

THE APPLICABILITY OF DIFFERENT GPS - TYPES WITH THE SURVEY OF FOREST ROAD NETWORKS AND PATHS IN GREECE

Vasileios C. Drosos¹, Vasileios J. Giannoulas², Rigas Ath. Giovannoulos³, Sarantis – Aggelos G. Liampas⁴, and Dimitrios Eur. Farmakis⁵

^{1, 3, 4, 5}Democritus University of Thrace, Department of Forestry and Management of the Environment and Natural Resources

²Aristotle University of Thessaloniki, School of Forestry and Natural Environment

Abstract

The appropriateness of different GPS (manual GPS, two receivers - one frequency, two receivers – two frequencies) in a far range of application in relation with their costs led us more concretely to the research of their reliability within the Greek forest and to the examination of their suitability for the path and forest roads network survey. The measurements were accomplished in different time of the year and under different forest conditions. To the statistic analysis the values of the total station were taken as true values. Finally the measurements accuracy with GPS in regard to the forest area was calculated, the suitable results were drawn and the relative suggestions for its forest application in Greece are indicated.

Keywords: G.P.S., reliability, survey.

1. Introduction

G.P.S. is considered as the most current data acquisition position system with conditions and perspectives for rapid development for the operators. Some applications of G.P.S. in forest practice are the following:

a. Geodesy

The high accuracy, which the phase measurements of carry wave offer, excellent working material for a set of geodynamic, geodetic and topographic applications (Seeber, 1993).

b. Forest cadastre

With the forest cadastre work usually the kinematics and “stop and go” methodologies are applied, while one uses the static and “stop and go” methods of investigation for the triangulation work. G.P.S. forms valuable working material for the geographical information systems (GIS) (Doukas et. al., 2000, Doukas, 2003). On this way it is to be brought possible phenomena with the geographical area in relationship. GIS are a new technology to collecting, memories, managing and analyzing data. Many companies in Europe make – programs to GIS, in order to renew forest maps, cadastre tables and to limit the forest with the help from digital maps to, those by Internet to be taken and in the field with GPS co-operate (Doukas, 2001).

c. Construction of roads

Apart from the surveys GPS can be used also with other applications of constructions of roads, like path mappings. With the installation of developed control systems in the earth working machines the accurate position of the machine can be determined, being based upon the GPS – technology (Doukas et. al., 1990, Vargannis et. al., 1996, Erdas, 1997).

d. Forest management - harvest and bringing of forest products

Handy GIS – programs and suitable database is to the modern forest management at the disposal (Sprenger, 2003 a, b).

In the final years the international data acquisition position system finds a large application with the forest management, since this instrument permits the researchers to determine the productivity of the machines used with the forest work (Taylor et. al., 2001).

e. Management of a fleet of fire-fighting vehicles

The path survey of a forest area gives the possibility for informing the suitable maps, in order to repel or extinguish a fire faster (Drosos, 2007).

Aim of the available work is the research of the accuracy of different GPS - types and their range of application within the Greek forest, with emphasis the examination of its suitability for forest road surveys.

2. Materials and methods

2.1. Research area

The measurements were accomplished in the years 2006 and 2007 in three different areas (Figure 1).:

a. In the university forest “Taxiarchis” with L1+L2 Topcon GPS and with the hand GPSmap 60CSx of Garmin.

In the first selected area “Livadia” were surveyed pasturelands with Christmas trees plantations and forest areas by oak with G.P.S. L1+L2.

The second forest area named “Solitaria” locates southwest of the Forest Office, on the borderline between the Public Forests of Polygyros – Palaiohora and the University Forest of Taxiarchis – Vrastama of Halkidiki.

96% of the region is covered by Broadleaved Oak (*Quercus Conferta*) and isolated trees of Fluffy Oak (*Quercus Pubescens*), Beech (*Fagus Moesiaca*), coppice of Trachea Pine (*Pinus Brutia*) and Black Pine (*Pinus Nigra*). The region is ranges 700 – 890 meters above the sea level and has an exposition SW and NW. The relief is mountainous and the slopes are not more than 45 %. The trees’ height varies between 15-25 m. The basic rock is the Marmarygiakos Shistolithos (FAMUF, 2002).

b. In the forest complex “Kromnis” in close proximity to the city “Gianitsa”, district “EDESSA”, with:

- L1 Etrex of GARMIN,
- L1 LEICA GPS,
- L1 THALES.

