COMPARATIVE STUDY ON THE DETERMINATION OF SURFACES FROM THE DIGITAL ORTHOPHOTOMAPS AND FIELD MEASUREMENTS WITH PRECISION GPS RECEPTORS

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Abstract

In the period between 2003-2007, digital and analog ortophotomaps at a scale 1:10 000 were designed for a series of territorial administrative units in Romania, based on aerial photography methods. The use of the digital support of the ortophotomaps facilitates the retrieval in real time of **the position, configuration and size of the agricultural and nonagricultural physical blocks surfaces,** which represent the primary technical database for the general cadastre.
In the case study of Bilca territorial unit from Suceava County, **315 physical blocks** were identified, out of which: **189 agricultural physical blocks** in the area outside the township, with a surface of **1853.81 ha** and **126 nonagricultural physical blocks**, within the built-up area, with a surface of **146.62 ha.** For the testing of the retrieval method of surfaces on digital support and from field measurements with GPS receptors, **six agricultural physical blocks from the unincorporated area** have been considered, with the numbers: 225, 243, 254, 275, 231 and 255, with areas comprised between **10.38 ha** (block 275) and **23.23 ha** (block 225).
The field measurements were carried out with the help of a GPS receptor (*Global Position System*), of a **GNSS South S82T type**, which ensured advanced technologies of satellite GNSS (*Global Navigation Satellite System* – GPS and GLONASS) measuring. Field observations were conducted with the kinematic positioning method in real time, which is also known as the RTK method ((*Real-Time Kinematic*). In the case of the carried out measurements the ROMPOS – RTK (*Romanian Position Determination System*) was used, which is based on the national network of GNSS Stations. By using the ROMPOS – RTK service for precise kinematic applications in real time, a horizontally positioning precision of up to ± 2 cm was acquired. With the help of **SurvCE** field software were determined the plane rectangular coordinates of the points from the outline of the physical blocks, directly into the national projection system STEREO-70. The absolute positioning precision of the considered points allowed for a thorough calculation of the physical blocks' surfaces.

Key words: digital ortophotomaps, GPS (*Global Position System),* kinematic positioning method in real time

The basic entities of the general cadastral informational system: **the plot**, **the construction** and **the owner** are identified, ascertained and registered in the technical database after performing the field measurements. For this purpose a series of modern measurement technologies are used. In the last decade the aerophotogrammetric elevation techniques (Boş, N., Iacobescu, O., 2007) and the technologies based on the *Global Positioning System – GPS* (Andrei, C., O., 2010) imposed themselves as the methods most used in this field. They are associated and completed by the detailed elevation performed with the aid of total stations.

The kinematic positioning method based on the use of GNSS receivers with two frequencies and on a short observation period in each of the unknown points assured the improvement of the horizontal and vertical precision in positioning points, up to values of centimeters (Hofmann – Wellenhof, B. et al., 2008).

Between 2003 - 2008 the photogrammetric technology was used for creating digital and analogical ortophotomaps at the scale of 1:10000 for a series of territorial-administrative units in Romania (Moca, V. et al., 2008).

After analyzing the digital graphic support of these ortophotomaps resulted the following primary data on the physical agricultural and non agricultural blocks: the cadastral number, the corresponding surface, the land use category, medium slope and others (Moca, V. et al., 2009, 2010). The global positioning technologies based on satellite navigation systems officially started being used in Romania after 1990.

At the beginning of 2008 *The National Geodetic Network of A-class GNSS – GPS Permanent Stations* included a number of **28 stations** uniformly distributed on the territory of

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the country. At the same time, *the B -class GNSS-GPS Network* with almost **303 stations** was introduced.

In the following years were accomplished a series of geodetic networks necessary for carrying out different general urban planning as well as for the introducing the general cadastral works (Păunescu, C., et al., 2011), on the basis of the National Geodetic Network of Permanent GPS Stations and the afferent positioning services.

In 2009 Romania adopted the *European Terrestrial Reference System (ETRS-89)*. In order to do so, the National Agency for Cadastral and Land Registration created a series of standard software applications. The **TransDatRo programme** distinguished itself from all the programs that were created. It was used for transforming the coordinates from the old S-42 reference system based on the Krasovski-1940 ellipsoid to the new ETRS-89 reference system.

