



Possibility of application of former Austrian cadastre documentation for chosen surveying works and for cadastre modernization¹ in Poland

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1 Introduction

Cadastre problem has become very important, not only in Poland but also in the world, lately. It is emphasized in many works made by various authors, published in countries, where cadastre serves for many reasons.

Terms: „grounds and buildings register“, „real estate cadastre“, „cadastral system“ and finally „cadastre“ itself, both in Poland and in the other countries, are almost literary equalled. Such statement results from the main aims of any cadastre. These terms, used interchangeably, describe generally a system, where such objects as: parcels, buildings and sometimes apartments are registered, with all suitable attributes, describing these objects.

Among cadastral objects, the most important one is a parcel. It comes directly from ancient Roman rule, affecting ownership right. It sounds: „*superficies solo cedit*“. It denotes, using other words, that all what is on the surface of the ground, belongs to its. It is evident and visible from this fact, that a parcel is the main cadastral object, while building and apartment are, so called, „allied (with parcel) objects“ [5]. It is a reason that one should pay the greatest attention to parcel and its data. It concerns especially parcel boundaries – the most important spatial attributes of any parcel, since they determine a range of ownership right. The more accurate boundary, the better described owner's right to the parcel.

In order to create real estate cadastre of high quality, one must then initiate into cadastre: accurate, reliable and up-to-date data, concerning boundaries. They can be obtained by means of various method and sources. One of them is cadastral map, coming from former Austrian cadastre.

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¹ The term: „modernization“, related to grounds and buildings register existing in Poland generally means, that in the nearest future this register will be finally run by means of information technology and cadastral data will be accurate, reliable and up-to-date. Moreover, each registered object, will have its value, called „cadastral value“. Such register, according to [5] will be regarded as „real estate cadastre“, and all steps made while modernization process lead to such multifunctional and multipurpose cadastre. It will be one of the layer of LIS [12].

One should add, that it should be meant here as: „cadastre, which had been created in XIX and XX centuries, on the Polish territory annexed earlier by Austrian Empire“.

2 A short historic outline of former Austrian cadastre

The base for founding cadastre was an Act from 1817, given by emperor Franz the 1st, concerning tax land [10, 14]. That time, were performed investigations over surveying cadastral technologies. That time was published surveying cadastral regulation and first surveys works were also made. Started in 1817 surveys were performed on the whole Austrian territory, included Polish annexed lands. Works, dealt with new created cadastre, lasted up to 1860 year. In 1871, so called „mortgage books“, were also improved through common Act – dealt with land registry. The former Austrian cadastre was based upon surveys, performed by means of various network points, determined in given reference system. As far as reference system is concerned, one may mention according to [2] and [5], that:

- there were 7 separate cadastral reference systems in order that to diminish the influence of the Earth curvature, for cadastral projection,
- for the origin point of each reference system, geographic coordinates were determined, on the base of astronomic observation; the direction of local meridian was also determined,
- in each system rectangular coordinates were used, and at the same time south orientation was used,
- it is not known the way of projection to the plane,
- for the part of Polish territory, former called „Galizia“, three reference systems were used (called: Lvov, Wien and Hugar reference systems) – fig. 1.

There is no certainty, what was the type of projection, used in Austrian cadastre. One may only assume, that it was Cassini-Soldner cylindric, equidistant and transverse projection [2]. 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 [2].



