RELIABLE TECHNIQUEOFGNSS/RTK POSITIONINGUNDER SEVERE OBSERVATIONAL CONDITIONS

M. Bakuła[1)], R. Pelc-Mieczkowska[1), 2)]

[1)] University of Warmia and Mazury in Olsztyn
Chair of Satellite Geodesy and Navigation
str. Heweliusza 5, 10-724 Olsztyn

ABSTRACT

Nowadays GNSS/RTK positioning is a very efficient technique for determination of coordinates especially when it is based on permanent reference stations. It allows every land surveyor to do his work easily and efficiently. However there are some situations when the use of RTK technique makes some difficulties, especially if the GNSS receiver has no full availability for satellites. It is well known that obstructions caused by trees, buildings, power lines etc. limit satellite availability. In those situations gross errors can appear. In order to avoid misleading coordinates occurring we can use more than one receiver. The paper presents practical tests and description of the GNSS/RTK technology based on the simultaneous use of three different GNSS receivers for the specific control points. Three different GNSS/RTK receivers can be placed on a special mounting beam and additionally RTK positions are send in real-time to a computer. The software on the computer analyses not only the precision but also the accuracy of determined RTK positions. In effect that solution can allow obtaining reliable coordinates even if observational GNSS conditions are very severe.

1. INTRODUCTION

Many studies have indicated that accuracy and reliability of GNSS static as well as kinematic measurements are significantly lower under the forest canopy than under unobstructed sky (Hasegawa et al. 2003; Bakuła et al. 2006). Avoiding terrain obstructions on the survey point that have negative influence on solving the ambiguity of phase measurements represents the fundamental condition for obtaining accurate coordinates. The measurement session length is of no lesser importance. Independent of the presence of terrain obstructions, in case of excessively short measurement sessions, even in case of determining the baseline by the fixed method, gross errors of even several metres may appear (Bakuła 2007). The degradation of accuracy under forest conditions is caused by lowering the signal strength and multipath effects while electromagnetic wave is penetrating the stems and canopies. The previous experiments conducted under forest conditions indicated that fixed ambiguity resolution does not guarantee the high accuracy of GNSS measurements results under canopy. What is more, very high precision characterises the results of such measurements and that is why there is no possibility of finding out *a priori* whether gross error occur or not in any particular situation (Bakuła et al. 2008; Bakuła et al. 2009). The GNSS/RTK positioning methods provide no independent control because there is only one vector determined when using single station resolution as well as when using virtual reference station (Vollath et al. 2002) (Fig. 1).

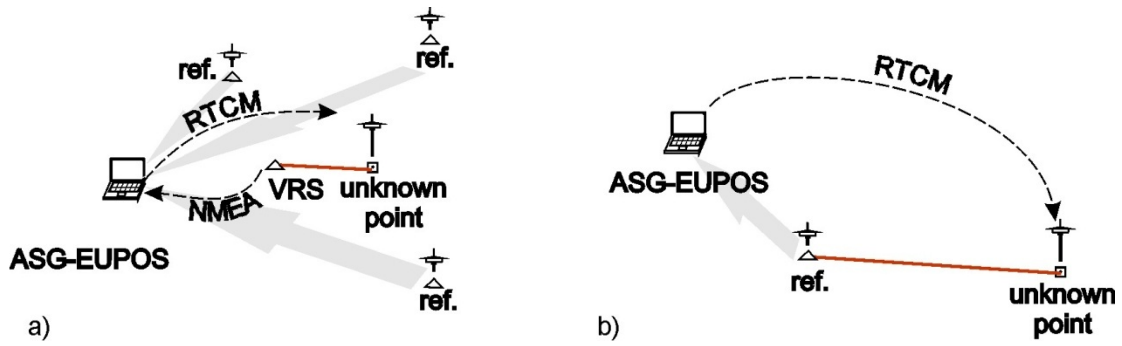

Fig. 1. Baseline computed in RTK positioning: a) Virtual Reference Station, b) single reference station.

The main challenge to tackle as concerns this issue of GNSS positioning in forest environment is not how to obtain precise or accurate position but how to make obtained position reliable.

2. METHODS

Field surveys were conducted on three test points situated within the area of the University of Warmia and Mazury campus in Olsztyn. Each of the three points was surrounded with high trees causing partial coverage of the horizon. Despite the fact that the experiments were conducted during early spring (March 23, 29, and 30, 2011) when the trees were still without foliage the measurement conditions can be considered very difficult because of high density of branches over the survey points (Fig.2).