The TransDatRo soft was tested in a large number of common points uniformly distributed on the territory of Romania and so its accuracy in transforming the coordinates was confirmed.

The root mean square (RMS) of transforming the coordinates from one reference system to the other ranged between 10-15 cm (Orosz, I. et al., 2011).

MATERIAL AND METHOD

For carrying out the comparative study on the determination of surfaces using the digital ortophotomaps and the field measurements made with GNSS receptors of geodetic precision, six agricultural physical blocks from the unincorporated area of the Bilca territorial unit from Suceava County were taken into consideration. The six agricultural physical blocks were identified on the basis of the following cadastral numbers: 225, 243, 254, 275, 231 and 255. In the territorial administrative unit of the Bilca township were identified 315 physical blocks with the total surface of 2000.43 ha. The structure of the 315 territorial blocks consisted in: 189 agricultural physical blocks with the surface of 1853.81 ha situated in the unincorporated area and 126 nonagricultural physical blocks with the surface of 146.62 situated in the incorporated area.

The georeferencing of the points from the digital contour of the physical agricultural blocks considered was performed in the cartographic system of the Stereographic projection – 1970, based on the Krasovski – 1940 terrestrial reference ellipsoid.

The field measurements were made with the GPS receiver (*Global Position System)* and consisted in the **absolute positioning** of the same points from the contour of the physical blocks that had previously been digitized on the ortophotomap. For this purpose it was used only one receiver with two frequencies, the **GNSS South S82 T type**. This receiver is realized with the most performing GNSS technology, the Trimble BD970 board. It represents the base for receiving the GPS L1, L2, L2C and L5 signal and the GLONASS L1, L2 signal.

The **NAVSTAR GPS** (*Navigation Signal Timing and Ranging) Global Positioning S*ystem is a global navigation satellite system independent from the weather conditions, developed by the USA Department of Defense (D0D).

The NAVSTAR GPS spatial segment has the following configuration:

- Number of Satellites: 24 Active, 4 Spare;

- **Geometry**: 6 planes, 4 satellites each;

- **Orbit**: MEO-20.200 km circular, 55° inclination (Block I satellites orbited at 63° inclination);

- **Orbit Period**: 12 hours;

- **Coverage**: Global.

The proper field measurements were made using the precise kinematic method of punctual positioning of the unknown points, in real time. Practically speaking the kinematic method of absolute positioning is based on a short period of observation in the unknown point.

The use of the **GNSS South S82 T** receiver and the real time kinematic positioning method, also known as **RTK *(Real Time Kinematic)*** was based on the following technical parameters for carrying on field observations:

- number of channels: 220, using the Trimble BD970 board;

- satellite signal followed: GPS, GLONASS;

- precise measurement of the GNSS phase signal, accuracy below 1 mm and 1 Hz band length;

- accurate tracking and accessing technology for the satellite signal;

- cold initiation time: 60 seconds;

- refresh rate of up to 50 Hz for recording the measurements and the position of the point;

- signal recapture: 1 second;

- RTK initiation time: 20 seconds;

- internal memory: 64 Mb (25 static hours with frequency of 1 Hz);

- length of the measuring base: ≤ 10-20 km;

- observation time: 30 seconds;

- accuracy in determining the position of the point, kinematically, RTK: 1 cm ± 1ppm (RMS)- horizontal positioning and 2 cm ± 1ppm (RMS)- vertical positioning.

The **ROMPOS** (*Romanian Position Determination System)* provides corrections for point positioning for both geodesic support networks as well as for the points from the limits of the buildings, with the following services:

- ROMPOS DGNSS: real time kinematic applications having the positioning precision between 0.5 and 3 m;

- ROMPOS RTK: accurate real time kinematic applications having the positioning precision 2 cm;
- ROMPOS GEO: post processing applications, having the positioning precision below 2 cm.

With the help of **the SurvCE software** and the services provided by ROMPOS RTK the plane rectangular coordinates of the points from the contour of the physical blocks were obtained directly in the Stereographic -1970 projection system. Starting from these coordinates and using the analytical method were calculated the surfaces of the six agricultural physical blocks situated in the cadastral sector included in the study.

