PARTICULAR REALIZATION CASES OF TOPOGRAPHICAL DETAILS NETWORK SOLVED USING GNSS TECHNOLOGY, IN FORESTRY

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In Romanian Forestry, the utilization conditions of GNSS technology are restrictive and this situation leads to the emergence of particular cases.

Most frequent cases for GNSS technology encountered in forestry are: the determination of points in forest gaps, points in the proximity of forest edge and points situated in forest compact interior.

The precision in point determination for GNSS technology in the case of forests varies as a function of site realities, a fact which imposes some minimal technical conditions.

The demands with concern to working conditions in GNSS technology are precise but there are situations which allow accurate determination of the points even in forests.

As a consequence, a series of points were determined using GNSS technology and conventional total station technology in some particular situations.

The results were compared using admissible tolerances. The possibility of the utilization of the method is presented in order to obtain final products in numerical, digital and analogical format.

Key words: *GNSS technology, technical conditions, forest gap, forest interior, forest edge, topographical details, topographical network, elevation angle.*

In Romanian forestry domain, the conditions for the utilization of G.N.S.S. technology cannot always be followed, as a consequence, a series of particular cases appear.

It is a well known fact that for the realization of appropriate observations, a condition to be respected is to avoid the covering of the horizon at an elevation smaller of 15º, also, a necessary condition is to avoid reflective surfaces which generate the multipath effect in the vicinity of sampling points.

A particular case of GPS observations in the forestry domain is represented by the positioning of the receivers in the vicinity of the forest edge.

MATHERIAL AND METHOD

The analysis of possible GPS observations in the forest proximity was performed using four geodesic GPS receivers, Trimble R3 model with L1 frequency, two receivers functioning as base and two as rovers.

The observations were performed using an experimental design with eight points situated along the same line, 10 m apart, reference point (1002) being situated at the forest edge.

The scheme of the experimental design is presented in *figure 1*.

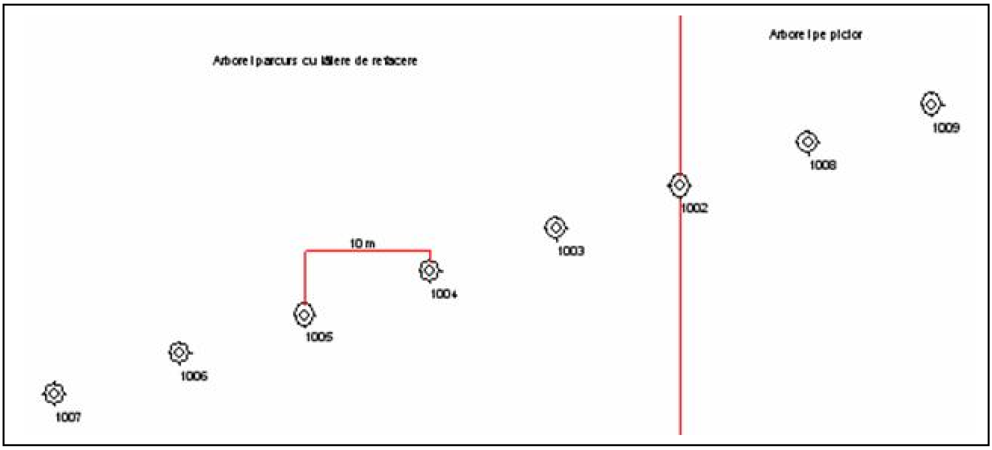

Figure 1 **Experimental design used to localize the points, GNSS technology**

Points 101 and 102 of known coordinates were determined with GNSS technology system, stationary modus with base receivers. At the sampling points of the measuring plots, the registration of data with rover receivers was performed in the stationary modus which took 20 minutes, with registration sessions of 15 seconds. As a consequence, the stationary rapid determination of the selected vectors was employed. GNSS technology with GPS system data processing was performed using Trimble Total Control (TTC) and the geocentric compensated coordinates on the reference ellipsoid WGS 84 were obtained.

Geocentric compensated coordinates corresponding to the National Reference System (Stereo 70) were obtained using the software Map Sys 7.0.

For the determination of the optimal distance for he GPS receiver positioning in the forest edge, avoiding the closure of the horizon at lesser angle than the angle established by Technical Norms (15º), a mathematical model was employed, based on trigonometric relationships.

$$tg\alpha = \frac{h_1}{d} \tag{1}$$

$$d = \frac{h_1}{tg\alpha} \tag{2}$$

$$h_1 = h - i_a \tag{3}$$

where:
h = average forest height;
i_a= apparatus height.