The research area is a crossing of forest roads, partly covered with beech forest and partly with grazes or shrubs.

D01 is not forest-covered. Tractor path with width 3.0 m.

D02 beech forest with tree height 15 m and stand density index 0.8 – 1.0. Path width 3.5 m.

D03 beech forest with tree height 15 m and stand density index 0.4 – 1.0. Path width 4.5 m.

D04 shrubs with a height of 2 m and stand density index 0.4 – 1.6. Path width 4.5 m.

c. In the summit of the mountains “Kissavos”, this lies opposite “Olympus”, with L1 Topcon GPS. The research area is forest grazes.

2.2. Instrument choice

The points that were used as control points were surveyed planimetrically and hypsometrically, with the total station TC 805.

The accuracy of the total station according to the technical specifications is 2-5 mm + 2 ppm according to the time of measurement and the distance.

The technical data of the used GPS are evident in the table 1.

2.3. Work method

2.3.1. Survey process with GPS

The use of the LEICA in 5 minutes duration method compared with 1 min, has not improved the measurements (Tables 2, 3), and has been last by the forest road survey the time-consuming method, i.e. 1 minute method used.

At the same time we tried Garmin, Topcon L1 and L1+L2 with the survey of grazes. The coordinates were calculated in the variation with the max. accuracy (fixed), i.e. many “quality signals of satellite are available”.

The research with forest road survey is extended with L1+L2 receiver on a mast.

While in the all GPS was applied the method “stop and go” in real time, with the GPS “promark” was used the method “Post processing”.

For the calculation of differences between the horizontal coordinates of total station and G.P.S is changed in the Greek geodetic system of 1985. Then these were compared and they were analyzed statistically so that is found the means square error of coordinates under the different conditions survey.

