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HIGH TECHNOLOGY IN FOREST ENGINEER WORKS

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Abstract

Older methods and instruments were characterized by low accuracy or low productivity and high costs of fieldwork. From the 80s appeared on the market new types of instruments identified to measure accurately, productively, with a small amount of field work, but large cost of purchasing the instrument and modified analytical methods and efficiency. The era that we are living is characterized by evolutions of great importance in the sector of space applications. Especially, in the field of geodesy science, the applications of position determination with the use of satellite systems in global scale offered valuable solutions in chronic problems while creating new prospects but also greater demands. GPS and GLONASS are continually improving and the European Galileo and Chinese Compass systems are emerging to provide additional benefits for world-wide users. The main target of this research is the investigation of the possibilities of the triple frequency GPS at field work for forest mapping. Previous works has been done by many researchers in all over the world. However, in this paper we concentrate on woodland area with receivers of two (2) frequencies (dual frequency) for both GPS and GLONASS satellites on. Also be able to receive signals from the third frequency GPS L5 and GALILEO, COMPASS satellites and the new L2C frequency for better and faster fixing in these environments. Finally are concluded proposals for the survey work in the forest cadastre, the forest opening up and the forest road construction, the study of temporal changes in the earth surface, for the measuring of forest data and for the civil engineer works.

Key words: frequency, field test, GPS, instrument, terrain condition.

Introduction

Older methods and instruments were characterized by low accuracy or low productivity and high costs of fieldwork. From the 80s appeared on the market new types of instruments identified to measure accurately, productively, with a small amount of field work, but large cost of purchasing the instrument and modified analytical methods and efficiency.

In order to choose the correctly instrument it depends on follow factors: the cost of instrument, the existed available instruments, the terrain conditions, the method of the work and the desirable precision of the work.

The era that we are living is characterized by evolutions of great importance in the sector of space applications. Especially, in the field of geodesy science, the applications of position determination with the use of satellite systems in global scale offered valuable solutions in chronic problems while creating new prospects but also greater demands. GPS and GLONASS are continually improving and the European Galileo and Chinese Compass systems are emerging to provide additional benefits for world-wide users. NAVSTAR/G.P.S. (NAVigation Satellite Timing And Ranging – Global Positioning System) or just GPS is a satellite system with which we can determinate the position of one point of observation X, Y, Z, in relation to a point of reference. This new system's development started at the beginning of the 70s and its use started at the beginning of the 80s by the USA's Ministry of Defense.

It has been designed for the needs of navy and for military purposes and its main target was to allow knowledge of any position, with ±10–15 m accuracy, in real time. It soon became clear that it could be used for even more accurate calculations so its use also expanded to geodetic applications. Generally GPS covered a great gap in the field of position's determination.

GPS receivers are used for navigation, positioning, time dissemination, and other research.

- Navigation in three dimensions is the primary function of GPS.
- Precise positioning is possible using GPS receivers at reference locations providing corrections and relative positioning data for remote receivers. Surveying, geodetic control, and plate tectonic studies are examples.
- Time and frequency dissemination, based on the precise clocks on board the SVs and controlled by the monitor stations, is another use for GPS.
- Research projects have used GPS signals to measure atmospheric parameters.
- Georeferencing: that is assigning correct latitude and longitude to the control points of satellite imageries and topographic maps.

Many groups are now researching the advantages of the third civil frequency available with Modernized GPS and an entirely new Global Navigation Satellite System (GNSS), GALILEO.

Studies have shown that the integration of the two systems provides stronger geometry and more availability (O'Keefe 2001). These properties allow for better blunder detection and higher reliability of the overall system. The increased availability gives better precision in the position domain (Lachapelle et al. 2002) and can provide improved satellite geometry in the most difficult signal masking environments, such as urban canyons (O'Keefe et al. 2002).

Beginning around 2008, civilians will have access to three GPS signals: L1 (1575.42 MHz), L2 (1227.60 MHz), and L5 (1176.45 MHz) (Van Dierendonck 2000). Both L1 and L5 are for civil aviation safety-of-life services. L2 is for non-safety critical applications. The use of these additional frequencies is expected to enhance the performance (accuracy, integrity, continuity, availability) of GPS. There are several ways to take advantage of the new frequencies:

- Calculate ionosphere delay in the airplane. This might eliminate the grid which is used for ionosphere delay corrections in WAAS (Enge et al. 1996).