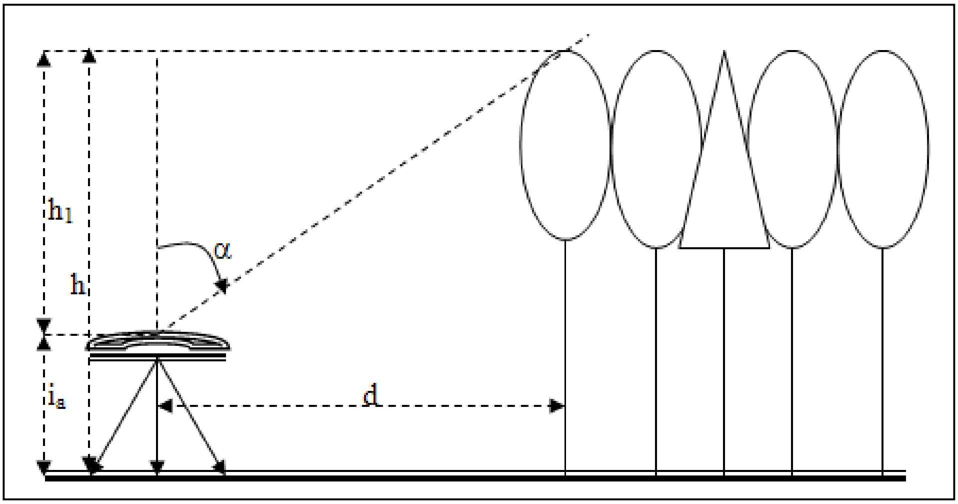

Figure 2 **Mathematical model employed for the calculation of the optimal location distance for the GPS receiver in the forest edge**

RESULTS AND DISCUSSIONS

If known values are introduced in equations 2 and 3, namely h=25,0 m and i_a=1,50, it follows:

$$d_{(m)} = \frac{25{,}0 - 1{,}50}{tg15^\circ} = \frac{23{,}50}{tg15^\circ} = \frac{23{,}50}{0{,}268} = 87{,}686$$

As a consequence, from a theoretical point of view, optimal distance for the location of the GPS receiver with respect to forest edge is 87,700 m (if horizon covering at a lesser angle of 15 degrees is eliminated).

Table 1 presents geocentric compensated coordinates on WGS 84 ellipsoid for examined points and the corresponding standard deviations.

Table 1

The listing of geocentric compensated coordinates on WGS 84 ellipsoid of the examined points and the corresponding standard deviations

Punct	X(m)	σx(mm)	Y(m)	σy(mm)	Z(m)	σz(mm)
0	1	2	3	5	6	7
1002	4017655.533	208.8	1630101.515	153.8	4662399.675	210.6
1003	4017661.294	181.6	1630093.769	119.6	4662397.269	155.8
1004	4017667.216	127.6	1630085.998	83.2	4662395.051	131.9
1005	4017673.303	72.2	1630078.321	63.6	4662392.881	76.7
1006	4017678.659	61.2	1630070.372	61.5	4662390.465	73.0
1007	4017684.307	58.2	1630062.506	53.2	4662388.094	69.4
1008	4017649.231	357.8	1630109.219	301.4	4662401.558	373.3
1009	4017644.577	590.5	1630117.249	430.9	4662404.511	635.6

Figure 3 presents the scheme of the corresponding vectors for the GPS determinations in sampling points. For the presented case, the alternative with two common vectors was employed, the choice being motivated by technical reasons.

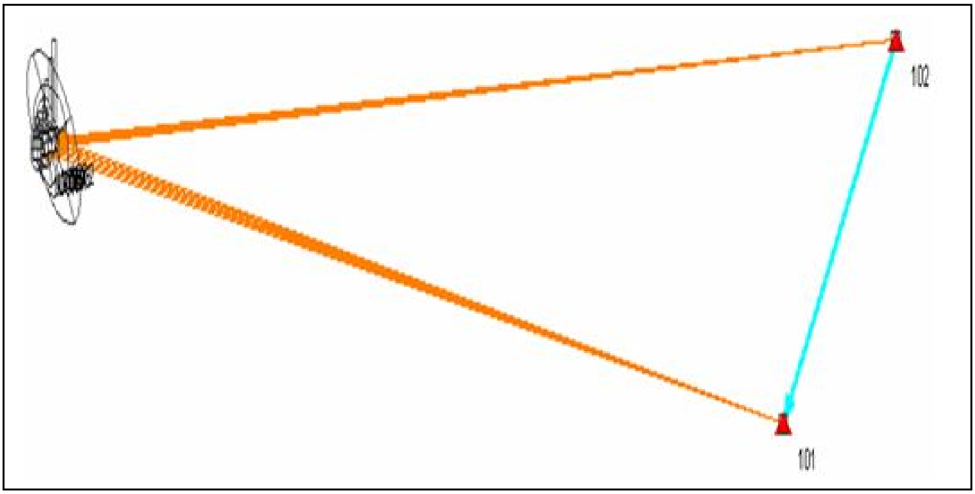

Figure 3 **Scheme of the corresponding to the observations GPS vectors performed at the sampling points**

By analyzing the data presented in *table 1,* column 2 and in *figure 4* one can observe that standard deviations corresponding to X coordinate are exponentially decreasing pace wise with the departure from the forest edge.