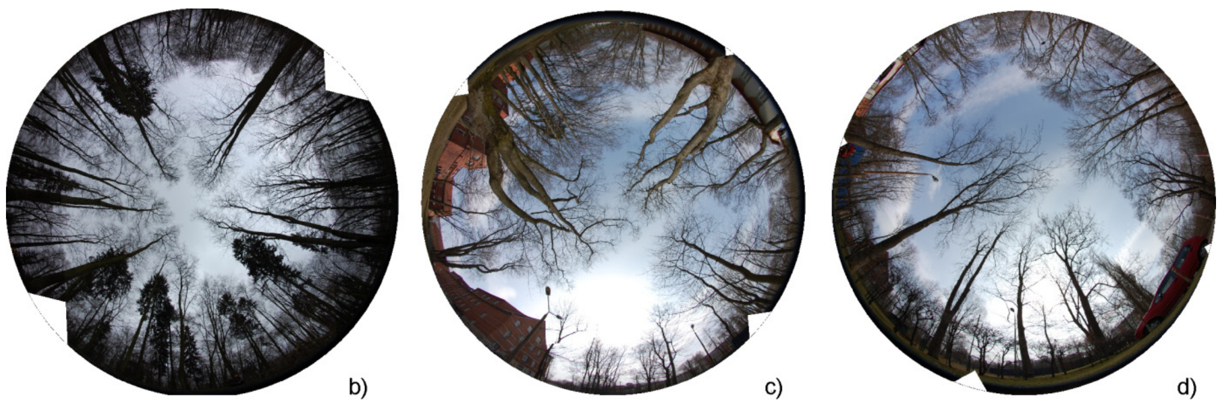

Fig. 2. Obstructions over survey points: a) point P, b) point D, c) point K.

The survey was conducted using three GNSS (Topcon Hiper Pro) receivers mounted on the specially designed linear base set on the land survey tripod. The design of the base allows setting three GNSS receivers on one land survey tripod in such a way that one of them is levelled and centred directly above the surveyed point while the other two are at the distance of exactly 0.5 m from it and all the receivers are at the same height and form a straight line (Fig. 3). Additionally, thanks to the installed compass positioning the receiver in the north – south line (as a consequence the marking of the receiver applied further herein: N-North, M-Middle, S-South). The use of such a base allows introduction of the additional, independent control based on three assumptions: fixed

distance of receivers from one another, their setting in line and their identical height position.

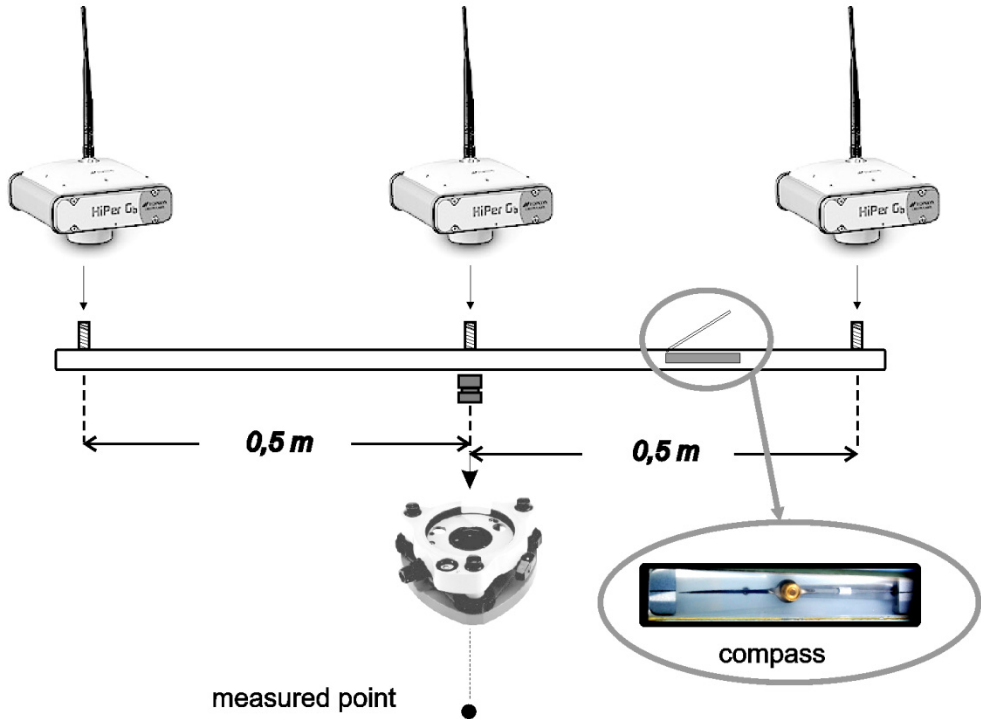

Fig. 3. Linear base concept.