RESULTS AND DISCUSSIONS

The administrative territory of Bilca, Suceava County has the following cadastral boundaries: in the **North** – the state boundary between Romania and Ukraine; in the **East** – the boundary with Frătăuţii Noi township; in the **South** - the boundaries with the townships of Gălăneşti and Vicovu de Jos and in the **West**- the boundary with Vicovu de Sus.

The geographic position of Bilca's territory mostly overlaps the **Dragomirna plateau** and a small part of **Rădăuţi depression**.

The geographical position of the territory in the northern part of Suceava lies between the northern latitudes of **47°53´45´´** and of 47°**57´30´´** and the eastern longitudes of **25°41´15´´** and **25°50´37´´** (Figure 1).

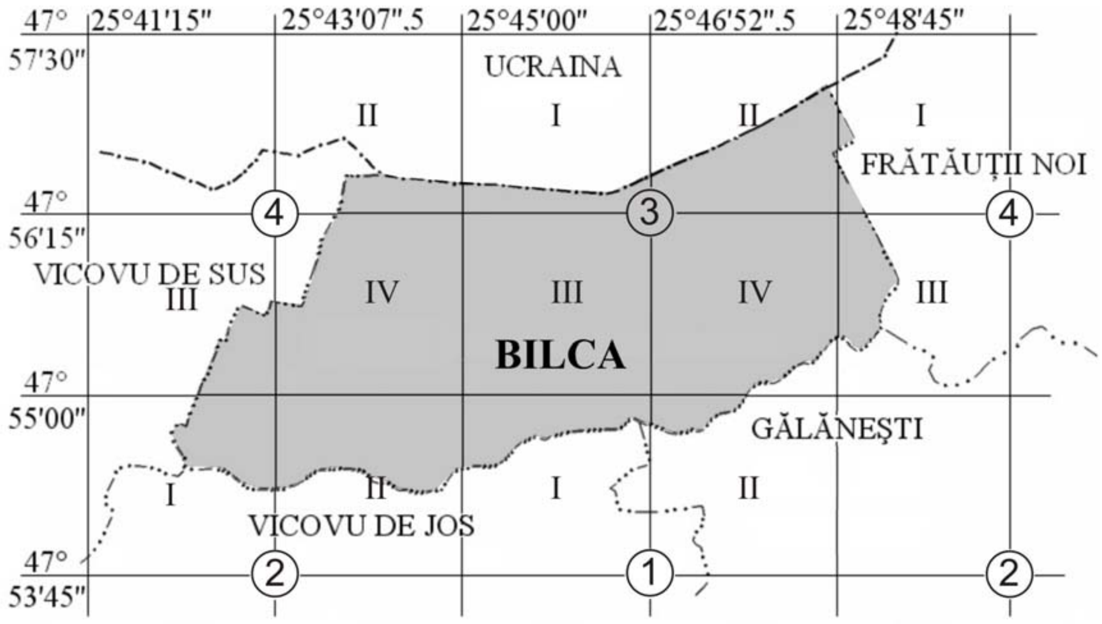

Figure 1 **Cartographic drawing on plane sheets of the Bilca territory at scales of 1:10 000 and 1:5 000**

a. Representation of the graphic database

The graphic support of the real estate fund and of the land property is officially represented by the actual system of plane rectangular coordinates of the Stereographic – 1970 projection. This "*local geodetic datum*" officially known as "*Pulkovo 42*" (S-42) or „*Dealul Piscului-România*" derives from the Krasovski-1940 terrestrial ellipsoid. By adopting in 2009 the **European Terrestrial Reference System (ETRS-89)** the gradual passage to the "*global geodetic datum*" which is based on the WGS-84 reference ellipsoid is also going to be put into practice.

In order to make the transformation of the coordinates from the local and the general datum the National Agency for Cadastral and Land Registration created the programme **TransDatRo**.

After introducing the GNSS (*Global Navigation Satellite System*) technology in the terrestrial precision measurements the user's need for software capable of transforming the coordinates from the local/general and international systems increased.

In order to use the digital fund of the ortophotomap and answer the user's different requests: **analysis, interrogation, consultation or report** and others the natural and antrophic graphic entities that exist in nature are used. They are associated to alpha-numeric information. Practically speaking, the digital ortophotomap represents a useful and necessary database for different activities in the field of agricultural planning and exploitation and respectively, the real estate fund management. In the case of general cadastral works both the digital and the analogue graphic database are used.

