Comparison between traditional road measurement methods and hand - G.P.S receivers

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INTRODUCTION

During the period 1985 to 1986, a new technology, the G.P.S., began to be established as the more up-to-date recording positioning system with conditions and prospects for rapid development for its users.

Some applications of G.P.S. in forest practice are the following:

a. Topography (Relief)

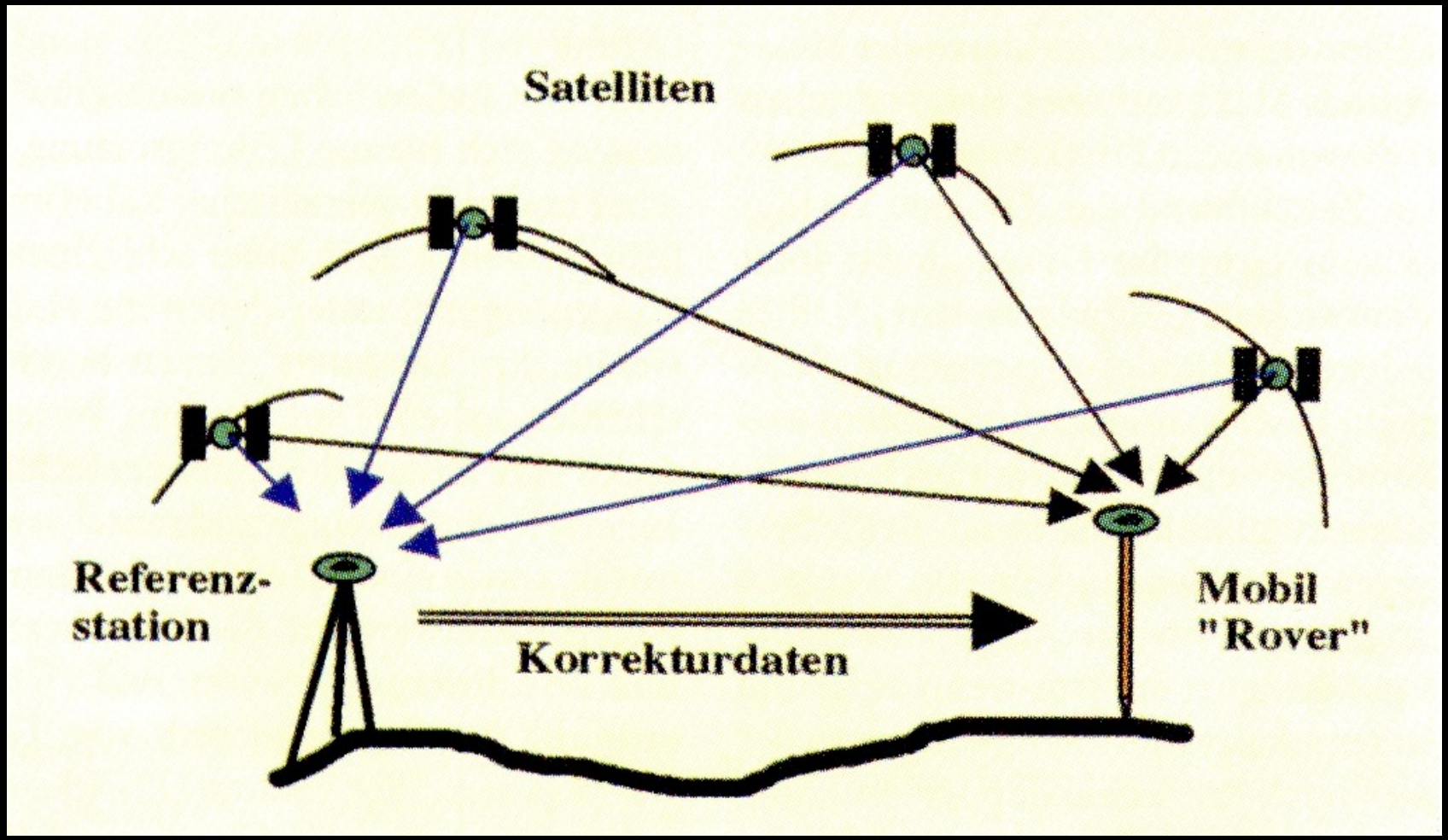
b. Forest Cadastre

c. Road Construction

d. Management of forest - Harvest and transport of forest products