As a result, one would have fewer wide area reference stations (WRS). This system would be less expensive.

- When radio frequency interference (RFI) is present, one can use the additional GPS frequencies as a backup navigation method. This system requires WAAS to continue broadcasting the ionosphere grid.
- Combine the above two methods to form a more robust navigation system. This combined system is more preferable than the two above methods.

Three frequency systems allow for better modeling of atmospheric errors, especially in the case of the ionosphere, which is dispersive. Three frequencies will also allow for more variation in ambiguity resolution methods. The GPS widelane combination of L1 phase minus L2 phase has been shown to reduce measurement errors, in terms of cycles, which allows for faster ambiguity resolution. This widelane combination has also been used as an intermediate step in resolving individual L1 and L2 ambiguities. This process is called cascading ambiguity resolution, in which frequency combinations that reduce the effects of the atmospheric errors are resolved prior to attempting to fix more difficult, shorter wavelength, ambiguities. By using the fixed information, the frequencies combination is used to assist with ambiguity resolution of the shorter wavelength ambiguities in an attempt to resolve the ambiguities on the base frequencies.

The basis of GPS is trilaterate from satellites. To trilaterate a GPS receiver measures distance using the travel time of radio signals. To measure travel time, GPS needs very accurate timing, which it achieves with some tricks. Along with distance, it is needed need to know exactly where the satellites are in space. High orbits and careful monitoring are the secret. Finally you must correct for any delays the signal experiences as it travels through the atmosphere.

Position is calculated from distance measurements (ranges) to satellites. Mathematically we need four satellite ranges to determine exact position. Three ranges are enough if we reject ridiculous answers or use other tricks. Another range is required for technical reasons.

Our research motivation is the investigation of the performance of a triple frequency GPS at field work for forest mapping.

Material and Methods

The research area was at Asvestochori. The instrument we used was the LEICA VIVA GS15 (Figures 1 and 2).

The basic technical specifications of the triple frequency satellite positioning system are shown in Table 1.

These steps below describe briefly how to setup, operate, take down, and process data for a GPS-RTK survey.

1. Setting up the base station for an RTK survey.

1.1. Set up of base station antenna and tripod.

1.2. Set up base repeater radio.

2. Set up of RTK rover for RTK survey.

2.1. Setting up the rover receiver.

3. Set up of independent RTK repeater radio for RTK survey.

4. Configuring the RTK survey.

5. Creating a new job for the RTK survey.

6. Starting the base receiver for a RTK survey.

7. Starting the rover receiver for a RTK survey.

8. To survey a point.

9. Ending a RTK survey.

We must be careful if base or rover batteries fail during the RTK survey, survey data may be lost.

In order to take the ASCII output files of RTK data we used special software in order to export various GIS output files, and those interested in creating various GIS are referred to the manuals for further information.

Note that ASCII TEXT files contain WGS-84 latitude and longitudes, and height above ellipsoid elevations. We used special software (CO-ORDS) in order to transform them to HGRS '87 (Hellenic Geodetic Reference System '87). Then we input the ASCII file in AutoCAD and export the digital map of the area.

Fig. 1. Pieces of the instrument LEICA VIVA GS15 with the technical equipment.

Fig. 2. Case of the LEICA VIVA GS15.

Results and Discussion

The Following figure 3 presents the surveying area with the contour lines. The main contour lines with red colour are

Table 1. Basic technical specifications of satellite positioning system LEICA VIVA GS15.