The sheets of the basic cadastral plans (*geodetic trapeziums*) were drawn up and edited at the scale of 1:10 000 and 1:5 000 with the nomenclature of the Stereographic – 1970 projection. The graphic component of the **Informational System of Bilca Territorial Unit** can be analogically represented on **5 plane sheets** at a scale of 1:10 000 or on **13 plane sheets** at 1:5000. In this context, the following trapeziums are mentioned: L-35-4-B-a-3 and, respectively, L-35-4-B-a-3-III (Figure 1).

b. Determining the coordinates of the control points by digitization and GPS measurements

The georeferencing of screen/raster data is the process through which a raster image representing a surface of land is transformed – by **translation, rotation, scaling and deformation** – in the official format of the coordinates in the Stereographic – 1970 projection system. Depending of the necessary precision, during the georeferencing process are used a series of transformation methods for raster images: **orthogonal** (*linear*); **afine** (*bilinear*); **projective** (*polinominal*) and **free**. Since the integration of the raster image is accomplished in a vectorial drawing that requires a "*constraint on coordinates*", the georeferencing process is also known as "*rectification*" or "*geocoding*". For verifying the results obtained after digitization and comparing them to those obtained from the field measurements with GPS receivers, six graphic entities corresponding to the agricultural physical blocks were taken into consideration. The agricultural blocks were identified on the basis of the codes: 225, 243, 254, 275, 231, 255 (*Figure 2*).

The CAD platforms represented by the programs **AutoCAD, MicroStation, Smartsketch** provide loading and integration in a vectorial composition of the raster images in a series of formats among which: BMP, GIF, TIF, JPG, PNG, RLF and others. In the georeferenced ortophotomap in the official system of coordinates of the Stereographic – 1970 projection were digitized the points from the contour of the six agricultural physical blocks (*Figure 2*).

The digitization process was based on *digitization with attachment of object data*. The process included the following stages: ***setting the digitization environment*** and the ***afferent digitization.***

In the case of the conducted study the **ground control points,** also called "*reference points*", were represented by all the fragment points from the geometric contour of the agricultural physical blocks.

The points situated in the corners of the limits of the physical blocks, easily to identify in the field, were defined as *main control points* while the others were called *intermediary points*.

In order to **exemplify** was presented the way the **control points** from the contour of **the agricultural physical block no. 231** were chosen and whose plane coordinates (X, Y) were digitalized on the ortophotomap and GPS measured in the field (Figure 3).

From the sequence of the geometrical contour of the agricultural physical block no. 231 resulted the way the **19 control points** were chosen and used in the field. The corner points were considered **main points** while those from the contour limits were called **intermediary points**, the latter having the role to provide the best constraint for the graphic image obtained by aerophotography (Figure 3).

Once the points from the georeferenced raster image were digitized the plane coordinates and the distances between those points were obtained, in the official system of coordinates of the Stereographic-1970 projection (*Table 1*).

The control points were positioned in the field taking into consideration the distances between them, that had previously been determined by digitization. The field observations were performed with only one **GNSS South S82 T** double frequency receiver. The plane coordinates in the Stereographic-1970 projection system were obtained with the help of the SurvCE field software and the ROMPOS RTK service (Table 1).

