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Determination of Coefficient of Usefulness of Former Austrian Cadastre Documentation for Legal-Surveying Works in Poland**

1. Introduction

Cadastre, especially real estate cadastre, should be one of important component of economy of each country. Although, there is no real estate cadastre in Poland, its role plays grounds and buildings register, established in 70' of passed century on the basis of [14] and [4] legal regulations. There have been also used documentations coming from former Austrian and Prussian cadastral systems, while Polish cadastre establishing. Now, Polish cadastre functions on the basis of the act [12], according to order [10] and in compliance with technological standards given in [7].

The most important object of any cadastral system is a parcel. In turn, the most important attribute of the parcel is boundary, which determines the range of ownership to real estate. At last, the onwership righ should be one of the basis of economy of each democratic country, including Poland [8].

In order to create well functioning cadastre one should input to cadastre accurate, reliable and update boundaries of parcels. One should add, that cadastre in Poland is now being the subject of modernization process¹. I tassumes, that one of base activities will be putting into cadastre, legal boundaries of parcels. Legal

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** Work, presented here is a result of researches, made by author within program no 10.10.150.910

¹ The term: "modernization", related to grounds and buildings register existing in Poland means, that in the nearest future this register will function by means of information technology and cadastral data will be accurate, reliable and up-to-date. Moreover, each recorded object, will have its value, called "cadastral value". Such register, will be regarded as "real estate cadastre", and all steps made while modernization process lead to such multifunctional and multipurpose cadastre.

boundary, according to [1] and [3] is a boundary determined directly in the field, with high accuracy, which has been taken by administrative decision or court verdict on the basis of suitable surveying file, accepted by chief of surveying documentation centre².

Because of the fact, that determination legal boundaries for all parcels would be extremely expensive, authorities decided that one can take temporarily, parcel boundaries with rather lower accuracy than it could be expected [7, 10].

Grounds and buildings register is currently appended by legal boundaries coming from such legal-surveying works as: real estate divisions, real estate delimitations and field works necessary for regulations of legal status of real estate. For these works, on the Poland's south-east territory, documentation (especially maps) of former Austrian cadastre is also used occasionally. This documentation is crucial for these works very often. Yet, taking into account the age of documentation and the way of its creating, usefulness of this documentation is limited, sometimes. It is worth mentioning, that for surveying-legal works documentation of former Austrian land register (ground books, mortgage books) is also used. Legal information, coming from these books is invaluable source, very often. It gives possibility to perform such works, where one must determine rights assigned to parcel and determine the range of these rights at demanded accuracy, resulting from suitable regulations.

So, it would be the good idea to determine, by easy way and not demanding complicated computer programme, coefficient of usefulness of former Austrian cadastre documentation, especially maps, for mentioned earlier works. It would make it possible to avoid precise analysis of source documentation of former Austrian cadastre and thus to save time by surveyor.

2. Detailed Unit of Cadastral Map

Cadastral map was the basis document of cartographic part of former Austrian cadastral file [11]. Cadastral map was prepared by means of plane table field survey in scales 1:720, 1:1440, 1:2880 and 1:5760. Cadastral map contained bound-

² Documentaion centre is an administrative surveying office in Poland, where all documentations, like surveying files, made by licenced surveyors are delivered and, in turn, accepted through decision and kept. It means, that they are suitably accurate, corresponding with surveying regulations and up-to-date. There are three levels of documentaion centres: local (district), regional and national. The local documentation centres perform their duties in some 380 districts in Poland. They are the most important for surveyors, who use mostly documentation kept there by means, first of all, of computer technology.

aries of parcels together with existed buildings, wells and other solid objects. The basis scale of cadastral map was 1:2880, resulting from nonmetric Wien system.

Cadastral map functioned by detailed units. Detailed unit was the basis of all surveying, cartographic and computational works. Detailed unit comes from triangulation sheet. There is no certainty, what was the type of projection, used in former Austrian cadastre. One may only assume, that it was Cassini-Soldner cylindrical, equidistant and transverse projection [13]. It is worth adding, that deformations caused by this projection increase themselves, if projected area is far away from the main meridian. Nevertheless, investigations proved out, that deformations observed in this projection are less than those, visible in typical Cassini projection [13].

The basis object of former Austrian cadastre was cadastral parcel. According to regulation from 1870, "parcel is a piece of ground which belongs to the same owner, has the same type of use and is located in the same commune".

