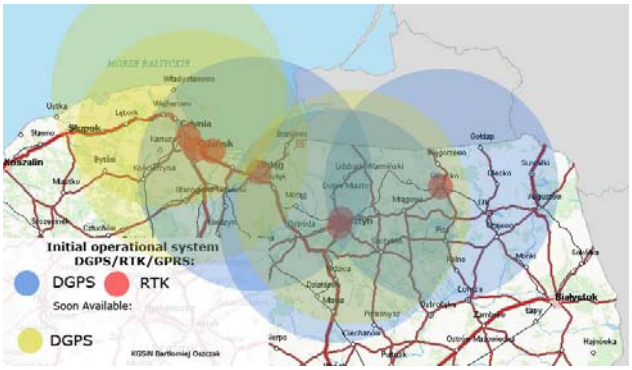

Figure 5. System design and theoretical range of the DGPS/RTK services in North-East Poland.

Distribution of corrections is possible using different GSM operators in Poland, which makes the system fully independent. Each mobile receiver is connected to the main system server via GSM network and has pre-defined primary GPS reference station. In case of failure of primary reference station (ex. internet breakdown), server detects the emergency situation and automatically switches the user to another nearest GPS station. Each GPS reference station can be remotely controlled from anyplace all over the world. The system can significantly increase GPS positioning accuracy even with the cheapest GPS receivers and is fully compatible with all GPS receivers having RTCM option. The only need for a user is the GPRS modem with an activated SIM card dedicated to server application. DGPS/GPRS positioning and navigation can be interesting alternative for European EGNOS as well as American WAAS system. RTK positioning and navigation with GPRS is a good solution in places where there is limited or difficult availability of UHF radio signals because of urban environment or different natural terrain obstructions (such as woods, hills, etc.).

3. Poland Rally Championship

Rally Poland is the second oldest Rally on the World (www.rajdpolski.pl) and also qualifying round to European Rally Championships. It is located in the North-East region of Poland (Fig. 6), 200 km north of Warsaw and 180 km south-east of Gdańsk, not far from the Polish-Russian border and from Kaliningrad district. The region is famous for its history, as well as for unbelievably charming glacial landscapes,a multitude of lakes, including Great Masurian Lakes, and forests covering a large area of it. For the reasons, the Warmia and Mazury region is frequently refered to as a "Land of Thousand Lakes" or the "Green Heaven of Poland". It is also a leisure centre for more than one million domestic and Western tourists every year.

Figure 6. Location of Rally Poland in North-East Poland.

4. System Preparation and Results

Before the experiments on the rally cars, GPS kinematic one-second interval measurements of all 7 rally stages were performed (Fig. 7) and calibration of the maps was made (Fig. 8).

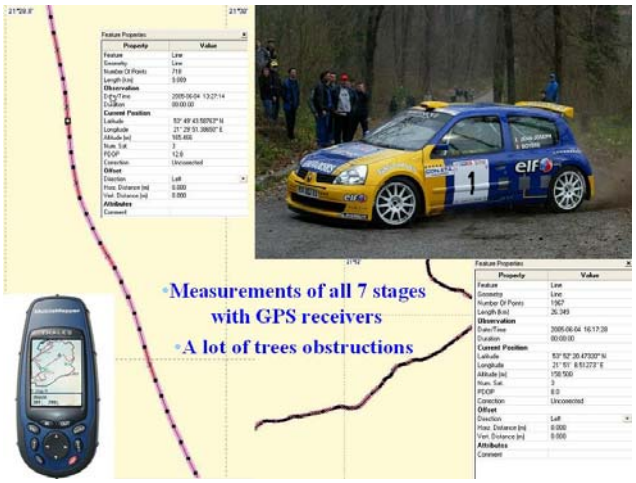

Figure 7. Collecting the data of all 7 rally stages.

At most the time the number of visible satellites didn't exceed 3-5 because of trees obstructions.

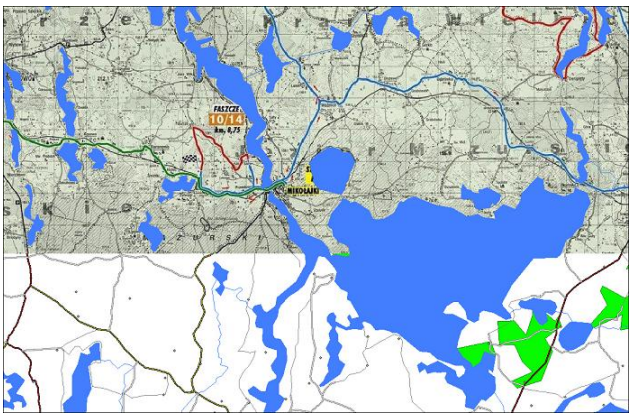

Figure 8. Calibration of two existing maps and 7 rally stages.

During all measurements a coverage of GSM/GPRS signal of three GSM operators existing in Poland was checked. Some of areas, especially unurbanized, didn't have sufficient GSM/GPRS coverage for teletransmission data (Fig. 9). Many GPRS terminals such as mobile phones don't have a self-test connection option which is necessary to be automatically reconnected to the GPRS network in case of lost of GSM signal. This option was implemented by hardware inside our black boxes. We reconfigured GPS+GPRS components with AT modem commands to check every 3 minutes whether GPRS connection was established. In case of lack response from APN (GPRS Access Point Network) GPRS terminal had a task to send enquiry again. In case of silent a terminal GPRS had a task to immediately restart. After consultations with famous polish driver Krzysztof Holowczyc in his garage in city of Olsztyn a special designed GPS boxes were designed and produced (Fig. 10).

