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ASPECTS REGARDING THE USING OF ORTHOPHOTOMAPS IN CADASTRAL WORKS

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Abstract

The introduction of cadastre in Romania as a matter of national interest and community obligation, in order to guarantee property rights, real estate market development, credit guarantee, etc., is dependent upon the digitisation of the basic cadastral plan at a scale of 1/5000 all across Romania. The technologies used are varied and the work is complex, involving large expenses. Within this context, the present work aims to determine whether and to what extent this cadastral plan can be obtained through the transformation or vectorization of the existing national orthophotoplans. The methodology is based on comparing the vectorised cadastral plan with the one obtained by level surveys, considered as a reference, and applied to six units (land areas) located in two different places. Comparisation has focused on the main stages of the vectorization process, namely on easily identifying parcels (property estates) and tracking their borders, on markings positioning accuracy, on surface errors that may arise in relation to real errors, and on aspects regarding performance, including hardware and software logistics. The results are good, fully satisfactory, suitable for practice in many categories of surveying projects and particularly advantageous in terms of performance that is ensured with minimum equipment. Some difficulties arise only in special cases on site, when additional evaluations and monitoring is required.

Key words*:cadastral plan, orthophotoplans, comparisation, vectorisation .*

INTRODUCTION

The delay in initiating the works for the introduction of cadastre hardly finds its grounds since the new GPS national/spatial geodetic network is practically achieved, the legislative, administrative and organisational framework is well consolidated, the hard and soft equipments are well represented, and the number of highly qualified, well-trained specialists is sufficient (Boș and Iacobescu, 2009).

Romania's choice in creating the basic cadastral plan at the national level, as presented in the current legislation, relies on the concept of „using the existing plans, as a cost effective solution"; this was probably thought to be more productive also, however none of these two arguments was confirmed in more than 15 years of work, for which reason the need arises for a new approach of the issue (Boș, 2003).

The lack of a coherent cadastral policy and of a work methodology that would ensure reasonable expenditure, including the technical requirements for new reference works, cannot however be justified, despite the fact that many theoretical solutions were proposed by beginners in the field during the two post-revolution decades. I hope my proposal to use the orthophotomaps for the purpose of obtaining the 1:5000 scale cadastral plans through vectorization falls within these efforts.

MATERIALS AND METHODS

The imagery (materials) used for the research, which covers the examined areas, consists of the digital orthophotomaps available for the entire national territory. These pieces are actually slightly different from each other depending on their main characteristics (Chițea et al, 2003):

- *for both locations, i.e.* Sf. Gheorghe and Tg. Mureș, we used the *standard, colour orthophotomaps at the scale of 1:5000,* obtained during the APIA 2005 action;

- in addition, *for Tg. Mureş location,* a 1:500 scale orthophotomap obtained as a result of an experiment performed in the year 2009 was also available.

The methods that were applied to perform the analysis and present the results are those commonly used and especially materialized in the *methodology used* for the whole of the works. At the core of this methodology lie the *direct observations* performed and retained on the occasion of the field works and data processing. We equally made use of *indirect observations* achieved through additional work stages dependent on collateral factors.

The methods used during the present study are: the direct comparison method, the statistical method.

RESULTS AND DISCUSSIONS

The main objective of our research is to render in digital format the parcels and the properties vectorized on the orthophotomap, respectively, all gathered in a cadastral plan. The shape and dimension of these units, as their defining elements, are reflected in the plane coordinates x, y of the polygon peaks that make up the parcels, which coordinates are given in stereographic '70 projection.