On the basis of control points, established mainly by trigonometric triangulation method (I, II and III class) and by graphical triangulation (IV class), measurement of commune boundaries and parcels boundaries was made. The parcel measurement was made using rule "from general to detail" method by means of plane table [6].

There was also made a process of recording status of possession in the presence of owners of parcels. This process was made on the ground on the basis of the list of possessors of grounds and buildings checked by court.

Area computation was made by analytical, graphic-analytical and planimetric methods.

On the basis of calculated areas, original parcels protocol was created. Next, cadastral map, with all details, was drawn [5].

3. Determination of Coefficient of Usefulness of Cadastral Documentation

As it has been mentioned earlier, surveyors are many a time in a doubt, when they want to use former Austrian cadastral documentation, especially cadastral maps, having big errors sometimes. Thus, they are not accepted for further use although their use would be probable possible. But surveyors are not fully conscious how to use them.

Quick and easy determination of coefficient of usefulness, would make it possible to estimate, if and how such map would be useful for surveying-legal contemporary works.

3.1. Assumptions for Determination of Coefficient of Usefulness of Cadastral Documentation

Coefficient of usefulness of former Austrian cadastral documentation, should fulfil some assumptions. Here they are:

- coefficient should be very easy to determine, without any assistance of special knowledge and without computer;
- it should be possible to determine coefficient at once, in documentation centre, in the moment, when cadastral map is given to surveyor;
- the value of coefficient usefulness should also inform about the range of use of cadastral documentation;
- coefficient itself should be expressed by means of such formula, which makes it impossible to throw away documentation suitable for future use.

Taking above assumption seems to be necessary so that determination of coefficient of usefulness of cadastral documentation will have practical aspect, without any complication and trouble.

Such assumptions are especially important from the view of practical aspects of performing these surveying works, where using cadastral documentations is necessary. It also means, that mentioned coefficient should give to the surveyor possibly best results. It simply answers a question: "can former Austrian cadastral documentation (especially cadastral maps) be suitable for application or not, while contemporary surveying works".

Coefficient should be the function of cadastral parcel area. Coefficient should also be the function of quality of parcel boundary points and, at least, the function of changes, made within a parcel, occurred in the past.

3.2. Rules of Usefulness Coefficient Determination of Former Austrian Cadastral Documentation for Contemporary Surveying-Legal Works

At the beginning, one take an assumption that coefficient will be included in $[0,1]$ interval. It means that:

$$w_p = \begin{cases} 1 & \text{– for fully useful documentation} \\ 0 & \text{– for useless documentation} \end{cases} \quad (1)$$

where w_p – coefficient of usefulness from $\{0,1\}$ interval.

It denotes that coefficient can take intermediate values, denoting partial usefulness. Taking such interval is of course the matter of agreement, but it seems that it is a right solution.

For coefficient determination, in case of surveying-legal works, a rough analysis of selected part of cadastral map is necessary. One should also remark, that in case when the former cadastral map serves as contemporary cadastral map, it must be always use for surveying-legal works. So, in spite of its quality, in such case a coefficient of usefulness will have 1.0 value.

Nevertheless, if new contemporary cadastral map exists, former Austrian cadastral map can be used only optionally, according to kind of performed work. Existence of new cadastral map, made after issuing decree [4] causes, that it is necessary to compare former cadastral map to contemporary one, in order to identify a selected part of field on these maps.

The first activity which one should do in such a case is identification former cadastral parcel with the parcel existing on contemporary map. Doing it, one take into account, that contemporary parcel can include, according to [10], some pieces of grounds used of different way, but former cadastral parcel, according to [9] is a one piece of ground used in the same way. It means, that contemporary cadastral parcel can include some parcels from former Austrian cadastre. Next discrepancies can result also from changes caused, for example, real estate divisions. In such a case one former cadastral parcel can include some contemporary parcels.

The second necessary activity is comparison the area of existing (contemporary) parcel (or group of parcels) with former cadastral parcel (or group of parcels), if one can assume their identity. Big discrepancies in areas point at bad identification between parcels or that there were essential changes in their structures caused, for example assemblages of grounds. Comparison of areas will have crucial sense for detemining coefficient of usefulness.

Essential activity in determination of coefficient of usefulness is also identification of boundary corners on former cadastral map and on existing, contemporary cadastral map. There is also important to qualify them to the suitable group from the aspect of their reliability.