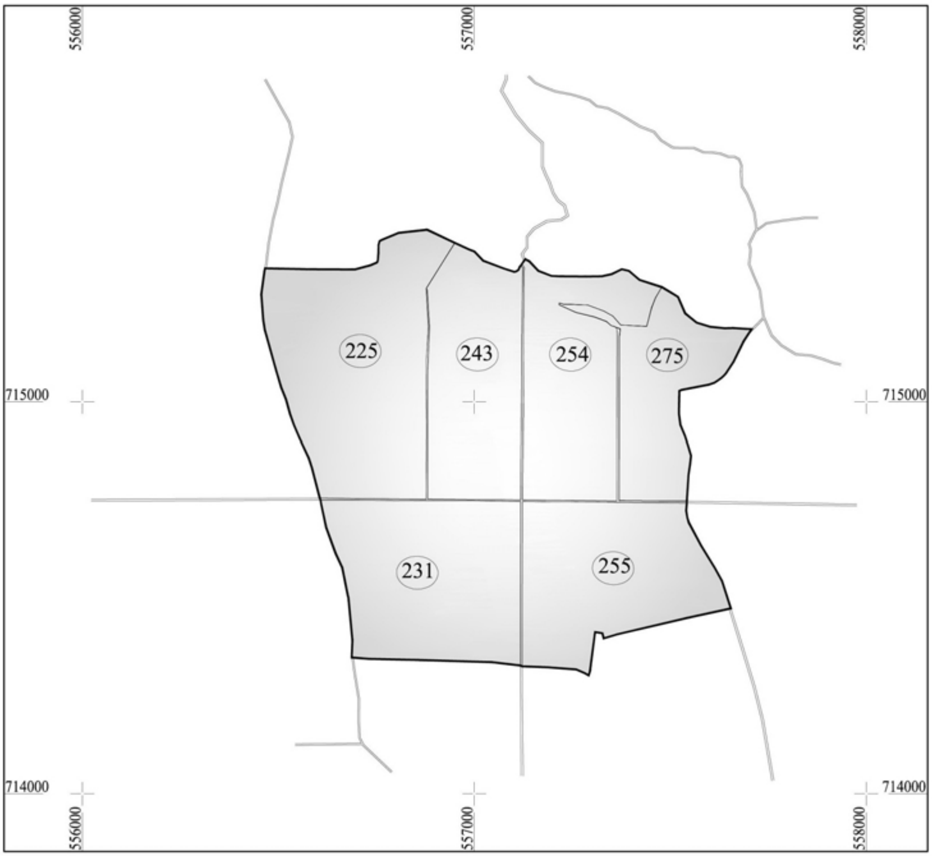

Figure 2 **The sequence of a cadastral sector in the digital ortophotomap format**

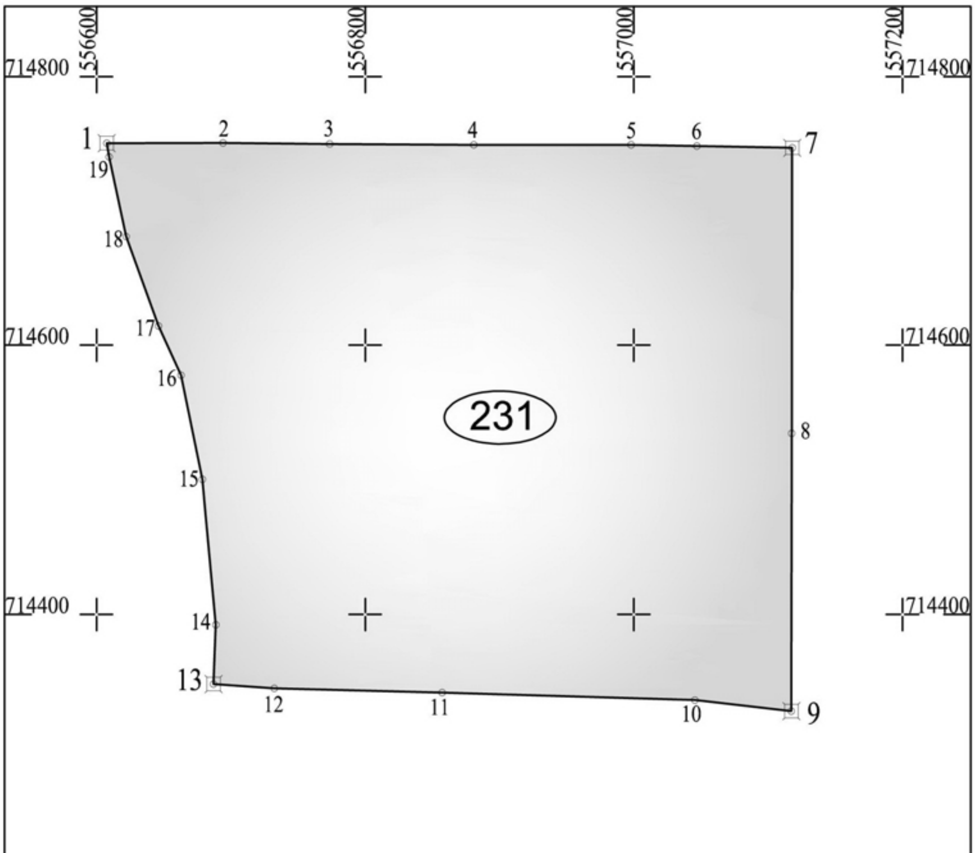

Figure 3 **Distribution of control points on the contour of the agricultural physical block no. 231**

c. The GPS positioning errors in relation to digital coordinates

The precision of the GPS punctual positioning measurements was analyzed on the basis of the differences between the values of **the double coordinates** obtained by **digitization (X_i', Y_i')** and the corresponding ones in the field that were measures in the control points **(X_i'', Y_i'')**, and presented in table 1.