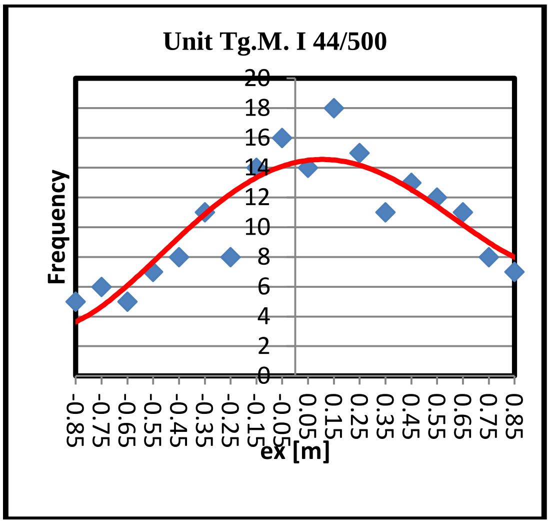
These coordinates, pertaining to all the points from the examined locations and units, are *the primary, entry data* for the works, being obtained in two distinct ways:

- *by means of the terrestrial method*, namely through geo-topographic surveys in their normal, well-known order;
- *through vectorization of the existing orthophotomaps*, using adequate methodology and equipment.

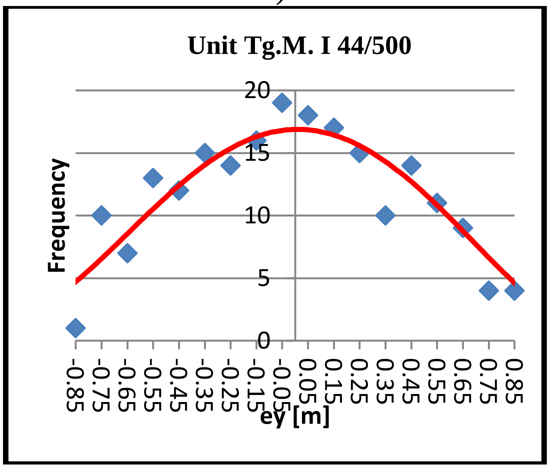
Through the adequate processing of these data and the comparison of the results, and taking as reference the terrestrial values, we can draw adequate conclusions on this paper's main objective.

For all the examined points, whose plane coordinates x, y were determined, irrespective of the considered location and unit, we calculated the total positioning error e_t. We initially deduced the two partial errors e_x şi e_y as differences between the abscissae and ordinates of the same point obtained through vectorization and through terrestrial surveys.

These values were then centralized and recorded in special forms and, in the end, the partial errors on the two axes were also represented graphically (Figure 1).



a)



b)

Figure 1. Distribution of partial vectorization errors
a) errors e_x b) errors e_y

The total errors e_t, very numerous and calculated for each vectorized point, were then processed to make them easy to follow and interpret, in two stages:

- *their grouping in 5 cm classes*, together with the specification of the number of points included in each class and the calculation of the individual and cumulative percentage errors, up to a certain level, against the total number of points from the unit (Table 1);
- *their stratification*, for the same purpose, on *25 cm* intervals, with the same columns as in the preceding classes, but also comprising the data for each location and unit as a whole (Table 2).

Table 1. Total positioning errors (e_t) on 5 cm classes
-Unit Tg.M. I 44/5000-

Total error (m)	Number of points		Percents %	
	layer	accum.	layer	accum.
<0.05	2	2	0.86	0.86
0.05-0.10	9	11	3.88	4.74
0.10-0.15	7	18	3.02	7.76
0.15-0.20	21	39	9.05	16.81
0.20-0.25	27	66	11.64	**28.45**
0.25-0.30	29	95	12.50	40.95
0.30-0.35	12	107	5.17	46.12
0.35-0.40	9	116	3.88	50.00
0.40-0.45	4	120	1.72	51.72
0.45-0.50	5	125	2.16	**53.88**
0.50-0.55	13	138	5.60	59.48
0.55-0.60	5	143	2.16	61.64
0.60-0.65	6	149	2.59	64.22
0.65-0.70	7	156	3.02	67.24
0.70-0.75	9	165	3.88	**71.12**
0.75-0.80	8	173	3.45	74.57
0.80-0.85	9	182	3.88	78.45
0.85-0.90	4	186	1.72	80.17
0.90-0.95	3	189	1.29	81.47
0.95-1.00	3	192	1.29	**82.76**
1.00-1.05	6	198	2.59	85.34
1.05-1.10	2	200	0.86	86.21
1.10-1.15	4	204	1.72	87.93
1.15-1.20	4	208	1.72	89.66
1.20-1.25	3	211	1.29	**90.95**
1.25-1.30	5	216	2.16	93.10
1.30-1.35	3	219	1.29	94.40
1.35-1.40	3	222	1.29	95.69
1.40-1.45	0	222	0.00	95.69
1.45-1.50	1	223	0.43	**96.12**
1.50-1.55	1	224	0.43	96.55
1.55-1.60	1	225	0.43	96.98
1.60-1.65	0	225	0.00	96.98
1.65-1.70	0	225	0.00	96.98
1.70-1.75	0	225	0.00	**96.98**
1.75-1.80	0	225	0.00	96.98
1.80-1.85	1	226	0.43	97.41
1.85-1.90	0	226	0.00	97.41
1.90-1.95	0	226	0.00	97.41
1.95-2.00	0	226	0.00	**97.41**
> 2.00	6	232	2.59	**100.00**