The most demanded, from the point of view their usefulness are corners being the crossing of three boundary lines at least [5, 6]. Such points, because they are object of interest their owners, are usually very confident, giving possibility to do correct identification of boundary line. Yet, especially big attention one should have to points, which are neither located in boundary of stream nor in boundary of forest. Points of crossing three or more boundary lines, which moreover fulfil mentioned condition, assigned to the first and the most accurate group, and gave them the biggest weight equal 1.0.

In turn, points of crossing three or more boundary lines, located at the edge of forest or stream must have less weight in the aspect of their usefulness. Less weight will also have points being connection of two boundary lines, not located on the edge forests and streams. Such points were assigned to the second group and arbitrarily weight equal 0.66 was given to them.

The least weight should be given to points where two boundary lines cross, located on the edge of stream or forest. They belong to the third group and have arbitrary weight equal 0.33.

Such classification of boundary points is, as it seems to be correct, because of different possibilities of their location within long period of time. It is necessary to take such assumption for comparison former cadastral map with the existing one.

The essential sense by surveying-legal works may have information if cadastral parcel, shown on former cadastral map is on its former shape or it changed because, for example, of parcel division made after cadastral map was created. This fact is essential taking into account the way of survey and drawing out cadastral maps in former Austrian cadastre. Updating survey was made there by a surveying tape, on the basis of original parcel boundaries. Changes, were also input on the map, on the basis of boundary parcel, not on the basis of the control. If that causes such boundaries have less accuracy in comparison to original parcel boundaries.

To resume, determination of coefficient of usefulness of documentation of former Austrian cadastre for surveying-legal works, in case when contemporary cadastral map also exists, must take into account:

- difference of areas between former cadastral parcel and contemporary existing cadastral parcel;
- qualification identified boundary points to one of the three groups of accuracies, classified earlier;
- circumstances, if former cadastral parcel was be the subject of changes at the moment of its use.

Thus, coefficient of usefulness – w_p is a function depended on partial coefficients: coefficient of area – w_{ar} , coefficient of boundaries – w_{bd} and coefficient of changes w_{ch} . One can show this function as follows:

$$w_p = f \left(\begin{matrix} \left(w_a [0,1] \right) \\ \left\{ w_b [0,1] \right\} \\ \left(w_c [0,1] \right) \end{matrix} \right) \quad (2)$$

where:

- w_p – coefficient usefulness,
- w_a – partial coefficient usefulness, depended on parcel area
- w_b – partial coefficient usefulness, depended on parcel boundary,
- w_c – partial coefficient usefulness, depended on parcel changes.

The first factor takes into account difference of areas between former cadastral parcel and contemporary existing cadastral parcel. The area of contemporary existing cadastral parcel is taken from descriptive part of cadastral register, but the area of former cadastral parcel is taken from parcels protocol or, if it does not exists, from sheet of possessing or from ground books (lwh). It has been assumed arbitrarily, that coefficient of area takes the value **1.0** in case of fully consistence of areas, takes **0.0** value in case when disconsistencies between areas will be more than 1/3 (33%). The flow of changes of this coefficient is shown on figure 1.

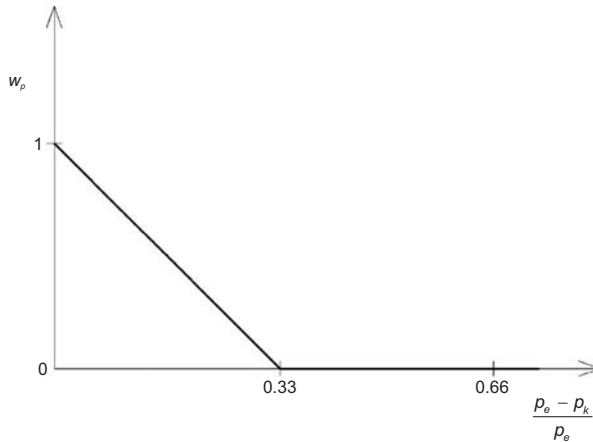


Fig. 1. Flow of changes of coefficient of area

Taking into account these assumptions, coefficient of area will have the value, described by formula (3)

$$w_a = \begin{cases} -3 \left| \frac{p_e - p_k}{p_e} \right| + 1 & \text{dla } \left| \frac{p_e - p_k}{p_e} \right| \leq 0.33 \\ 0 & \text{dla } \left| \frac{p_e - p_k}{p_e} \right| > 0.33 \end{cases} \quad (3)$$

where:

- w_a – coefficient on area,
- p_e – area of the parcel being revealed in contemporary cadastre [m²],
- p_k – area of the parcel of former Austrian cadastre [m²].