Fig. 1: Reference systems and their ranges, used in former Austrian cadastre (source: [4] modified by authors)

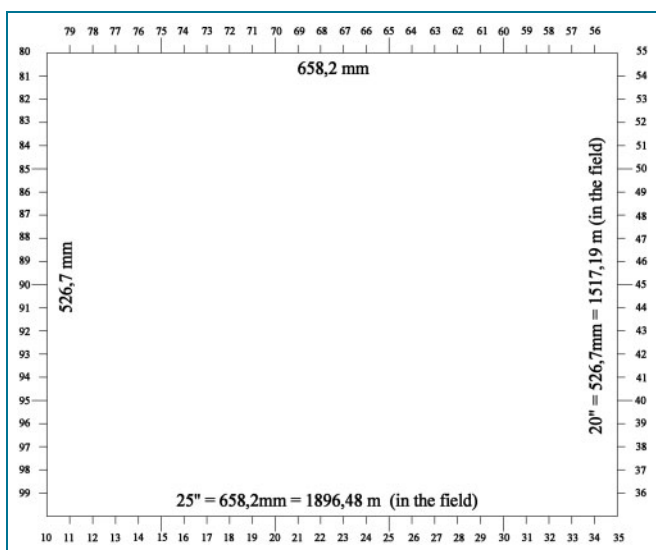


Fig. 2: The sample of former Austrian cadastral map frame, together with arrangement of „zoll dividing lines“ and their numeration (prepared on the base of [2])

Parcels measurements were performed on the base of networks points. Network of the I, II and III range was established through field surveys, while network of IV range was determined through graphic method, by means of plane table. Detailed surveys were also performed by means of plane table.

The basic scale of cadastral map was scale 1:2880, resulting from accepted nonmetric, Wien system of measure, being in use that time. One part of the cadastral map (so called „detailed unit“) is shown on fig. 2.

After the second world war, on the base of existing documentation of former Austrian cadastre, a grounds register was established in the south-east part of Poland. In turn, on the base of existing documentation of former Prussian cadastre a grounds register was established in the north and west parts of Poland. It is worth mentioning, that the former Austrian cadastre comprises some 17 % of Poland territory, while former Prussian cadastre comprises some 40 % of Poland area (fig. 3).

One should remark, that these documentations are also used nowadays in Poland, although mostly inappropriate, because of lack of scientists and technician rules of their possible application. It is worth remarking that such documentation is, many a time, priceless source of terrain in-



Fig. 3: Ranges of former cadastral systems in Poland (source: [2] modified by authors)

formation, giving possibility to perform such surveying-legal works as delimitations and partitions. In such works, extremely important problem is showing, where the range of ownership right is. It means that surveyor must prove, where real estate boundary is – with suitable accuracy, coming from obligatory regulations.

3 Possibilities of using documentation of former Austrian cadastre for surveying works

Real estate cadastre in Poland is created step by step through grounds and buildings register modernization process. It is assumed, that one of the most important activities, within modernization process, will be initiating to cadastre so called „legal boundaries“ of parcels. One may remind, after [1] and [5], that legal boundary is such boundary, which has been determined by licenced surveyor, with high accuracy, through direct measurement in the field, and that it has been accepted by administrative office or by court, on the base of suitable surveying file, made by surveyor, and kept in surveying documentation centre².

Newertheless, to bring such boundaries, described above, into practice, is extremely expensive. Although its application in Poland would be surely the best solution, yet from the economy point of view, it is not possible, for the time being, to perform such a task [5]. So, it has been assumed in regulations, that parcels boundaries in

² Documentaion centre is a very important administrative surveying office in Poland, where all documentations, like surveying files, made by licenced surveyors are delivered and, in turn, accepted through decision. 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 documentaion 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.



cadastre now, may be accepted with rather big tolerance, expressed by means of error of boundary points location [7, 13]. So, one may use, while data receiving, not only direct field method but also photogrammetry method [3]. One may also use other methods, yet under condition that received results will be in accordance with suitable criteria³ (concerning boundary data), given in [13].

Among them is cartographic method, used for obtaining boundary data. It depends on, that various maps are used, by means of various technologies and devices [5]. Although this method does not generally give high accuracy of the boundary data, but taking into account mentioned earlier regulation, one may assume that this method may also be used while grounds and buildings register modernization process, applied to forest and cropland areas. So, one may use for this purposes existing maps of various types.