The surface area errors, which accompany the values resulting from vectorization, derived from the values obtained for a certain cadastral unit (parcel) through vectorization (S_v) as compared to the one obtained through topographic surveys (S_t), respectively:

$$e_s^i = S_v^i - S_t^i \qquad \text{(relation 1.)}$$

Table 2. Total positioning errors (e_t) on 25 cm layers
-Location Tg. Mures I scale 1/5000-

Unit	Total error layers e_t(m)	Number of points		Percents %	
		layer	accum.	layer	accum.
44	< 0.25	66	66	28.45	28.45
479		*16*	*16*	*11.27*	*11.27*
Total		**82**	**82**	**21.93**	**21.93**
44	0.25-0.50	59	125	25.43	53.88
479		*28*	*44*	*19.72*	*30.99*
Total		**87**	**169**	**23.26**	**45.19**
44	0.50-0.75	40	165	17.24	71.12
479		*32*	*76*	*22.54*	*53.53*
Total		**72**	**241**	**19.25**	**64.44**
44	0.75-1.00	27	192	11.63	82.75
479		*28*	*104*	*19.72*	*73.25*
Total		**55**	**296**	**14.71**	**79.14**
44	1.00-1.25	19	211	8.19	90.94
479		*8*	*112*	*5.63*	*78.88*
Total		**27**	**323**	**7.22**	**86.36**
44	1.25-1.50	12	223	5.17	96.11
479		*6*	*118*	*4.23*	*83.11*
Total		**18**	**341**	**4.81**	**91.18**
44	1.50-1.75	2	225	0.86	96.97
479		*5*	*123*	*3.52*	*86.63*
Total		**7**	**348**	**1.87**	**93.05**
44	1.75-2.00	1	226	0.44	97.41
479		*9*	*132*	*6.33*	*92.96*
Total		**10**	**358**	**2.67**	**95.72**
44	>2.00	6	232	2.59	100.00
479		*10*	*142*	*7.04*	*100.00*
Total		**16**	**374**	**4.28**	**100.00**

The partial errors e_x and e_y, namely the differences between the dx and dy coordinates on the two axes, calculated for the 998 vectorized points, were presented as tables. Their analysis indicates that:

- *the absolute values* are generally comprised between -2.50 m and +2.50 m, and sometimes, in difficult cases, even between -2.50 m and 3.00 m;
- from the *distribution* viewpoint, they fall within the Gauss curve, with a maximum

value of the small errors of up to 0.50 m (Figure 1).

The total positioning errors (e_t), much more important for result interpretation, were also calculated for the whole set of vectorized points using the well-known relation (1.). These errors identified within the study units were initially grouped in *5 cm classes*. Then, since the tables and values concerned were too numerous and difficult to follow, the total positioning errors were grouped in *layers* with larger *25 cm* intervals for all the locations and work units. These layers contain each and every time and for each class pertaining to the layer the total errors $\boldsymbol{e_t}$,, as well as the corresponding *individual* and *cumulative* percentages.