The second part of formula (2) – called coefficient of boundaries – describing coefficient of usefulness of cadastral map for delimitations or subdivisions, depends on kind of boundary corners being in the field and also depends on the quantity of identity points – both on former Austrian cadastral map and on the contemporary cadastral map. In order to compute this coefficient one should classify all identified points (on former Austrian cadastral map and on contemporary one) into mentioned earlier groups, taking them suitable weights. Taking into account these assumptions, formula of coefficient of boundary (4) is as follows

$$w_b = \frac{n_i}{n} w_i \quad (4)$$

where:

- w_b – coefficient of boundaries,
- n_i – quantity of boundary points of defined kind i ,
- n – quantity of all boundary points on contemporary cadastral map,
- w_i – weight of point of i kind, where w_i (0.333; 0.667; 1).

The last factor of coefficient of usefulness takes into account changes taking place on the parcel that time, when cadastral map was only one and obligatory on this part of Poland's territory, that is up to 1918. All changes in parcel shapes were marked in so called "appendixes", being on the last page of parcel protocol or list of parcels. Thus, in order to check if the parcel is original one or its shape was changed, one should look if this parcel is in the major part of the parcel protocol or it is in appendix. Coefficient, taking into account such fact, that parcel had some changes in its shape in the past, revealed in appendix to parcels protocol is called "coefficient of changes". For original, source parcel, coefficient of changes will have 1.0 value, because changes made of its shape, resulting for example from its subdivision, does not disqualify at once and automatically such documentation, from the aspect of their future use. So, this coefficient for parcels which changed their shape to 1918 year, taken arbitrarily as 0.75. Yet in case, when one contemporary cadastral parcel contains more than one former Austrian cadastral parcel, this coefficient would be computed from formula (5)

$$w_c = \frac{\sum_{i=1}^n w_{c_i}}{n} \quad (5)$$

where:

- w_{c_i} – coefficient of changes for parcel i , whereas $i = (1, \dots, n)$,
- n – quantity of parcels contained in contemporary cadastral parcel.

Taking into account above assumptions, formula (6) has been proposed. It describes coefficient of usefulness of cadastral documentation for delimitations and subdivisions, as

$$w_p = w_a \cdot w_b \cdot w_c \tag{6}$$

where:

- w_p – coefficient of usefulness of cadastral documentation,
- w_a – coefficient of area,
- w_b – coefficient of boundaries,
- w_c – coefficient of changes.

The maximum value of coefficient of usefulness of cadastral documentation may be 1.0, but minimum value is equal 0.0

3.3. Verification of Taken Assumptions

In order to verify correctness of taken assumptions, determination of coefficient of usefulness of cadastral documentation for selected region, has been made. As the object of researches has been chosen Kulerzow cadastral unit located in Mogilany commune. Areas of parcels of former Austrian cadastre have been received from parcel protocol, but areas of contemporary cadastral parcels have been received from existing cadastral registers.

As a result of researches, coefficient of usefulness of cadastral documentation was determined for 108 cases. For each case also partially coefficients (mentioned earlier) have been determined. Distribution of obtained values of coefficient w_p – shows figure 2.

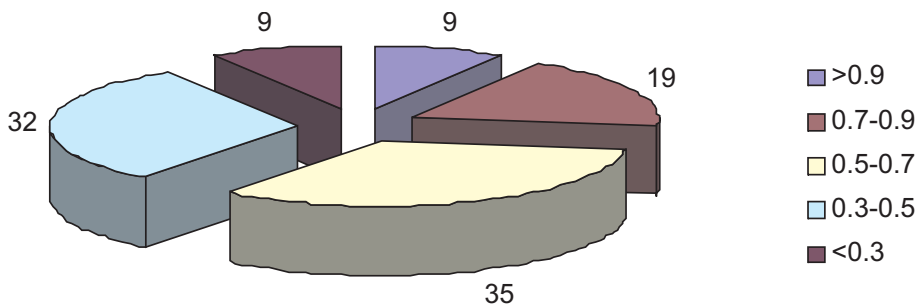


Fig. 2. Results of values of coefficient of usefulness w_p – for selected region

In order to verify, if taken parameters serving for determination of coefficient of usefulness are correct, an analysis of correlation of coefficient of usefulness and mentioned parameters. Analysis has been made by “Statistica” programme.