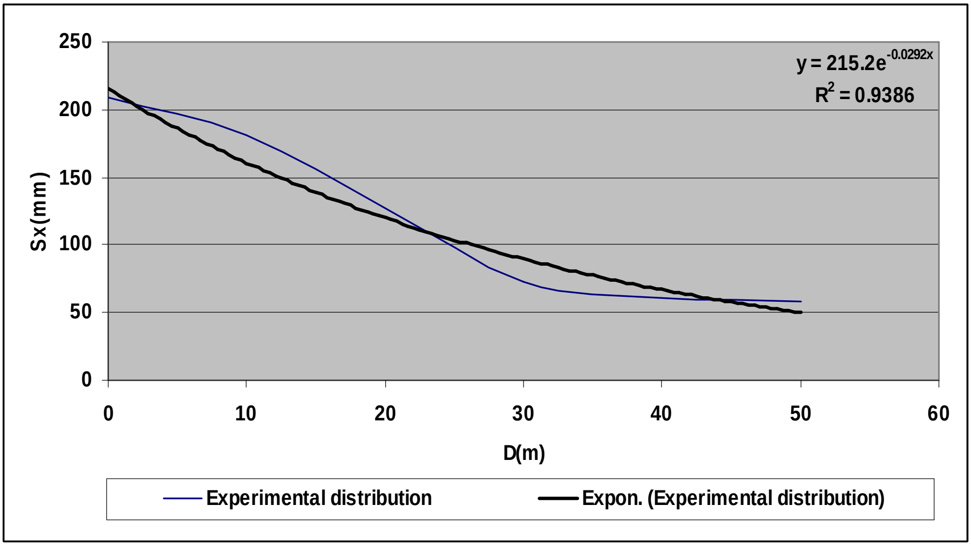

Figure 4 **Experimental distribution of the standard deviations s_x corresponding to the compensated coordinates X, of the sampled points, in geocentric system on the WGS 84 ellipsoid**

Between experimental and theoretical exponential distribution there is a pronounced correlation.

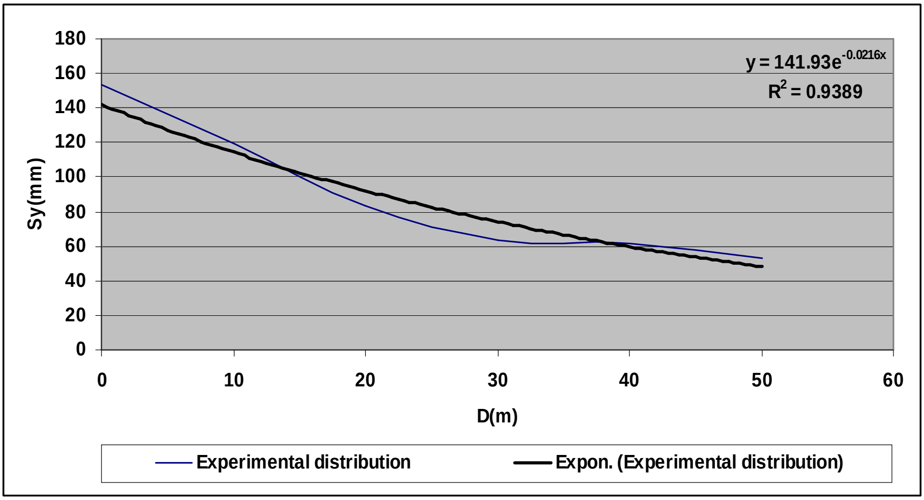

Figure 5 **Experimental distribution of standard deviations s_y corresponding to compensated coordinates Y, of the sampled points in geocentric system on WGS 84 ellipsoid**

By analyzing the data presented in *table 1* column 5 and figure 5 one can observe that standard deviations corresponding to Y coordinate are decreasing exponentially pace wise with the departure from the forest edge. Between the experimental and theoretical exponential distribution there is a pronounced correlation.