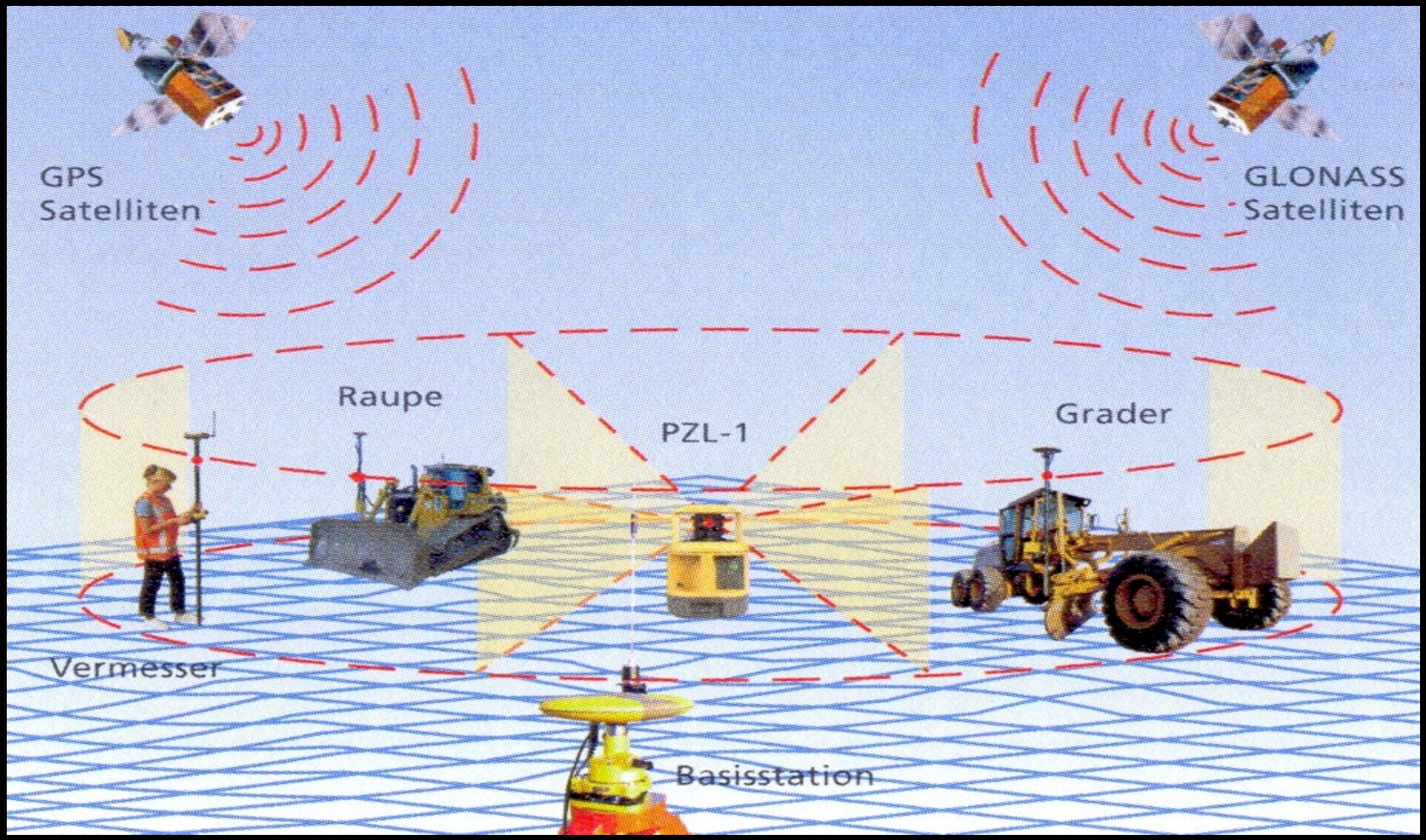
e. Management of fire-fighting vehicles' fleet

Topography (Relief)



Road Construction (a)

Road Construction (b)



Management of forest - Harvest and transport of forest products (a)

Management of forest - Harvest and transport of forest products (b)

Management of fire-fighting vehicles' fleet

Management of police vehicles' fleet

- The aim of this paper is the investigation of the usefulness of hand – G.P.S. (low cost) and its reliability in the Greek forest and the moreover in the control of its suitability concerning to the traditional methods of roads imprinting.