These differences (δX_i) and (δY_i) represented the necessary support for determining the errors of the measurements made with the GPS precision receivers, in relation to the coordinates obtained by digitization on the georeferenced ortophotomap.

In the case of the physical **block no. 231** the differences ranged between **–0.018 m** and up to **-0.260 m**, and respectively, between **0.075 m** and **0.215 m** (table 1).

Table 1

Evaluation of the precision in determining the coordinates of the digitalized control points and measured GPS on the limits of the agricultural physical block no. 231

Point no.	Plane rectangular coordinates Stereophotographic – 1970				Differences between digitized and measured coordinates	
	Digitized on ortophotomap		GPS measured in the field			
	X_i' (m)	Y_i' (m)	X_i'' (m)	Y_i'' (m)	± δX_i (m)	± δY_i (m)
1	**714750.503**	**556607.799**	**714750.359**	**556607.628**	0.144	0.171
2	714750.484	556694.270	714750.634	556694.190	-0.150	0.080
3	714750.011	556773.312	714749.821	556773.572	0.190	**-0.260**
4	714749.246	556880.969	714749.171	556880.839	**0.075**	0.130
5	714749.121	556998.123	714749.171	556997.963	-0.050	0.160
6	714748.385	557046.772	714748.245	557046.992	0.140	-0.220
7	**714746.732**	**557118.102**	**714746.932**	**557117.934**	-0.200	0.168
8	714534.360	557117.474	714534.378	557117.550	**-0.018**	-0.076
9	**714327.898**	**557117.399**	**714328.103**	**557117.235**	-0.205	0.164
10	714336.437	557045.261	714336.252	557045.417	0.185	-0.156
11	714341.752	556857.255	714341.884	556857.311	-0.132	-0.056
12	714345.196	556732.478	714345.039	556732.363	0.157	0.115
13	**714348.337**	**556686.855**	**714348.194**	**556687.085**	0.143	-0.230
14	714392.132	556688.692	714392.337	556688.834	-0.205	-0.142
15	714500.331	556678.951	714500.116	556678.756	**0.215**	0.195
16	714577.509	556662.920	714577.674	556662.978	-0.165	-0.058
17	714614.114	556646.102	714614.225	556646.167	-0.111	-0.065
18	714680.980	556622.179	714680.844	556622.023	0.136	0.156
19	714739.990	556609.215	714740.179	556609.341	-0.189	-0.126
The algebraic sum of the difference between the [δX_i] and [δY_i] coordinates					**-0.040**	**-0.050**

The algebraic sums of the differences between the digitized and the measured coordinates of the 19 points situated on the contour of the physical block no. 231 were different from zero both on the abscissas and on the ordinates: [δX_i] = - 0,040 m and [δY_i] = - 0,050 m.

Since the two algebraic sums were different from zero, it was noticed that in those differences were included random errors as well as repetitive remnant errors. In this case it was necessary first to eliminate the influence of the systematic errors and then evaluate the precision.

The mean systematic error of the row of measurements on the abscissas and the ordinates was calculated with the formula:

$$d_{0x} = \frac{[\delta x_i]}{n} = \frac{-0.040}{19} = -0.00211\ m$$

$$d_{0y} = \frac{[\delta y_i]}{n} = \frac{-0.050}{19} = -0.00263\ m$$

The random errors from the abscissas and the ordinates were calculated in relation to the differences between the digitized and measured coordinates **$\pm\delta X_i$** and **$\pm\delta Y_i$** and respectively, the systematic errors **$\pm d_{0x}$** and **$\pm d_{0y}$** with the formula:

$$\Delta dx_i = \pm\delta x_i - (\pm d_{0x}) \text{ şi } \Delta dy_i = \pm\delta y_i - (\pm d_{0y})$$