During the survey in all the points the RTK data from the NAWGEO_VRS_3_1 service of the ASG-EUPOS system that was received via the GPRS terminal was used. The results of measurements generated at 1 s interval were transmitted in the NMEA standard to the computer. All the information of importance from the perspective of the further analyses is contained in the NMEA standard GPGGA message that contains, among others the determined coordinates, the information on the GPS solution and the DOP coefficient value (Fig. 4). All the positions, independent of the solution type, were recorded in the computer.

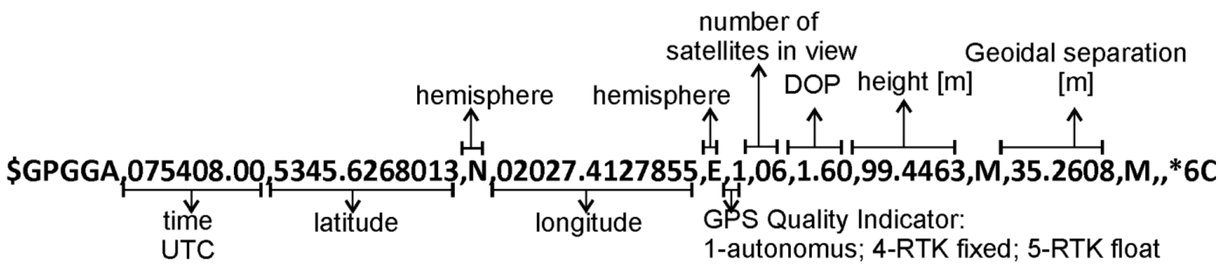

Fig. 4. GGA message format (European Standard 2000).

The *fixed* type coordinates (the ambiguity determined as an integer) determined during the survey were analysed in real time by the author-developed application operating on the PC. The major task of the developed application was to inform the user about obtaining the coordinates considered reliable. For the purpose of survey results reliability evaluation at the level of the application the above described conditions, i.e.

the linear distance between points determined by the individual receivers equal to 0.5 m, their positioning on the common line and equal height were verified (Fig. 5).