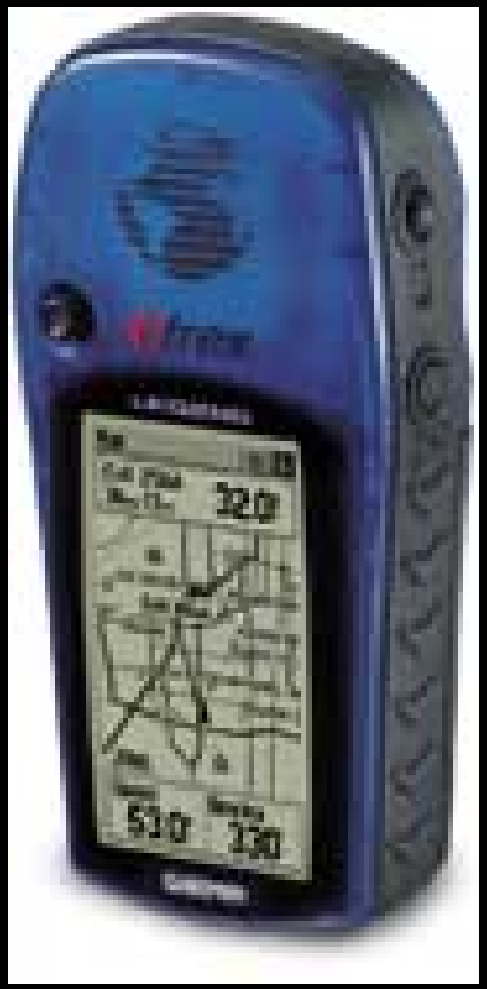
Research area

The university forest of Taxiarchi - Vrastama lies in southern and southwestern slopes of the Holomonta mountain on the prefecture of Halkidiki and is situated at a distance from Thessaloniki about 73 km. It is found between latitudes 40°23′ - 40°28′ and longitudes 23°28′ - 23°34′ its height is 320-1165 m above the sea level. At the selected area "Solinaria" of the university forest of Taxiarchi - Vrastama (Figure 1) was taken up a road both with classical topographic methods (total station and compass), as well as with G.P.S.

Research area

Instruments (a)

Frame	Fully watertight, mixture of plastics resistant at the impact, waterproof
Size	11.2 cm H x 5.1 cm W x 3.1 cm D
Weight	about 150 gr
Operating temperatures	-15 to 70°C
Receiver	12 parallel channels / differential ready
Receipt time of the signal	about 15 seconds/first times about 5 min
Rate of informing	continuously per 1 second
Precision of position	15 m
Precision of speed	0.1 knots
Antenna	Incorporated
Tension	2 batteries AA 1,5V, life span 22 hours in position "Battery save mode"