System Differential GPS Corrections	
1.0	The GPS system consisting of two receivers interchangeable between each other with supporting accessories, software to perform all the required applications.
Receiver GPS GNSS	
2.0	Have receivers of four (4) frequencies for both GPS and GLONASS satellites on. Also be able to receive signals from the third frequency GPS L5 and GALILEO satellites and the new L2C frequency for better and faster fix.
2.1	Each receiver offers 120 channels and two frequencies L1 and L2 on simultaneous detection of up to 60 satellites at both frequencies. The receiver performs measurements of phase and frequency waves two carriers L1 and L2 code measurements and C / A and P in L1 and L2 frequencies. Each receiver has: • Sixteen (16) channels of continuous detection of the frequency of L1. • Sixteen (16) channels of continuous detection of the frequency of L2. • Sixteen (16) channels of continuous detection of the frequency of L1 GLONASS and sixteen (16) channels of continuous detection of the frequency of L2 GLONASS + (4) SBAS (WAAS, EGNOS, GAGAN, MSAS)
2.2	Ability to record observations in kinematic and static procedure for post-editing in the office.
2.3	The rate of measurements' recording to qualify by 0.05 sec to 300 sec. The angle of the satellite measurements for recordings (cut – off angle) to be eligible.
2.4	The refresh rate of the position to be eligible by 0.05sec (20 Hz) to 1 sec (1 Hz).
2.5	The system offers complete reference design parameters (availability of satellites, static figures Precision PDOP, GDOP, and azimuth angles of the satellites, sky map) all the data is tabular and graphical format.
2.6	Has built-in anti-jammining on both frequencies L1 and L2.
2.7	Have reliable technology of reception under trees.
2.8	The mobile receiver to receive network RTK corrections and supports networked RTCM messages type of issue until v3.1.
2.9	The receiver is controlled via the serial port to any other program that runs on any platform.
2.10	The data from both receivers are recorded in CF Compact Flash or SD cards in both the receiver and the keyboard with selectable by the user to register.
2.11	The ISDN cards have at least 1GB of memory
2.12	The mobile receiver (rover) communicates with Bluetooth built-in antenna for kinematic and REAL TIME applications.
2.13	The rover receiver (mobile) consists of the antenna, keyboard, batteries and pole with the support and its weight is not more than 3.5Kg.
2.14	The operating temperature range of the receiver is -30°C to +65°C.
2.15	The storage temperature range of the receiver is -40°C.
2.16	The resistance to humidity is 100% (total precipitation).
2.19	The RTK is fully integrated in receivers.

Table 1. Contination.

2.20	The integrated software of the receiver allows and the following measurements: • Surveying • Identification of reference systems • Mapping of all methods of orientation (north, sun, point, line, arrow navigation) • COGO applications for determining coordinate points with many geometric methods. Specifically: cuts straight to the field in straight distance calculations, arrows, shift, speed tracks, routes • Transformation etc. The user has the ability to create its own set of rules for all applications supported by the system and planning at the office before the field measurements.
2.21	The software has the ability to create lines and polygons as well as the possibility of introducing coding points, lines and polygons.
RTK performance	
3	The reliability of positioning should be better by 99.99%
3.1	For Real Time approach to achieving the following accuracies: Position 10mm +1 ppm; Elevation 20mm +1 ppm.
3.2	Continuously independent continuous control algorithms to resolve the ambiguity phase.
3.3	Equipment modem and GSM modem are removable from the receivers and not integrated.
3.4	To be making points with a frequency of 20Hz (0.05sec) without degradation of accuracy.
3.5	Time for On-the fly positioning in Real Time situation is 8 sec (typical) after connecting to satellites.
3.6	The display controller to display continuously the situation to resolve ambiguities.
3.7	The display controller to provide all information as the number of detectable satellites and the condition of the battery or memory card capacity.
3.8	The display controller to display graphic signs with engraving.
3.9	The system to read signs marking just ASCII files.
3.10	The scheme to import and export files onboard ASCII measurement sites offline with a program on a PC in a format of choice.
3.11	The system can import and export onboard DXF files points / lines / polygons without connection to program in a computer.
3.12	The system must support connection to GSM. The connection between the GPS receiver and GSM modem to be without power.
3.13	The system has the possibility of simultaneous wireless modem, and GSM modem in the body of the receiver.

every 2 m while the intermediate contour lines with green colour are every 40 cm.

In this paper we presented an overview of a GPS system, we mentioned its characteristics and some of its drawbacks. RTK method was briefly described. Measurement results showed that in open sky with the triple frequency GPS offered the most accurate and quick solution for the digital terrain model creation. When high precision and accuracy measurements are required for example in forest cadastre the triple frequency GPS is the answer. GPS L5 is the new third GPS frequency with GPS and GLONASS. Through higher power emission GPS L5 offers easy and faster signal acquisition and tracking. Advanced signal modulation schemes improve multipath rejection performance. Galileo will add another 30 satellites to the GPS and GLONASS constellation. This will provide an average of 20 satellites in view 24/7 and will further improve speed and accuracy. Also the new L2C frequency is another one frequency for better and faster fix in wooded environments. Also it can be able to receive signals from the Chinese COMPASS.