To check the way the random errors were calculated, the algebraic sum on the abscissas and on the ordinates must respect the following conditions:

$$[\Delta dx_i] = \pm\ 0.00000\ m$$
$$[\Delta dy_i] = \pm\ 0.00000\ m$$

Further on were calculated the squares of the values of the random errors **Δdx_i^2** and **Δdy_i^2**, on the base of which were expressed their absolute sums on the abscissas [**Δdx_i^2**] and the ordinates [**Δdy_i^2**]. The following precision indicators were determined:

- The mean square error of a difference, for the coordinates X and respectively Y:

$$S_{\Delta dx} = \pm\sqrt{\frac{[\Delta dx_i^2]}{n-1}} = \pm\ 0.161\ m$$

$$S_{\Delta dy} = \pm\sqrt{\frac{[\Delta dy_i^2]}{n-1}} = \pm\ 0.159\ m$$

- The mean square error of one simple measurement, for the coordinates X and respectively Y:

$$S_{0x} = \pm\frac{S_{\Delta dx}}{\sqrt{2}} = \pm\ 0.114\ m$$

$$S_{0y} = \pm\frac{S_{\Delta dy}}{\sqrt{2}} = \pm\ 0.112\ m$$

- The mean square error of the arithmetic mean for the coordinates X and respectively Y:

$$S_x = \frac{S_{0x}}{\sqrt{2}} = \pm\ 0.081 m;\ S_y = \frac{S_{0y}}{\sqrt{2}} = \pm\ 0.079 m$$

Depending on the random errors on the abscissa (Δdx_i) and the ordinate (Δdy_i), the precision in determining the coordinates for the number of control points taken into consideration for the analyzed agricultural physical block was evaluated according to the following indicators:

- The mean square error of a difference from the row of double measurements:

$$S_{\Delta dx,y} = \pm\sqrt{\frac{[\Delta dx_i^2]+[\Delta dy_i^2]}{n-1}} = \pm\ 0.226\ m$$

- The mean square error of only one difference from the row of double measurements:

$$S_{0x,y} = \pm\frac{S_{\Delta dx,y}}{\sqrt{2}} = \pm\ 0.160\ m$$

- The mean square error of the arithmetic mean for the row of double measurements:

$$S_{x,y} = \frac{S_{0x,y}}{\sqrt{2}} = \pm 0.113 m$$

By eliminating the remnant systematic errors from the row of measurements resulted lower errors values for the individual errors of identical precision as well as for the row of measurements on the two coordinates.

d. Determining the areas with digitized coordinates and measured GPS

On the basis of the digital support of the ortophotomap were extracted the plane coordinates of the contour points that were used to calculate the surfaces of the physical blocks (*Table 2*). The following general formulas were used:

$$2S = \sum_{i=1}^{n} x_i\left(y_{i+1} - y_{i-1}\right)\ (m^2)$$

$$-\ 2S = \sum_{i=1}^{n} y_i\left(x_{i+1} - x_{i-1}\right)\ (m^2)$$

In a similar way were also computed the surfaces of the other physical blocks.

Table 2

Surface and perimeter of block no. 231

Point no.	Plane digitized coordinates on ortophotomap		D(i, i+1) Distances
	X (m)	Y (m)	(m)
1	714750.503	556607.799	-
2	714750.484	556694.270	86.471
3	714750.011	556773.312	79.043
4	714749.246	556880.969	107.560
5	714749.121	556998.123	117.154
6	714748.385	557046.772	48.655
7	714746.732	557118.102	71.249
8	714534.360	557117.474	212.373
9	714327.898	557117.399	206.462
10	714336.437	557045.261	72.642
11	714341.752	556857.255	188.081
12	714345.196	556732.478	124.825
13	714348.337	556686.855	45.731
14	714392.132	556688.692	43.934
15	714500.331	556678.951	108.437
16	714577.509	556662.920	78.925
17	714614.114	556646.102	40.284
18	714680.980	556622.179	71.017
19	714739.990	556609.215	60.417
1	714750.503	556607.799	10.508
-	S = 187384 m²		1773.768

For controlling the way the calculations for the determined surfaces were made there is a condition that the sum of the areas of the physical blocks should be equal to the surface of the cadastral sector, with constriction on this size.