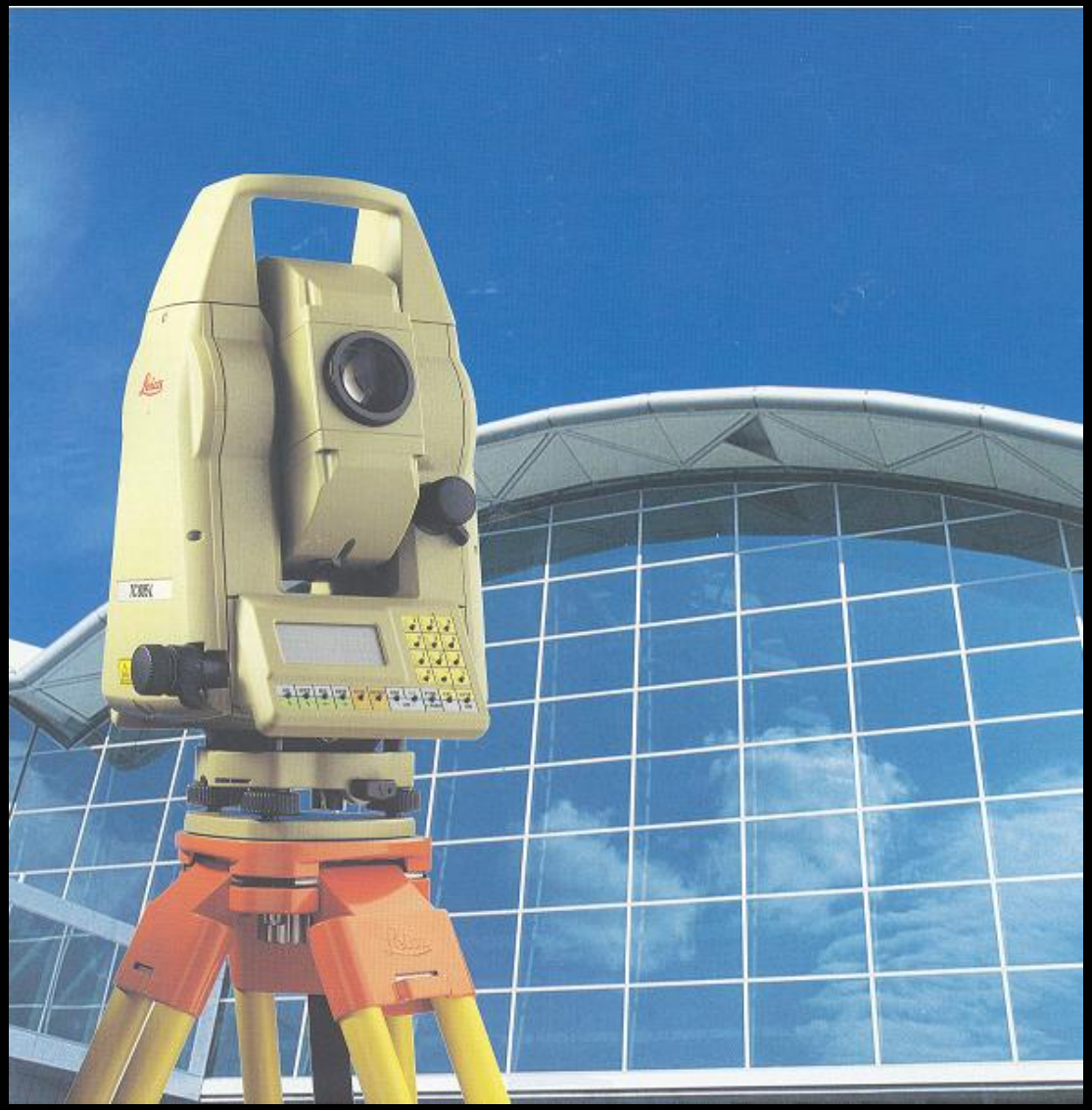


Instruments (b)

▲ MC-1202

▲ MG-3101

Instruments (c)



Work method

1. Imprinting process with the total station

- a. Dependence from the triangular network of region
- b. Calculation of the polygonal traverse

2. Imprinting process with G.P.S.

- a.Measurements for the polygonal traverse's dependence and
- b.Detailed measurements for the road's imprinting.

3. Imprinting process with compass

Error theory

- a. The average of the measurements' divergences by the apparent true value by the formula of the mean numerical error m_n:

$$m_n = \pm (e) / n$$

Where: e = the sum of the absolute values of the actual differences (error). n = the observations' number.

- b. The mean square error of the measurements m_s:

$$m_s = \pm [(ee) / n]^{0.5}$$

Where: $e = E_t - E_C$ or E_G

E_t = the true values of the coordinate from the total station.

E_C or E_G = the coordinate that was measured with compass or G.P.S.

n = determined the number of measurements.

- c. The criterion of the mean square error of the average m_M.

The above-mentioned errors defined the error of each individual measurement of the series and not the probable value of the average value. The mean square error of the average value (m_M) is given from the formula:

$$m_M = \pm [(ee) / n \times (n-1)]^{0.5} = \pm m_s / (n)^{0.5}$$

i.e. the true value X varies between the numbers (L + m), (L - m).

RESULTS

Tabel 2
Precision of research methods

Method of measurement	Coditions of measurement	Mean numerical error m_n m		Mean square error m_s m		Mean square error of the average m_M m	
		E	N	E	N	E	N
Compass	Short lenght (≤ 160 m)	1,130	2,639	2,055	3,750	0,358	0,653
	Long lenght (> 160 m)	6,566	8,433	6,571	8,460	1,549	1,994
G.P.S.	Favourable ($\Sigma_1..\Sigma_4$)	4,476	7,498	6,297	9,529	1,096	1,659
	Unfavourable ($\Sigma_4..\Sigma_5$)	6,817	11,967	7,377	12,392	1,739	2,921
G.P.S.	Points at the rights side of the forest road	6,358	12,041	6,778	12,240	1,644	2,969
	Points at the left side of the forest road	6,458	11,035	6,887	11,446	1,670	2,776
	Points on the axes of the forest road	7,83	12,088	9,123	12,417	2,213	3,012
Compass	Total	3,447	5,615	4,412	6,271	0,618	0,878
G.P.S.	Total	6,733	11,476	7,597	11,914	1,064	1,668

CONCLUSIONS AND SUGGESTIONS

In regards to the total station concerning the other instruments we can conclude:

1. The time that is required for the carrying out of the measurements is very long (because of the centring and the leveling of the instrument, orientation etc.) compared with the other methods.