Especially G.P.S. in forest engineer works gives the following advantages:

Topography (Relief)

The high accuracy, which the measurements of carrier wave phases offer, constitutes an excellent tool for a series of geodynamic, geodetic and topographic applications (Seeber 1993).

G.P.S. system has been used by the laboratories of Superior and satellite geodesy, in order to support the Greek Trigonometric network and for the implementation of the new Hellenic Geodetic Reference System HGRS '87. It was used for the monitoring the small movements and deformations of the earth's crust or from dams, to accomplish hydrographic photographs and underwater wirings (Sakkos and Vorrias 1998).

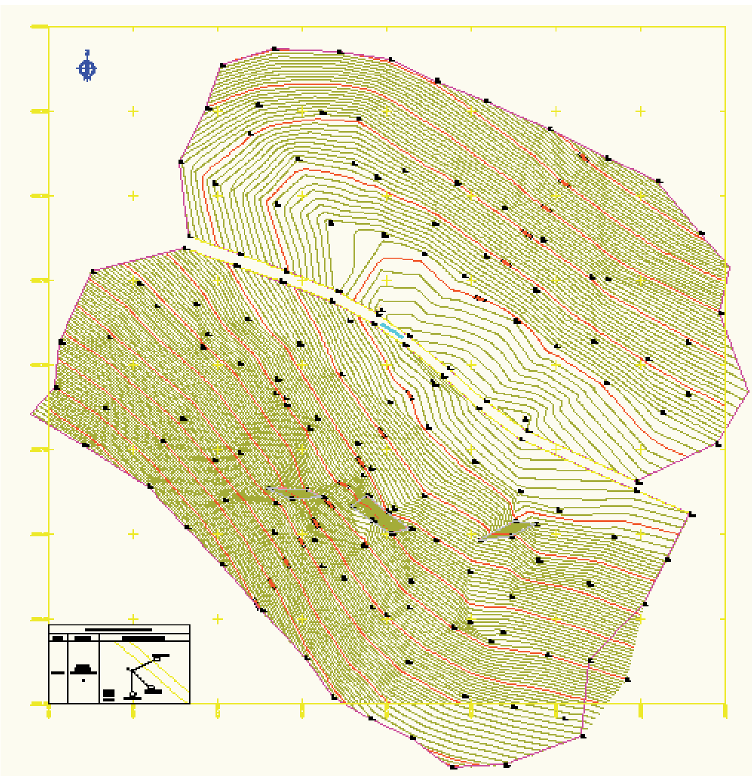

Fig. 3. The surveying area with the contour lines.

Forest cadastre

For the cadastre work the kinematic and semi-kinematic methodologies are applied as usual, while for the works of the triangulation use becomes of the static and semi-kinematic methods of determination. G.P.S. constitutes a valuable tool for the geographical information systems (G.I.S.), which connect phenomena with the geographical space. G.I.S. is the new trend in technology to collecting, storing, managing and analyzing data. Many companies in Europe manufacture G.I.S. – programs, in order to renew the cadastral maps, cadastral tables and delimitation of forest cadastre with the help of digital maps that are taken central via Internet and are cooperated with G.P.S. in the field.

Road construction

Afterwards the abolition of the Selective Availability, the global positioning system has an extended use in the road construction replacing the topography's classical methods that were based on the use of the total station, theodolite and level. G.P.S. – system can be a useful means for the survey engineer, which occupies the road's construction premeditations and designs (Varvanis and Vasiliadis 1996).

Except from the surveying, G.P.S. (the global positioning system) can also be used in other applications of road constructions, like way staking. In relation to the installation of gradient developed control systems in the earthwork machines, the exact place of the machine can be determined, being based upon the technology of G.P.S.