For statistical analysis of taking parameters of coefficient of area – w_a three discrepant cases (where coefficient of area was very small) – have been removed. These cases might considerably disturb the analysis itself.

At the first stage, an analysis of dependency between partial coefficients (that is w_a , w_b and w_c) and then, in the relation to w_p (Figs 3, 4).

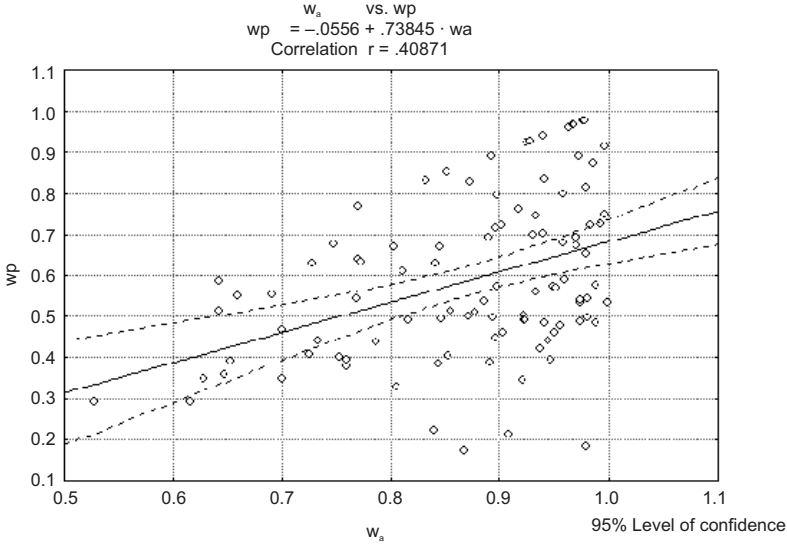


Fig. 3. Graph of dependency w_p from w_a

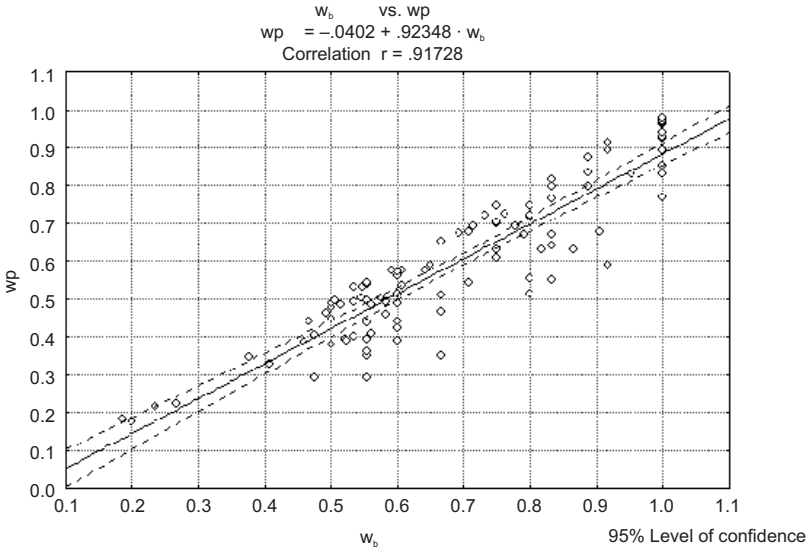


Fig. 4. Graph of dependency w_p from w_b

Analysis shows at big influence both w_a and also w_b for value w_p . An influence of w_c is less important and this probably comes from the fact, that most of analysed cases were related to original parcels, which were not subdivided later. Considering small quantity of parcel changes, partial correlations between coefficient of changes and the rest parameters one may accept as not important.

Analysing graph of dependency w_p from w_a and w_p from w_b one can see more influence coefficient w_b for increasing coefficient w_p than coefficient w_a . This remark confirms analysis of correlation between following partial coefficients and coefficient w_p . Values of Spearman correlation shows table 1.

Table 1. Spearman correlation for w_p , w_a , w_b and w_c

	w_a	w_b	w_c	w_p
w_a	1.00	0.05	-0.16	0.41
w_b	0.05	1.00	0.14	0.90
w_c	-0.16	0.14	1.00	0.20
w_p	0.41	0.90	0.20	1.00

High value of coefficient correlation for coefficient w_a (0.41) and w_b (0.90) confirms their significant influence on the value of coefficient w_p . In turn, Spearman coefficient correlation between w_c and w_p has little value -0.20. Essentially, coefficient of changes has almost, in this case, insignificantly influence on the value of the coefficient of usefulness. Nevertheless, one cant exclude a case, where quantity of changes in original parcel shape will be so big, that the influence of this coefficient on final estimation of cadastral documentation usefulness will be significant. One should also remark, that value of correlation between w_a and w_c is negative (-0.16). It comes to the conclusion that increasing of quantity of changes of parcel influences negative on correct value of area of analysed parcel.