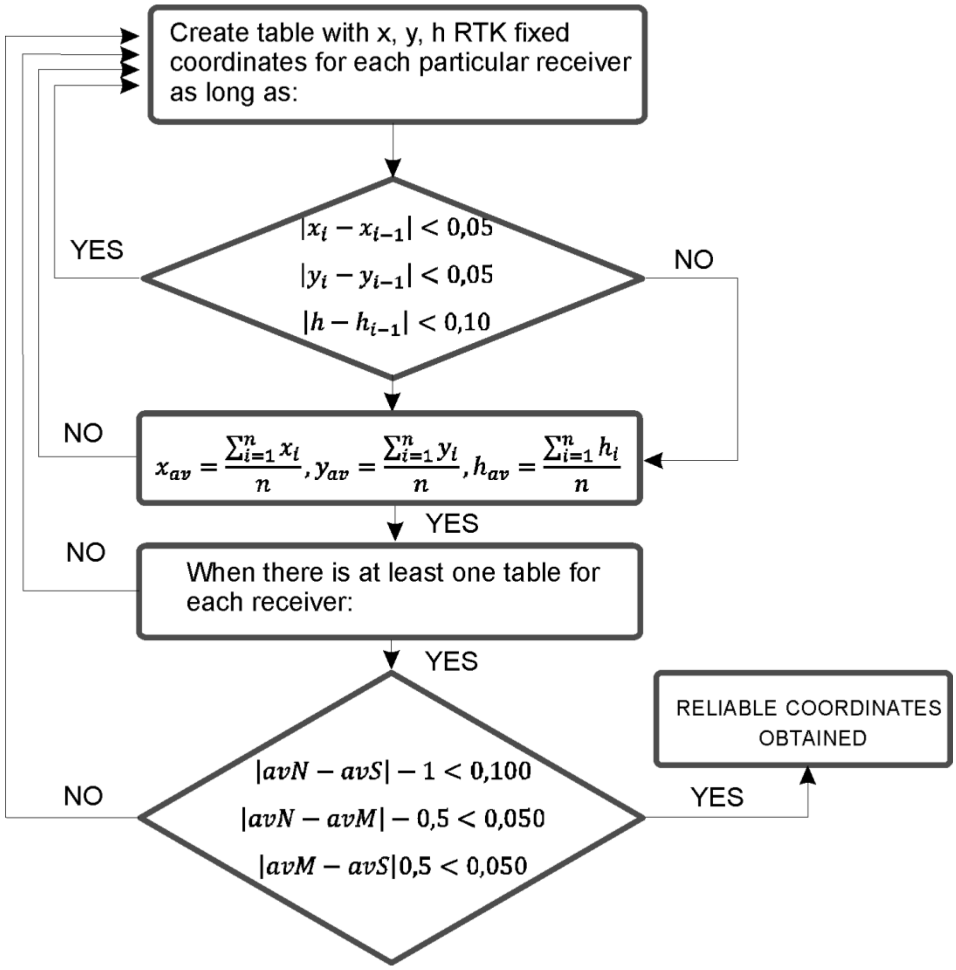

Fig. 5. Simplistic diagram of the algorithm.

Six survey sessions, each lasting until determination of credible coordinates were conducted for each survey point. Before every session all the receivers and the application analysing the survey results were reinitialised thanks to which the results obtained were independent.

3. RESULTS

As a result of the experiments conducted the total of over 17,000 positions were obtained, out of which 3102 positions obtained as a result of solving the ambiguity as the integer and those positions (of the *fixed* type) were considered in further analyses. According to the ASG-EUPOS system assumptions the accuracy of the position determined using the NAWGEO service should be better than 0.03 m horizontally and 0.05 m vertically (Oruba et al. 2009). The positions obtained during these experiments were characterised by high precision (consistent with the requirements for the RTK methods) within the group of consecutive *fixed* type determinations, which is characteristic for the GNSS/RTK positioning under conditions of limited availability of satellites and it was signalled in the literature earlier.

At the first stage of analyses the horizontal and vertical points positioning errors in relation to the values considered true were computed. While precision in the individual groups was within single digit values in centimetres, the accuracy of position determination ranged from a few millimetres up to 7 metres horizontally (Fig. 6) and 16 m vertically (Fig. 7). Presence of gross errors was not reflected in the precision analysis available to the used during survey (values of the VRMS, HRMS, DOP), which is also characteristic for surveys conducted on forest located points.