Management of forest – Harvest, skidding and transport of forest products

Simple in the use GIS-programs and suitable database help in the modern management of the forest (Sprenger 2003). During last years, the global positioning system has been useful as an application within forest management; as far as this instrument allows the researchers to clearly define the productivity of the machines that used in forest work. G.P.S.-system is more advantageous compared with the traditional methods of forest management, as it requires less work time and is extremely precise. One reaches this with the installation of receivers in the cultivation and harvesting machines. By the production of a road map one can define the route and speed of the vehicles and the ground pressure, which are practiced on the road, with computation of the traffic frequency.

Management of fire-fighting vehicles' fleet

The surveying of a forest area's roads gives the possibility of designing the suitable maps, in order to prevention or extinguish a fire faster. Great effect, particularly in Europe and Japan, finds also the combination of G.P.S. and electronic maps for the management of vehicle fleets, e.g. to fire brigade, police and ambulances. Each vehicle watches its travel on an electronic map, which provided with information about the direction change, the weather, and road and traffic conditions. With this manner the central station improving their route reaches the control of all vehicles' travel at any moment. This usefulness of G.P.S.-receivers gets a greater importance in extreme emergency situations, like the danger before fires, in extreme health circumstances, whereby the reaching of the fastest route is urgent.

Conclusion

It is a third generation instrument for measurements, that includes the most modern GNSS technology and tracks all existing satellite signals and those planned for the future. This includes GPS, GPS L5, Galileo, Compass, GAGAN, WAAS, EGNOS and MSAS. This state of the art equipment will contribute to an efficient and effective performance in the field.

GPS technology offers several advantages: First of all, the service is free worldwide in order to locate a position. Second, the system supports unlimited users simultaneously. Third, one of the great advantages of GPS is the fact that it provides navigation capability. By integrating the navigation, positioning, and timing abilities of GPS with other technologies such as GIS and data collection, electronic displays, and communications, a vast amount of applications can be created. Combining the GPS data with GIS allows for greater capabilities than what GPS and GIS can provide individually. With the combination of two technologies one is able to display the field/actual site on a PC and take serious decisions. In forestry there is no shortage of uses. In forest cadastre, forests opening up, forest road construction and landings, heavy equipment of recording and monitoring, and all sorts of field data collection application have already been initiated. Mechanical site preparation, juvenile spacing, mechanical brushing and planting, forest health (i.e. insect and disease tracking), forest fire monitoring, research plots and others are some of Forestry applications that the use of GPS brings a new era. Forestry applications that use GPS are continually changing. GPS can be used to create and maintain digital map databases for the forests we manage. In connection with the zoning plans we can sustainable develop the mountainous areas.

References

Enge P., Walter T., Pullen S., Kee C., Chao Y. C., Tsai Y. J. 1996. Wide Area Augmentation of the Global Positioning System, Proceedings of the IEEE, Volume 84, No 8: 1063–1088.

Lachapelle G., Cannon M. E., O'Keefe K., Alves P. 2002. How Will Galileo Improve Positioning Performance? GPS World, Volume 13 (9): 38–48.

O'Keefe K. 2001. Availability and Reliability Advantages of Galileo/GPS Integration. Proceedings of ION GPS-01, Salt Lake City, USA, 2001: 2096–2104.

O'Keefe K., Ryan S., Lachapelle G. 2002. Global Availability and Reliability Assessment of the GPS and Galileo Global Navigation Satellite Systems. Canadian Aeronautics and Space Journal, Canadian Aeronautics and Space Institute, 48 (2): 123–132.

Sakkos L., Vorrias E. 1998. Following of the small movements of the earth's crust within the earthquake range of Migdonia basin from two observation rows with G.P.S. Thesis work of the Sector for Geodesy and science of surveying. Aristotle University of Thessaloniki. (in Greek).

Seeber G. 1993. Satellite Geodesy, Foundations, Methods and Applications. Published by Walter de Gruyter. New York, 531 p.

Sprenger A. 2003. Forest – G.I.S. in the InterNet: Customers define their kind of condition. Forest newspaper, No 10: 12–13.

Van Dierendonck A.J. 2000. Signal Specification for the Future GPS Civil Signal at L5, Proceedings of ION Annual Meeting 2000, San Diego, CA, June 26–28.

Varvanis A., Vasiliadis Th. 1996. G.P.S.'s applications at the construction of roads. Thesis (diploma) of the Sector of Geodesy and Science of Surveying. Aristotle University of Thessaloniki. (in Greek).