One of such possibilities gives us, a still existing cadastral map, coming from former Austrian cadastre. It is a component of cadastre source documentation, being its graphic part. This documentation also comprises descriptive part, mainly in the form of „sheets of possessing“, „parcels protocols“ and „list of owners“. Among them, the first one – sheet of possessing – is strongly connected with cadastral map, since it was created on the base of the map and should be fully compatible with it.

Analyzing possibilities of using cadastral documentation for contemporary surveying works, one can remark, that the most important task within them, is transformation process of raster map, produced while scanning map, by means of scanners.

Scanned cadastral map, called later „raster“, does not have neither any coordinates expressed in any obligatory reference system, nor geometric features, necessary for its properly using especially in those surveying works, where boundary parcel problem is important and crucial. Moreover, such map comprises some errors. Here they are:

- errors resulting from field surveys,
- errors resulting from details mapping,
- errors resulting from using map and its age,
- errors resulting from scanning map process.

One should add, that cadastral maps can be transformed into suitable reference coordinate system, only on the base of control points. Unfortunately, the lack of detailed description of projection, applied for cadastral maps [8, 11], and also small quantity of still existing cadastral network points, makes such transformation impossible to perform. It is worth remarking, that mentioned transformation is usually made automatically, between two reference systems, by means of computed earlier coefficients, as it always happens.

Properly chosen type of transformation, and also properly chosen control points, makes it possible to minimize or even exclude the influence of errors, described above. The only one exception are errors resulting from field survey and errors of network points.

The value of transformation error depends on map scale. Usually, one may assume (although it has been not de-

scribed, so far), that transformation error of whole sheets of the map should be:

$$m_t = 0,1 \text{ mm} \cdot M \quad (1)$$

where: m_t – transformation error,

M – map scale denominator.

As a limit error – m_g , one can take $3 \cdot m_t$ value.

Using formula (1) for any sheet of cadastral map, prepared in 1:2880 scale, one should take transformation error as $m_t = 0,29 \text{ m}$. Unfortunately, taking into account applied projection and also age of the maps, one should expect rather worse result that, given above. One may also assume, that it will be an error less than $3 \cdot m_t$ value.

Control points can be obtained through three methods. They are complimentary each other. The first method depends on, that so called „zoll dividing lines“, mentioned earlier, are taken as control points. Strictly speaking, we take into account points, resulting from crossing out zoll dividing lines with the outer line of map sheet frame. Rules of cadastre creating make it possible to determine true, field distances between these points. The negative side of such approach is undoubtedly the lack of control points. It can cause some deformation in the middle of cadastral map sheet, while transformation.

The second possibility of obtaining control points, is suitable using surveying documentation, kept in documentation centre. Such documentations, taking into account their quality and their range, could be very useful to choose control points for transformation. Unfortunately, like in delimitations and partition cases, they may be prove as completely useless. In spite of doubt, it is advisable to applicate such points, especially in case, when there are a lot of documentations.

The third way of obtaining control points for cadastral maps transformation, for grounds and buildings register modernization purposes, is direct measurement of specific field points, like trees or so called „three boundary strips“, where three parcel boundaries meet each other in one point. One should mention, that such situation occurs not very often. If so, such point is a very accurate and proper one for raster map transformation.

The first method (of obtaining control points) is chosen mostly. In this case, one can take a local reference coordinate system or calculate coordinates of „zoll dividing lines“ points, on the base of sheet map number. In spite of, in this case, lack of control points inside sheet map, obtained results are satisfying. Transformation, performed in this way, causes that rasters have suitable geometric features, make it possible to carry on vectorization process. In order to locate exactly such raster in the space, it is necessary to perform the second stage of transformation, made on the base upon points, identified both in the map and in the field. Their position must be got from the map (through vectorization process) and also determined in the field, through direct measurement. Obviously, it is necessary to verify these points earlier.

Such prepared raster maps can serve for vectorization process. One should mention, that while grounds and buildings register modernization, the most common way of receiving data about parcel boundaries is nowadays, men-

³ These criteria are: 0.6 m i 3.0 m, respectively for urban areas and cropland and forest areas.

tioned earlier, cartographic method, where vectorization process of transformed out maps, plays very important, key role.