Figure 9. Testing GSM/GPRS coverage on all 7 rally stages.

Figure 10. Design and production of GPS boxes.

Serious safety problem was developed during tests with various models of rally intercoms. GSM/GPRS can jam some intercoms and in this case driver and pilot make sick during the noise sounds in their ears. Of course while jamming they're cannot communicate each other. A jam occured every second when GPRS terminal had tried to send informations to the server. The solution for that problem is to check which intercoms are jammed or to use a special designed ferrite throttle, but in both solutions we need a lot of time. At last we have found that only one model of intercom was jammed during the tests of all intercoms of 10 rally drivers (Fig. 11). Finally GPS antennas were gummed into the car's roofs and GPS receivers were screwed down in different places inside the cars e.g. on the back floor behind the seats, under the seats, in the luggage boot. (Fig. 12). Data can be collected in real time via Internet or GPRS. Information coming from 10 Rally Cars were collected to the SQL Server continuously in one second interval. In real time mode these all data were independently displayed simultaneously in the rally main control room and in the rally press conference room located in one of largest Hotel (such as coordinates, rally ID, velocity and time).

Figure 11. Serious safety problem during European Rally Championships with GPRS jamming.

Figure 12. Localisation of GPS components on the cars.

E.g. when in the PRESS ROOM was shown maximum amount speed of chosen car in the same time in the MAIN RALLY CONTROL ROOM stuff could observe general situation of a rally (Fig. 13).

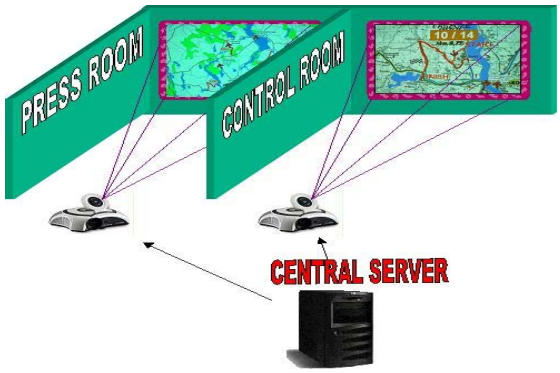

Figure 13. Different screens are displayed simultaneously in the press room and the rally control room.

We used server-based application specially designed for the Rally Poland (Fig. 14). There is possibility to show in post mission mode the position of chosen cars in our rally application. Some of our GPS cars had accidents and dispite them information were continuously sent to server.

Figure 14. Real time GPS monitoring of rally cars during European Rally Championships.

All data transmitted from rally cars were recorded in the computer in SQL base (about 60 Megabites of text informations). Good news was that the rally drivers had synchronized official start times with a GPS time, so a comparisons of results were easily done (Fig. 15). From day one of GPS monitoring there was an emergency situation because the main Internet connection located in Hotel which collected all informations from rally cars through VPN link had broken down in conference rooms. adopted emergency procedures and remote reconfiguration of GPS/GPRS boxes inside rally cars made during championships.

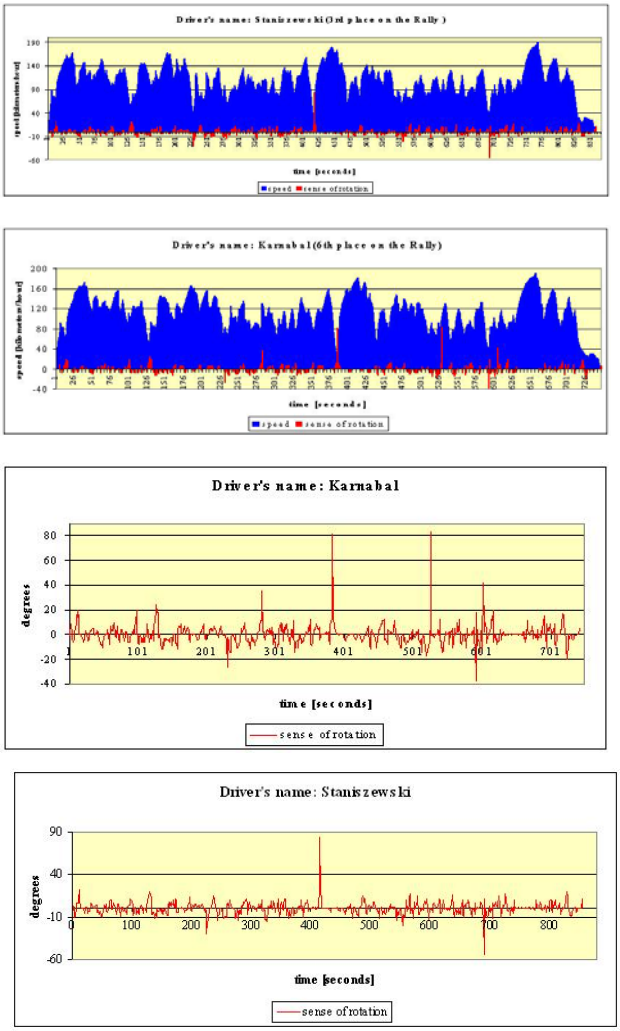

Figure 15. Comparison of two the best rally drivers equipped with GPS components.

5. Conclusion

Presented system has shown that GPRS/GPRS techniques could be adopted for positioning and monitoring of the fast moving objects such as rally cars even in the hilly and wooded areas. It also may be used as a diagnostic tool in the professional training of the rally drivers.

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