MOBILE MAPPING APPLICATIONS BASED ON THE CYPRUS PERMANENT GPS NETWORK

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KEY WORDS: GPS Permanent network, static, kinematic, RTK, mapping applications

ABSTRACT:

This study describes the design and the installation of a pilot permanent GPS network in Cyprus, and evaluates its operation in order to produce the substructure for mobile mapping applications and any other type of relevant applications. The Continuously Reference Stations transmit their data via radio modems or GSM network and also have the capability to communicate with the users via internet browsers. Several applications using all the available information in static, kinematic and autonomous navigation mode are carried out. At first, three groups of applications for mobile mapping are identified and investigated: the first group concerns applications requiring low accuracies (up to 10m), the second group concerns applications requiring medium accuracies (up to 1m), and the final group concerns applications requiring high accuracies (up to a few cm). A detail report about the first experimental results, aspects and conclusions is drawn. Furthermore, the effectiveness of using only GPS code measurements in order to reduce the application costs is also investigated.

1. INTRODUCTION

This paper describes the phase of a research project which aims to design, establish and evaluate the operation of a GPS permanent network in Cyprus which was named Positioning System Improvement (PSI). The PSI network will consist nine dual frequency GPS receivers which will be established to the territory of the Republic of Cyprus, which is not dominated by the Turkish army, and illustrated in figure 1. The purpose of the establishment of each station is to provide single and dual frequency data for relative positioning and also to transmit DGPS and RTK data for real time users. The PSI will have a wide regional coverage where ever cellular phone service is available. As a result the GPS measurements could be used in airborne mapping operations such as aerial photography, LIDAR, remote sensing, bathymetric, boundary and cadastre surveys, topographic surveys, hydrographic surveys, emergency and accident response surveys, construction surveys, machine control and stake-less grading, tracking and navigational, asset inventory – utility location and recovery, mobile mapping–imaging, pavement inventory, precise timing, as well as, deformation studies, atmospheric modeling and seismic monitoring. Several case studies using phase and code GPS data, especially on kinematic mode, are carried out and the evaluation of the results is discussed.

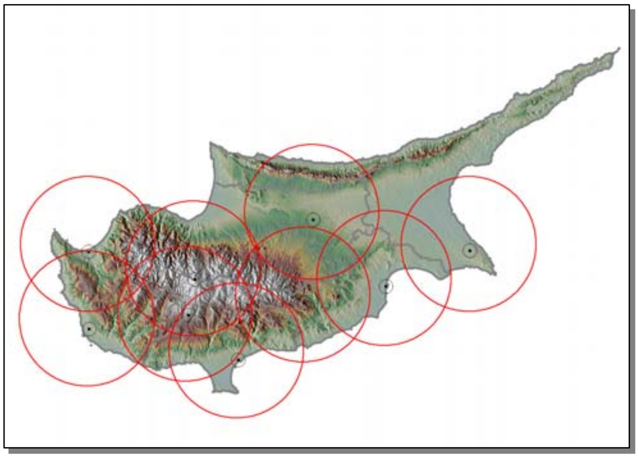

Fig 1. The proposed Cyprus permanent GPS network

2. NETWORK ESTABLISHMENT

The first aim is to ensure the optimum performance of our GPS reference station network. For this reason we address the key factors which are taken into account in selecting a site for our permanent stations. These are:

- GPS Sky Visibility
- Electromagnetic interferences
- GPS Antenna Stability
- Multipath
- Easy access
- Network Geometry
- Electrical Power and Communications for **R**eal **T**ime **K**inematic (RTK) Surveys
- Equipment Protection

The distance between stations must be under 35 Km, while the height could vary from 100 m up to 1900 m.
In addition to the aforementioned key factors, concerning where to place a reference station, some helpful details like,
• Monument construction
• Antenna installation
• Installation ideas
• Water proofing
should be taken into account. Special attention should be given to the radio noise sources and in general the interference which can be assumed as originated from these sources.
As it is known, the strength of the GPS satellite signal is very low, so nearby sources of Electrical or Radio Noise can cause significant problems by interfering with the GPS signals. These types of noise may originate from:

- Electrical transmission lines
- Nearby commercial radio or television broadcast stations
- Radio dispatch stations
- Police, fire & other emergency services
- Taxi services
- Pickup and delivery services.
- Airports

For that reasons several maps which draw the critical sites and the telecommunication network were used for the optimum site selection. A sample figure of signal quality, according to our key features selection, for Pafos permanent station on L_1 frequency is presented below.

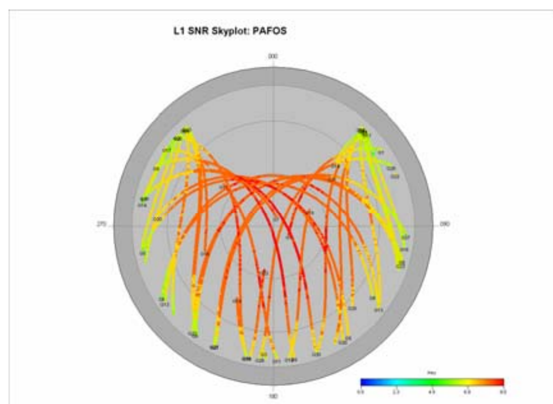

Fig 2. Skyplot of SNR values on L_1 frequency for Pafos GPS station

3. FIELD TESTS

The case studies include several groups on mainly kinematic accuracy requirements, because this mode of operation together with high productivity rates concerns the mobile mapping applications. Kinematic tests were planned at various distances from the permanent stations with main purpose of testing the substructure and accuracy quality. The equipment used in this study was the SR520 and GRX1220 of Leica Geosystems. The initial Stop and Go mode (SGS) test was performed using the GRX1220 geodetic GPS receiver in broader area of the Pafos city. The campaign was scheduled in order to have the maximum GPS visibility. The recording interval was set equal to 5 sec and the occupation time was almost 40 sec (8 epochs). The measured points were processed from the two permanent stations of Pafos and Polis (northwest of Cyprus) in order to test the method effectiveness on various baseline distances. Specifically, the test distance varied from 1 to 21.5 Km.