In order to obtain more accurate analyses of influence of following partial coefficients on the value of coefficient of usefulness, partial correlation testing between these coefficients has been made. Results of test are given in table 2.

Table 2. Partial correlation for coefficients w_p

Variable of explanation	Beta	Partial	R-squar e	t(97)	Level p
w_a	0.37	0.92	0.008	23.610	0.0000
w_b	0.90	0.99	0.012	57.232	0.0000
w_c	0.06	0.36	0.014	3.7840	0.0003

High value of coefficient partial correlation for w_a and w_b shows that these two coefficients essentially influence on w_p value. In case of w_c this influence is less important. Partial correlations prove earlier analyses of Spearman correlation; it points out correct selection of parameters serving for following coefficients.

In order to analyse the influence of quantity of points belonging to groups of accuracy and quantity of points not identified on Austrian cadastral map, Spearman correlation and partial correlation of the influence of quantity these points on w_b value. Analysis of partial correlations, describing the influence of quantity of points belonging to classified groups and quantity of not identified points on Austrian cadastral map and being located on contemporary map on the value of coefficient of boundaries w_b – shows table 3.

Table 3. Partial correlation for coefficient w_b

Variable of explanation	Beta	Partial	R-square	t(96)	Level p
no points	-0.87	-0.89	0.057	-18.801	0.0000
point 1	0.39	0.65	0.076	8.335	0.0000
point 2	-0.15	-0.30	0.162	-3.063	0.0028
point 3	-0.18	-0.35	0.167	-3.711	0.0004

It is clearly visible the influence of identified boundary points, both on former Austrian cadastral map and on contemporary cadastral map, – on w_b value. Increasing of quantity of points, which were not identified on Austrian cadastral map, and located on contemporary cadastral map, in significant way makes worse coefficient w_b . If there is no possibility to identify correctly suitable points on Austrian cadastral map and on contemporary cadastral map, use of cadastral documentation is significantly difficult. Coefficient w_b is also more worse if quantity of boundary points belonging to the second and the third group of accuracy (which location in the field is doubtful) increases. Partial correlations are respectively -0.30 i -0.35. The major factor influences on increasing coefficient of w_b is in turn quantity of points belonging to the first group of accuracy (partial correlation 0.65). This influence is in consistence with assumptions, because these points belong to the most “sure”, that is they are permanent in the field, and their big quantity in the relation to all boundary points, increase possibility of use of former Austrian cadastral maps, significantly.

Analysis of Spearman correlation coefficients and partial correlation proved, that selection of parameters serving for coefficient of usefulness of former Austrian cadastre documentation w_p has been correct. Of course, values of these parameters may change in the future if estimation of the value of this documentation will be more sure.

4. Conclusions

Presented approach in determination of coefficient of usefulness of former Austrian cadastre documentation (mainly cadastral maps), gives possibility to estimate level of confidence this documentation. It is worth adding, that if former Austrian cadastral documentation play the role of contemporary cadastral documentation – their use is obligatory, no matter how they are accurate and worthy.

In case, when former Austrian cadastral map functions simultaneously along with contemporary cadastral map, it is necessary to close and tie these maps very strong.

One can state, that the most confidence one can have to old, former Austrian cadastral maps, which have coefficient of usefulness more than 0.7. Maps, which have coefficient of usefulness less than 0.5 are difficult to use.

On the basis of presented researches one can suggest formula (7) to determine coefficient of usefulness of former Austrian cadastre documentation. Here it is:

$$\begin{aligned} 0.7 \leq w_p \leq 1.0 & \text{ – full usefulness,} \\ 0.5 \leq w_p < 0.7 & \text{ – partial usefulness,} \\ w_p < 0.5 & \text{ – usefulness doubtful.} \end{aligned} \quad (7)$$

Above values may of course be corrected after verification, being results of the next, practical tests.

One should also remark, that determination of coefficient of usefulness for one parcel is easy and does not demand any complicated calculations. All documentations needed for its determinations are kept in surveying documentation centre, mentioned earlier.

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