Result interpretation shows that:

1. The positioning precision of the points that define the parcel polygon can be expressed both as absolute values, as well as, clearer, as percentage of those falling within a certain limit.
2. The grouping of the total errors for the studied units (sectors) in ± 5 cm classes provides basic information, both as numbers and as percentages.
3. The graphic representation of these errors according to frequency, respectively the percentage of their occurrence as compared to their total number, is even more suggestive. The differences group themselves around a compensating curve, making it possible to establish a polynomial regression equation which shapes the layout of the two variables (figure 1);
4. In some cases, the value of the correlation coefficients is high, exceeding 0.90, which indicates a tight link between the differences in the two sets of coordinates and the frequency of their occurrence expressed as cumulated percentage (Figure 2).
5. The purpose of these curves is to allow rapid determination of the frequency of occurrence of some differences (total errors) of a certain size. For instance, in the case of a ±0.50 m limit with its origin on the ordinate, we can deduce that the probability for the vectorized elements to fall within this tolerance is of 45-46%, while the ± 1.00 m difference (error) would include 80% of these elements (Figure 2).

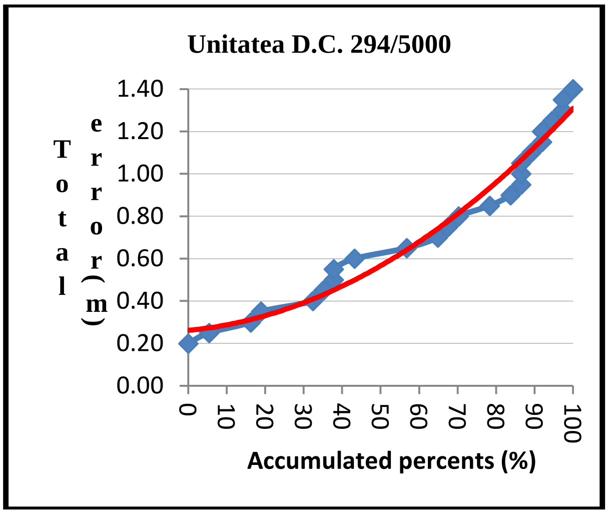


Figure 2. Total positioning errors (e_t) through vectorization

6. The same values that were expressed as number of points and error percentages in the 25 cm layers, both individually and in correlation, can also be found in the study units (Table 2).
7. The data by location, respectively the general data, fall within the same limits as the data by unit. Thus, for Dalnic – Covasna location, 52% of the determinations fall within the ± 0.50 m limit, while a little over 80% of the vectorized cases fall within the ± 1.00 m limit.
8. The lower percentage recorded for Tg. Mureş I/500 of only 27% and 62% for the ± 0.50 m and the ± 1.00 m tolerances, respectively, is due to the image quality and to difficulties in tracing some hidden boundaries (Table 3).

In conclusion, the results of our research clearly illustrate point positioning precision through vectorization of the orthophotomap and, implicitly, the possibility of drawing up the cadastral plan. Although the procedure is easily available and productive, the precision of the results is limited especially by the natural conditions, which makes them useful only for certain categories of works.

With respect to the surface area analysis, the percentage values obtained from the differences were stratified in 0.5% intervals from which we deducted the frequency of occurrence of these differences resulting from the vectorization process (Table 4).