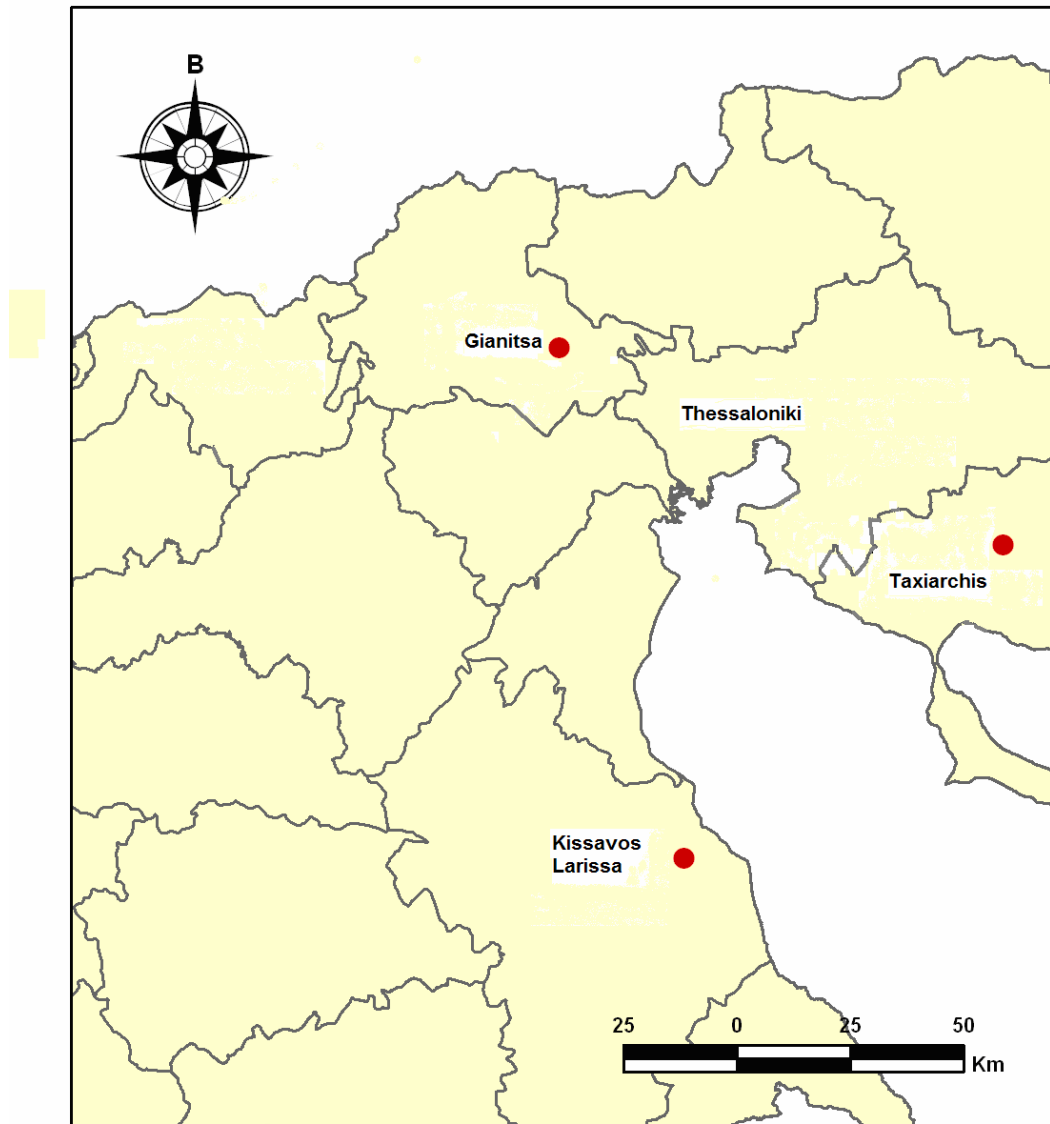


Figure 1. Research areas.

Table 1. Technical data of G.P.S.

GPS type	Technical data
GARMIN e-trex Vista	Receiver: 12 parallel channel Antenna: integrated Code: L1 Accuracy RMS: <15 m
GARMIN GPSmap 60CSx	Receiver: 12 parallel channel Antenna: integrated Code: L1 Accuracy RMS: <10 m
LEICA GS20	Receiver: 12 parallel channel Antenna: integrated and extern Code: L1 Accuracy RMS: By simple measurement 5 m, 1m real time EGNOS or 30 cm by DGPS (L1 post processing)
Pro Mark 2	Receiver: 12 parallel channel, base and rover Receipt time of the signal: about 15 seconds Antenna: integrated and extern

	Code: L1 Accuracy RMS: By simple measurement 5 m, 1m real time EGNOS or 30 cm by DGPS (L1 post processing)
Topcon L1	Receiver: 40 L1 GPS (20 GPS L1+L2 during the days Cinderella), base and rover Antenna: integrated and extern Code: L1 Accuracy RMS: 1m real time by EGNOS or 30 cm by DGPS
Topcon L1+L2	Receiver: 20 GPS L1+L2 (GD), 20 GPS L1+GLONASS (GG), 20 GPS L1+L2+GLONASS (GGD), base and rover Receipt time of the signal: about 15 seconds/first times about 1 min Antenna: GPS/GLONASS, integrated UHF and extern Code: L1 +L2 Accuracy RMS: 3 cm by DGPS

2.3.2. Error theory

The measurements were accomplished in the year 2006, i.e. after the abolishment of the selective availability. To the statistic analysis the values of the geodetic station were taken as true values. For the examination of the measurement errors the following was calculated:

a. The average of the measurement avoiding from the true value with the formula of the mean arithmetic error μ_a :

$$\mu_a = \pm (v)/n \quad (1)$$

where:

(v) = the sum of the absolute values of the actual differences (error) v_1, v_2, \dots, v_n ,

n = the amount of the observations.

b. The mean square error of the measurements μ_r :

$$\mu_r = \pm [(vv)/n]^{0.5} \quad (2)$$

where:

$v = E_t - E_G$, E_t = the true values of the coordinate from the total station, E_G = the coordinate determined with GPS, n = the number of measurements.

Finally the measurements accuracy with G.P.S. was calculated, the suitable results were drawn and the relative suggestions for their forestry application made.