2. The need for visual contact between the points is necessary, while with G.P.S. is not required is not necessary

3. In relation to the G.P.S. it is necessary to measure during the daily light and under favorable weather conditions, which with G.P.S. is not.

4. The battery is a necessaty for the measurement of the distances and of the angles, where as for the compass it is not necessary.

5. It is necessary for someone to hold the target as well as a trained personnel to handle the instrument, while for the G.P.S. it is not necessary.

6. High reliability and precison of the measurements are offered in relation to the others methods.

7. Accurate imprinting of the relief, which is independent from the existence or not of dense vegetation, while the G.P.S. requires open sky.

CONCLUSIONS AND SUGGESTIONS

- As regards to the G.P.S.:

1. The time of carrying out the measurments is incomparably shorter than whichever classical topographic method.
2. There is need for visability between the points that were imprinted.
3. It functions under whichever weather conditions for 24 hours per day.
4. The employment of one individual without specialised knowledge is required.
5. In view of the reliability and precision of the measurments it is at a disadvantage if we compare it to the classical topographic methods (Mean numerical error at DE equal with m_n = 6.733 m and at DN equal with m_n = 11.476 m, mean square error at DE equal with m_s = 7.597 m and at DN equal with m_s = 11.914 m and mean square error of the average m_M = 1.064 m at DE and at DN equal with m_M = 1.668 m).

It is put down however that up to the point P_4, where the height of the trees was 15 – 20 m and the sky was relatively open (Figure 5) the corresponding data (Table 2) were N_m = 9.5 m and E_m = 6.3 m, while afterwards the point P_4, where the height of the trees was varied round the 35 m and the sky was relatively closed, we have N_{ms} = 12.4 m and E_{ms} = 7.4 m.

Figure 5

CONCLUSIONS AND SUGGESTIONS

6. There are no imprinted regions under dense vegetation.
7. Because of the eastern orientation of the polygonal traverse larger deviations are observed in regard to the north direction 11.914 m in comparison with the deviations in regard to the east direction 7.597 m. This means numerical errors are gross errors especially because of the measurments at the point P_4.
8. The errors are dependenton on the position and number of the satellites of which receiver takes the signals and not from the position of the references points of the G.P.S. (Table 2) and this is confirmed by the larger error at north direction than at east direction (Table 2).

CONCLUSIONS AND SUGGESTIONS

As regards to the compass:

1. The time of carrying out the measurements is shorter than with the total station and higher than with G.P.S.

2. The measurements are dependent from the experience and the skill of the observer.

3. The measurements become under nearly all weather conditions during the daily.

4. Two individuals are required for the measurments of the azimuth and for the measurment of the distance with the measure tape. However kept each iron article away because that can influence the final measurments.

CONCLUSIONS AND SUGGESTIONS

5. Lower reliability and precision of the measurements by the total station and higher than the G.P.S. Mean numerical error at east direction equal with m_n = 3.5 m and at north direction equal with m_n = 5.6 m, mean square error at east direction equal with m_s = 4.412 m and at north direction equal with m_s = 6.271 m and mean square error of the average value at east direction m_M = 0.618 m and at north direction equal with m_M = 0.878 m. However gross errors no turn occurs, because in the case of an error the result is a parallel shift.

6. The imprinting is independent of the presence of vegetation or not.

7. Because of the axle turn for the adjustment on the map the magnetic deviation d = + 2^g.385 increases the distance from the beginning, it also increases the error, i.e. for L = 160.65 m, m = 2 – 3.7 m, while for L = 160 - 191.58 m, m = 6.5 - 8.4 m (Table 2).

CONCLUSIONS AND SUGGESTIONS

1. It is suggested that the hand – G.P.S. is utilized in the forest road construction as well as the preliminary designing and mapping of a forest road on a small scale (< 1 : 10000).

2. The development and application of the utilization services of the geographical place, in palmtop (Palm Computers), which will allow via the use of a hand – G.P.S., it is known the exact position of the equipment in each time. The application of this technology in the forest and in forest areas, even if it presents difficulties, particulary in forest extensive areas is very useful.


les Houches
CHAMONIX
le Biollay
Arto Tuisku

THANK YOU
FOR THE
ATTENTION