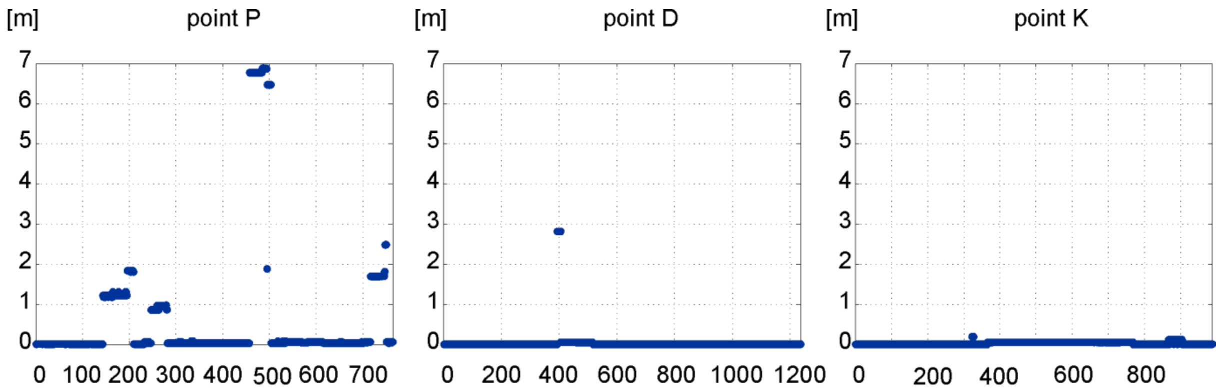

Fig. 6a. Horizontal accuracy of *fixed* RTK positions

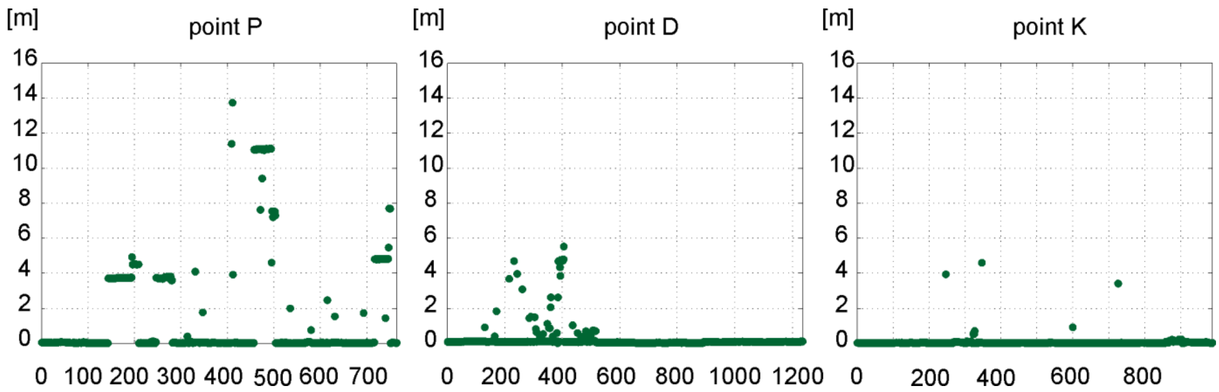

Fig. 6b. Vertical accuracy of *fixed* RTK positions.

The application used allowed obtaining 18 positions only (six for each survey point) but those positions were reliable and the position accuracy was no worse than 5 cm horizontally (except session 3 point P) and 10 cm vertically (except session 6 point P) which is a slightly worse result than the declared accuracy of the NAWGEO service, but still satisfactory (Fig. 7). The waiting time for the reliable solution was from a few seconds to several minutes at points K and D and from a few seconds to almost one hour in point D. That time depends on the constellation of satellites over the survey point at a given time and the intensity of terrain obstructions.