The tolerance was calculated with the formula:

$$\mathbf{T_S = 0.0003\ N\sqrt{S}\ \ (m^2)}$$

where: **N** – the denominator of the planes scale;

S – the surface expressed in square meters.

Table 3

Surface and perimeter block no. 231

Point no.	Plane measured GPS coordinates on field		D(i, i+1) Distances
	X (m)	Y (m)	(m)
1	714750.359	556607.628	-
2	714750.634	556694.190	86.560
3	714749.821	556773.572	79.390
4	714749.171	556880.839	107.270
5	714749.171	556997.963	117.120
6	714748.245	557046.992	49.040
7	714746.932	557117.934	70.950
8	714534.378	557117.550	212.550
9	714328.103	557117.235	206.280
10	714336.252	557045.417	72.280
11	714341.884	556857.311	188.190
12	714345.039	556732.363	124.990
13	714348.194	556687.085	45.390
14	714392.337	556688.834	44.180
15	714500.116	556678.756	108.250
16	714577.674	556662.978	79.150
17	714614.225	556646.167	40.230
18	714680.844	556622.023	70.860
19	714740.179	556609.341	60.680
1	714750.359	556607.628	10.320
-	S = 187485 m²		1773.680

For the ortophotomap's scale of **1:10 000** and the surface of the cadastral sector of **996 163 m^2** resulted the value of **2994 m^2.** In the conducted study the surfaces of the six agricultural physical blocks were also established in relation to the coordinates resulted from the GPS precision measurements (table 3).

At closing the physical blocks on the total surface of the cadastral sector taken into consideration, in case of the surfaces determined with the coordinates resulted from GPS measurements, the following formula was used for identifying the tolerance:

$$T_S = E_t \sqrt{S} \ (m^2)$$

where: E_t – the admissible error in appreciating the position of the limits between the properties;

S – the surface expressed in square meters.

The *technical norms* of introducing the general cadastre and land registration have regulated the admitted error in appreciating the positioning of the points and the limits between the properties, with values of **0.05 – 0.10 m** for the incorporated areas and **0.10 – 0.20 m**, for the unincorporated areas.

For the officially admitted error of **0.15 m** in appreciating the limits between properties, valid for the unincorporated areas of the cadastral units with the surface of **995845 m^2** the tolerance obtained was equal to **150 m^2**. The discordance between the surface of the cadastral unit calculated from the coordinates of the digitalized points and respectively from the coordinates of the GPS measured points in the field was of + **318 m^2**. In the study the closing error of the digitized surface was compensated first on the area that was established by GPS precision measurements.

The cartographic presentation of the cadastral sector on the plane elevation trapezium, at a scale of 1:5000 pointed out its inclusion in the geodetic trapezium with nomenclature **L-35-4-B-a-3-III** and **control area** of **540.9816 ha**, that represent the undistorted size from the projection plane. This process continued with the compensation and the constriction of the areas of the agricultural physical blocks on **the control surface of the geodetic trapezium**, that from a cartographic point of view consists in the bounder lines of the cadastral sector.

CONCLUSIONS

The geospatial database that was consulted from the digital ortophotographs assured the necessary accuracy in establishing the agricultural and nonagricultural graphic surfaces, for coordinating the services and the decisions taken at the level of the local community.

The mean square error of only one difference from the row of double measurements of the plane rectangular coordinates on a set of **19 commune points**, using the digital ortophotomap method and the GPS receivers measuring method on the field was of ±**16 cm.**

The accuracy provided by the measurements of the relative planimetric position of the commune points for **the six agricultural physical blocks** situated in the unincorporated area ranged between ± **15 cm** and **±20 cm**.

The methods and the proceedings used at the comparative study on determining the surfaces of the physical blocks from the unincorporated area, on the basis of the commune points lead to a surface of **99.6163 ha** for the digitization and of **99.5845 ha** for precise punctual positioning with GPS receivers.

The difference of +**318 m^2** between the digitized surface on the ortophotomap and the GPS measured one in the field of the cadastral sector taken into consideration and assigned to the six agricultural physical blocks was compensated first, on the area obtained by GPS measurements.

The constraints and the compensations of the areas of the agricultural physical blocks were made on the control surface of **540.9816 ha** of the trapezium of cartographic presentation of the cadastral sector.

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