For every occupied point, we calculated the distance between the point obtained from DGPS and the one from kinematic post-processing (SGS-PP). Also a post processed single point position (SPP) based on C/A code data was estimated and evaluated accordingly. The comparison between obtained positions from phase (fixed) solutions using different permanent station data shows a agreement at the order of 2 cm, value which meets the manufacture's accuracy specification.

Figures 3 and 4 show the achievable 3D positioning error of differential positiong using code data on various distances from the permanent stations.

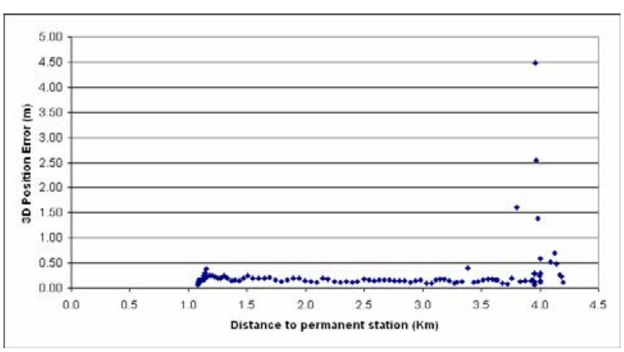

Fig 3. DGPS position error using C/A code data from Pafos station

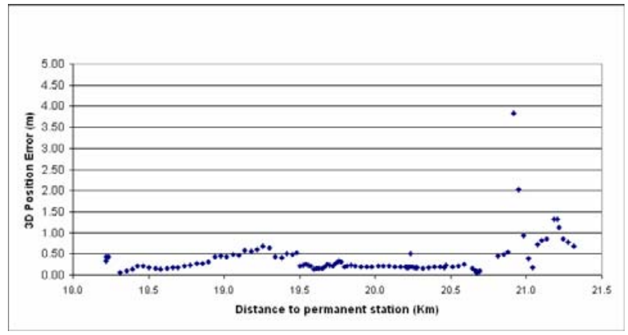

Fig 4. DGPS position error using C/A code data from Polis station

The results confirmed the expected precision for the code differential mode, which was sub-meter. As a mobiler locator, one can use the results for management and observation of moving vehicles. Also, DGPS can be characterized as the best mobile method for map generation (or update) with scale smaller than 1:3000 due to high productivity of collecting the necessary information. No need for initialization, cycle slip fixing and ambiguity resolution and of course the much less installation cost.

As it concerns the SPP and DGPS comparison, we have to point out that the standard deviations of differential GPS are much smaller than that of single GPS. The positioning precision of DGPS is about 5-10 times higher. As an example Figure 5 plots the 3D position error for the occupied points. But, the SPP precision can be found suitable for a GPS campaign which performed in order to update map scale smaller than 1:30000.

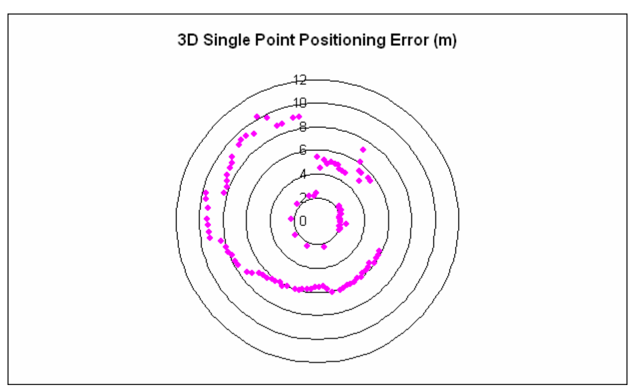

Fig 5. Single point position error using C/A code data

Table 1 shows the results of all the test methods as mentioned above. According to this table more than 70% of the mobile SPP locations keep the error within 5-10 m, and the probability of the location error over 10 m is almost 1%.

Method	Num. of Positio-ning	Position Error <2 m	Position Error <5 m	Position Error 5<10 m	Position Error > 10 m
SPP	110	8 7.3%	22 18.2%	81 73.6%	1 0.9%
DGPS< 5 Km	110	108 98.2%	2 1.8%	--	--
DGPS< 10-25 Km	110	107 97.3%	2 1.8%	1 0.9%	--

Table1. The estimated location error by single and differential GPS positioning

On the contrary, for DGPS positioning the location error remains much less under of 2 m for over 95% and an important criterion of non dependence with baseline length up to 22 Km is shown. This optimum conclusion encouraged us for keeping the distance between stations in each common triangle to be under the 35 Km except for some special cases.

4. CONCLUSIONS

This paper introduced a new permanent GPS network installation study and describes basic test fields used for location and mapping services. This suggests the basic factors which play critical role on selecting and establish a Continuously Operating Reference Stations GPS.

The first tests which applied shown that the positioning precision level obtained for differential GPS, phase fix solutions, RTK and single point positioning is characterized more optimistic than the expected for the capability of each method and using this infrastructure according to the results of table 1.

Several static and RTK tests (via internet) will be applied in the near future in order to evaluate the capability of the network on longer baseline distances using all the proposed permanent stations.

ACKNOWLEDGEMENTS

This research is supported by the Research Promotion Foundation of Cyprus <www.research.org.cy> with the EPYEΞ/0406/02 contract. Specifics about this project are given at the website :
<http://www.geoimaging.com.cy/gps/index.htm>.

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