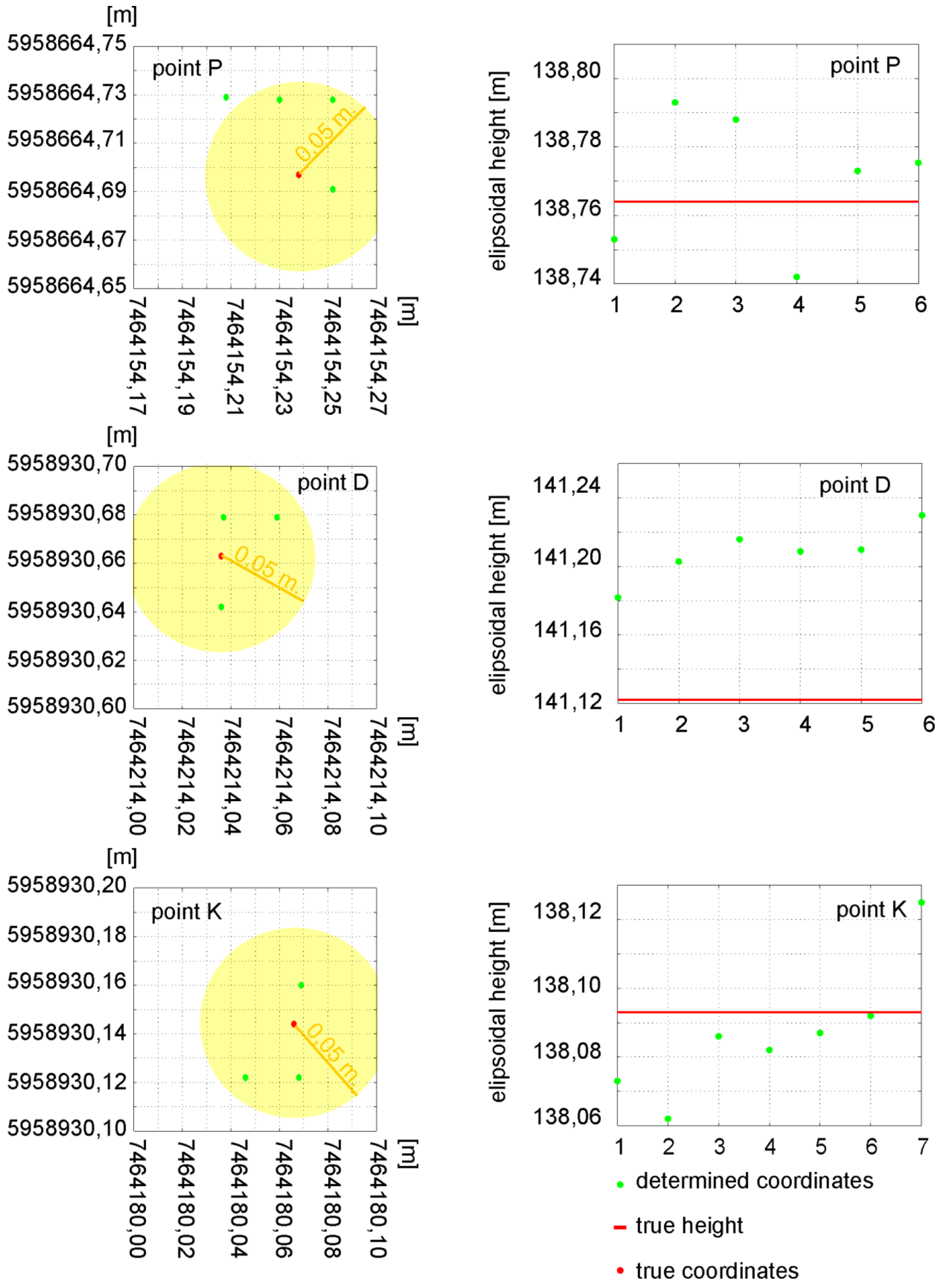

Fig. 7. Horizontal and vertical deployment of RTK positions with the use of proposed application.

4. Summary

Application of the ordinary RTK method for point coordinates determination in wooded areas bears the risk of emergence of difficult to detect gross errors of even as much as a few metres and that is why avoidance of terrain obstruction at survey points

is required. Land survey practice, however, shows also the need of conducting satellite positioning also where availability of satellites is limited. Introduction of complementary control allowed obtaining not only accurate but also, which is even more important, reliable coordinates of points that were obstructed within the shortest time possible. Although the application developed is still at the testing stage, the results obtained (positioning accuracy under very difficult survey conditions at the level of 0.05 horizontally and 0.10 vertically) allow believing that the solution proposed in this paper will allow performance of GNSS/RTK surveys in forests and wooded areas, which might be used in forest land survey, land survey services for investment projects and integration of the existing control networks with the ASG-EUPOS system.

REFERENCES

Bakuła M., Oszczak S., Pelc-Mieczkowska R. (2009) ***Performance of RTK Positioning in Forest Conditions: Case Study.*** **Journal of Surveying Engineering, American Society of Civil Engineers, Vol. 135, No. 3, ASCE, ISSN 0733-9453/2009/3-125-130.**

Bakuła M., S. Oszczak, R. Bornus, W. Jarmołowski, R. Pelc-Mieczkowska, Gregorczyk R. (2008) ***Zastosowanie technologii GPS do wyznaczenia współrzędnych osnowy realizacyjnej obwodnicy miasta Wyszkowa.*** **ACTA SCIENTIARIUM POLONORUM, Geodesia et Descriptio Terrarum, 7 (4), 27-36.**

Bakuła M. (2007) ***Static network code DGPS positioning vs. carrier phase single baseline solutions for short observation time and medium-long distances*** **Artificial satellites, 42/3:167-183. Warszawa 2007.**

Bakuła M., Oszczak S. (2006) ***Experiences of RTK Positioning in Hard Observational Conditions During Nysa Kłodzka River Project.*** **Vienna, Austria, Reports on Geodesy, No. 1(76), pp. 71-79.**

European Norm, 2000, EN 61162-1:2000, Cenelec, Belgium.

Hasegawa, H., and Yoshimura, T. (2003) ***Application of dual-frequecy GPS receiver for static surveying under tree canopy.*** **Journal of Forest Research, Springer-Verlag, Tokyo Inc, 8(2), 103-110.**

Oruba A., Leończyk M., Ryczywolski M., Wajda S. (2009). ***ASG-EUPOS po roku.*** **Geodeta - magazyn geoinformacyjny, 4/2009 (167):10-14, Geodeta Sp. z o. o., Warszawa 2009.**

Vollath U., Landau H., Chen X., Doucet K., Pagels Ch. (2002) ***Network RTK Versus Single Base RTK – Understanding the Error Characteristics.*** **ION GPS 2002, 24-27 September 2002, Portland, OR**

KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI

UNIA EUROPEJSKA
EUROPEJSKI
FUNDUSZ SPOŁECZNY

[2)] AUTHOR IS SUPPORTED BY THE EUROPEAN UNION WITHIN THE EUROPEAN SOCIAL FUND