3. Results

From the research and investigation of the data of the research areas resulting in from the geodetic station, and GPS, due to the error theory, the specifications of the tables 2, 3 and 4 were abstracted.

a. By the survey of forest roads

Table 2. Accuracy of the GPS – types by the forest road survey

GPS TYPE	Method	Time of year	Measurement conditions (PDOP and number of satellites)	Number of measurements	Mean square error of the measurements μ_r in m	
					N	E
GARMIN e-trex Vista	Real time Stop and go	March 2006 in Gianitsa	By all Forest roads	59	4.919	4.190
GARMIN GPSmap 60CSx	Real time Stop and go	March 2007 in Solinaria	By all Forest roads	52	4.492	3.523

L1 THALES Pro Mark 2	Post processing Stop and go	August 2006 in Gianitsa	By all forest roads (PDOP<6, n>4)	32	0.373	0.348
LEICA	5 min real time Stop and go	August 2006 in Gianitsa	By all Forest roads (PDOP<6, n>4)	11 by the D01	1.260	0.999

* The research is extended.

4. Conclusions-Discussion

4.1. Conclusions

- The receipt possibility of the signal is better in some periods of the year, than others. The use of mast improves the receipt possibility.
- With the forest routes for a crown-close 0,8 - 1 plays the foliation an important roller with the signal receipt (comparison between D01, D03, D04 and D02 in the Table 3).
- Areas under close planting cannot be surveyed (Table 3).

4.2. Accuracy

- While toward the forest roads D01, D03 in two time periods nearly the same error is calculated, but more is in August than in March, it toward D04 opposite (more in March) (Table 3). The errors (accuracy) depend more strongly on the position (PDOP) and number of received satellites (SNR), i.e. local conditions, than the time period.
- The "post processing,, method achieved better results, as "the stop and go,, (Table 3).
- The use in the forest of the receiver with still several satellites (GALILEO), improves the signal receipt, but not the accuracy. For the improvement of the signal generally speaking Greece reference - correction stations should be used.
- When using GPS L1 + L2, during the area determination in forest grazes, is more satisfying the point measurement than L1, but in forest and built area reacts it more sensitively (accuracy mode) than the L1 – GPS (Table 4).

4.3. Suggestions

- We suggest the evaluation of the GPS on the construction of forest roads only by the generally project and mapping of a forest road in small scales (<10000).
- To the improvement of the accuracy first, Greek reference correction stations system (HEPOS) should be established and compressed thereafter.
- Where there is no point measurement possibility, the use of laser range finder from a GPS -point lying near is recommended.

Table 3. Accuracy of the GPS Leica GS20 by the forest road survey

GPS TYPE	Method	Year time and area (PDOP and number of the satellites)	Per cent that Signal receipt possibility	Measurement conditions (Crown-close) (Tree height)	Number of the measurements (km)	Mean square error of the measurements $\mu\tau$ in m
LEICA GS20	1 min real time Stop and go	March 2006 in Gianitsa (PDOP<6 n>4)		Forest road D01 (Grazes)	21	2.513
			97%	Forest road D02 (0.8-1.0) (15 m)	26	6.357
				Forest road D03 (0.4-1) (15 m)	10	2.258
				Forest road D04 (0.4-0.6) (2 m)	14	1.774
				Total	71	4.344
		August 2006 in Gianitsa (PDOP<6 n>4)		Forest road D01 (Grazes)	17	1.216
			37%	Forest road D02 (0.8-1.0) (15 m)	12	(Survey is not possible)
				Forest road D03 (0.4-1) (15 m)	20	1.803
				Forest road D04 (0.8-1.0) (2 m)	12	2.378
				Total	61	-

* The research is extended

b. By the survey of forest grazes

Table 4. Accuracy of GPS Types by the forest grazes survey.

GPS TYPE	Method	Year time	Measurement conditions (PDOP and number of the satellites)	Number of measurements	Mean square error of the measurements $\mu\tau$ in m	
					Point	Height
Garmin e-trex Vista	Real time Stop and go	June 2006	Forest grazes (Kissavos)	29	3.02	2.37
Hipper pro L1 TOPCON	Real time Stop and go	June 2006	Forest grazes (Kissavos)	64	0.107	0.162
Hipper pro TOPCON L1+L2	Real time Stop and go	December 2006	Forest grazes (Taxiarchis)	7	0.066	0.055
			Building and forest area (Taxiarchis)	4	0.215	0.063

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