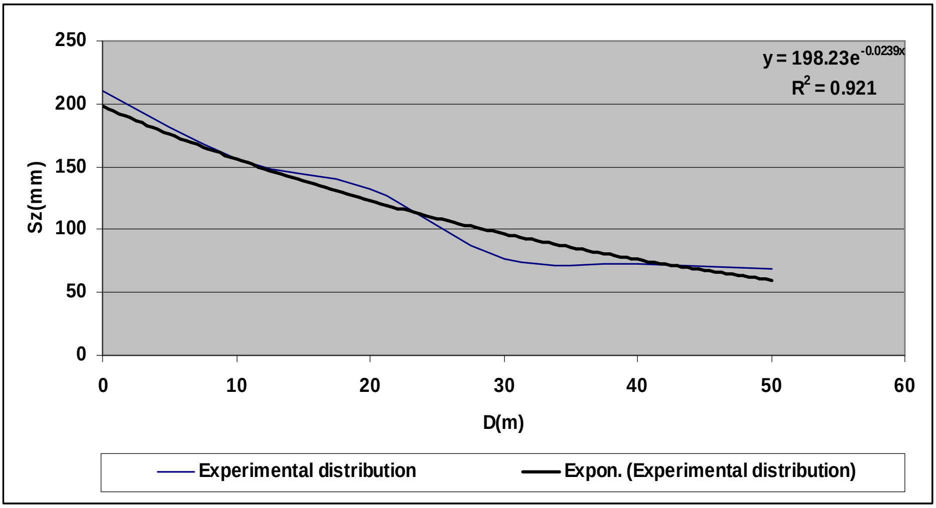

Figure 6 **Experimental distribution of standard deviations s_z corresponding to compensated coordinates Z, of the sampled points in geocentric system on WGS 84 ellipsoid**

By analyzing the data presented in *table 1* column 7 and figure 6 one can observe that standard deviations corresponding to Z S_z coordinate are decreasing exponentially pace wise with the departure from the forest edge. Between the experimental and theoretical exponential distribution there is a pronounced correlation.

Table 2

The coordinates' list of the national reference system for examined points, determined using gnss technology, gps system

Number of points	x (M)	y (M)	z (M)
0	1	2	3
1002	645350.506	279527.219	177.671
1003	645347.447	279517.848	177.509
1004	645344.409	279508.297	177.626
1005	645341.264	279498.771	177.900
1006	645338.522	279489.282	177.465
1007	645335.592	279479.753	177.268
1008	645353.631	279536.963	176.893
1009	645356.373	279546.399	177.656

Table 3

The inventory of coordinates for sampling points 1000 and 1001, excepting the vegetation season

Nr. pct.	x	y	z	Observations
0	1	2	3	4
1000	645450.592	279537.155	186.225	excepting the vegetation season
1001	645338.108	279590.837	173.993	excepting the vegetation season
1000	645450.323	279537.436	185.989	vegetation season
1001	645337.854	279591.094	173.751	vegetation season

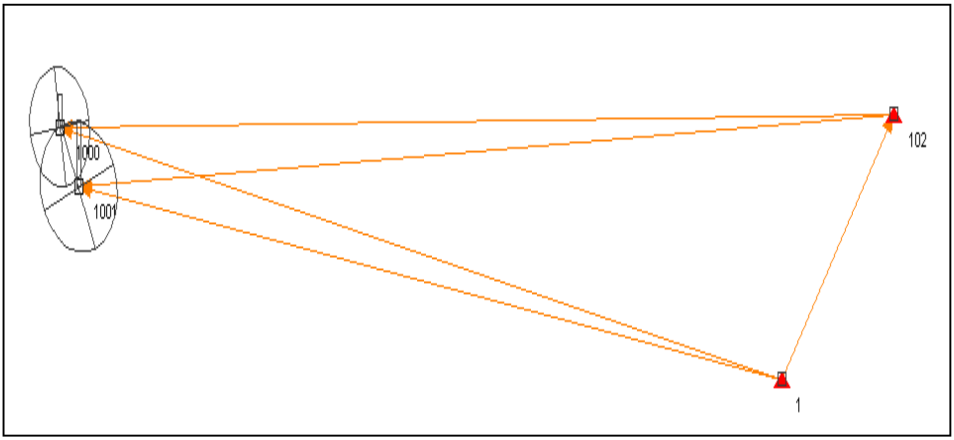

Figure 7 **Scheme of the GPS vectors corresponding to observations Performed in the forest stand, forest patch 45**

CONCLUSIONS

The realization of the observations using GNSS technology in the forestry domain, although requires a series of conditions, can offer conclusive results with regard to the precision of determination of various details.

For a superior precision of calculated points, one must take into consideration the distance between GPS receivers installed at the forest edge.

Although the realization of observations in compact forests or almost compact forests is still in the preliminary phase, the meager quantity of existing data referring to high precision GPS determinations shed light on the fact that in the future works will be performed after solving some technical problems.

One must take into consideration that the realization of GNSS observations in forestry domain must be correlated with the quiescent phase of the vegetation, in broadleaved forest stands and with height in coniferous forest stands.

The presence of forest gaps, enclaves, clearings in compact forests opens the possibility for the realization of GNSS observations which, after a proper processing (rigorous post-processing) can offer precise results.

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