Table 3. Total positioning errors (e_t) on layers of 25 cm -Location Tg. Mures I scale 1/500-

Unit	Total error layers e_t(m)	Number of points		Percents %	
		layer	accum.	layer	accum.
44	< 0.25	19	19	4.20	9.74
479		*28*	*28*	*17.07*	*17.07*
Total		**47**	**47**	**13.09**	**13.09**
44	0.25-0.50	26	45	13.33	23.07
479		*25*	*53*	*15.24*	*32.31*
Total		**51**	**98**	**14.21**	**27.30**
44	0.50-0.75	44	89	22.56	45.63
479		*33*	*86*	*20.11*	*52.42*
Total		**77**	**175**	**21.45**	**48.75**
44	0.75-1.00	33	122	16.93	62.56
479		*13*	*99*	*7.93*	*60.35*
Total		**46**	**221**	**12.81**	**61.56**
44	1.00-1.25	20	142	10.26	72.82
479		*11*	*110*	*6.71*	*67.06*
Total		**31**	**252**	**8.64**	**70.19**
44	1.25-1.50	12	154	6.15	78.97
479		*16*	*126*	*9.76*	*76.82*
Total		**28**	**280**	**7.80**	**77.99**
44	1.50-1.75	6	160	3.08	82.05
479		*4*	*130*	*2.44*	*79.26*
Total		**10**	**290**	**2.79**	**80.78**
44	1.75-2.00	6	166	3.08	85.13
479		*14*	*144*	*8.54*	*87.80*
Total		**20**	**310**	**5.57**	**86.35**
44	>2.00	29	195	14.87	100.00
479		*20*	*164*	*12.20*	*100.00*
Total		**49**	**359**	**13.65**	**100.00**

This frequency was given in percentages, both for the interval as well as cumulatively. In the end, we drew up a similar situation for the centralized values exclusively. A series of findings useful to practice can be listed with respect to percentage differences.

1. Under favorable conditions, when the boundaries and points that define the parcels are visible, the results are good and the surface area errors do not exceed 1% in 60-70 cases, rarely reaching 3% (table 4.).

2. The boundaries which prove difficult to identify and record substantial coordinate errors during the vectorization process also entail important surface area differences. Thus, for Tg. Mureş I location, both at the 1:5000 and 1:500 scales, the class defined by a tolerance of up to 1% hardly includes 50% of the determinations, while 80 vectorized surfaces fall within a 3% tolerance class (Table 4.).

3. The bigger scale (1:500) used as an experiment does not improve precision as expected considering the poorer image quality, so that the results are almost identical to those recorded at the 1:5000 scale (Table 4.).

Table 4. Added percentage differences of the areas

Location	Unit	Percents under			
		±0.5	**±1,0**	**±1,5**	**±3,0**
D.C.	294/5000	33	73	86	100
	557/5000	38	57	62	86
Tg.M. I	44/5000	13	57	53	79
	44/500	13	38	50	76

4. The correlation between the surface area difference and its size raised problems. On the graphics based on these two variables, the curve resulting from value correlation and the regression equation, of a polynomial type or some other type, do not point to a tight link between the two variables (Figure 3). However, *the correlation coefficient* is low also due to the reduced number of available determinations. When seen as a whole, these graphics indicate, however, a slight tendency of decrease in the surface area percentage errors as the surface area increases.

To conclude, all the graphics and tables drawn up indicate, in a clear and natural way, that *the surface area errors depend on the point positioning precision* reflected in the x, y coordinates obtained through vectorization.

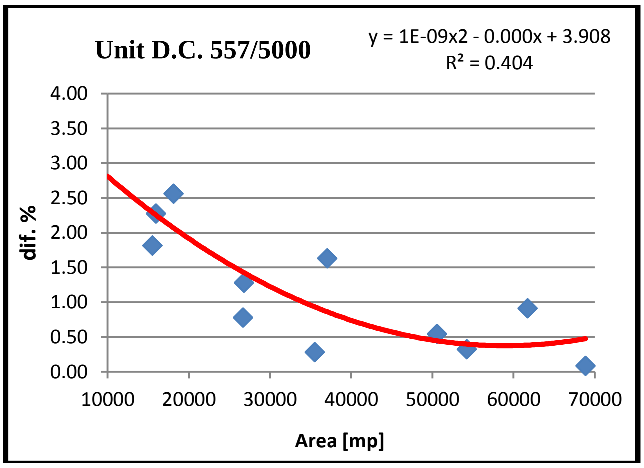


Figure 3. Correlation of percentage area differences with its size

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