Presented above problem of obtaining, from cadastral map, parcel boundary data is substantial not only for grounds and buildings modernization process, but also for the other surveying works, like real estate delimitations and divisions, where parcel boundary data are crucial.

Application cadastral documentation for real estate delimitations and divisions always demands great surveyor's experience, and sometimes it must be made through individual approach. There is no one universal sample while performing them, especially by means of cadastral map. Thus, extremely important is suitable cadastral maps interpretation, from the point of view of their usefulness. Taking into account, that that is a great variety of cadastral maps in south-east part of Poland, their correct estimation is often especially complicated. One should also emphasize, that, real estate owners demonstrate mostly more confidence to former cadastral maps, than to those, contemporary made.

In the case of real estate delimitation and division, by means of former Austrian cadastral map, a very substantial problem is the most accurate fitting-in raster map into field. It can be done within local reference system, in closely neighbourhood of real estate, being an object of these processes.

There are essentially two ways of obtaining control points in such a case. The first one, not burdensome, although giving many a time wrong results, is application surveying files, resulting from surveys, done on adjoining real estate. The second way of obtaining control points (for fitting-in raster), used while delimitations and divisions process, is field survey. This way seems to be much more sure than the previous one, and giving better results. While survey, one should measure these details, which show undoubtedly the boundary line. One should pay special attention to these details. Here they are:

- „three boundary strips“, that is a place determined by crossing three boundary lines in one point,
- old trees, which were planted very often in boundary lines,
- points of old fences,
- corners of old buildings.

It is worth mentioning that such details were applied in interwar period **of time** and after the second world war, in order to verify former cadastral Austrian documentation [2, 3].

One should remark, that field survey range, in case of lack such details, must be significantly extended. It mainly results from the necessity of determination, which details were measured from one plane table station, while survey. It has important meaning for raster fitting-in accuracy.

In the case of real estate delimitations and divisions, as it has been mentioned earlier, the only small part of cadastral map is used. It causes, that if control points are chosen properly, the type of transformation method has not significant importance. Nevertheless, in order to maintain exact set of parcel boundaries, as much as possible, it seems to be reasonable to use for this purpose conformal trans-

formation method [9]. It will be mainly Helmert transformation method and multipolynomial conformal transformation method. Conformal transformation is mainly advisable, because of the necessity of preserving correct parcel shape. In spite of the fact, that cadastral maps, especially source maps and their copies, may be deformed because of their paper shrinkage, yet for a small area one can assume, that they will be inconsiderable, and almost equal within this area.

Both in the case of real estate delimitations and divisions, some chosen control points will not fit to the rest. In such a case it is essential to determine, which of them are the best for raster map fitting-in.

The choice of these points can be made through analysis of multivariant fitting-in raster map. Such method, applied in [6] depends on both analysis of parcel area, transformation control points errors and analysis of distances between parcel boundary points. The analysis range will depend, first of all, on type documentation. One should remark, that parcels areas and control points errors will be analysed mostly. Observed sometimes discrepancies between values of control points errors, may be result of separate surveys, performed on the base of different plane table stations, while establishing former Austrian cadastre.

While performing variant transformation, an essential problem is determination of limit error of control point position. Points, having errors exceeded assumed limit, will be rejected. Such limit is taken *a priori*. The best of all solutions is to take criteria for errors, as two or three times more, than assumed transformation error.

Analyzing former Austrian cadastral maps, one can often find a case, that cadastral parcel significantly changed its shape within long period of time. Such a case occurs, for example, if parcels are situated in the close neighbourhood of roads, rivers or streams and also nearby forests or timberlands.

In such a case (when changes are visible in the field) that is, if parcel boundary is not identical with, let us say, boundary of the riverside, one can not applied as control points these boundary points, which are situated close to the river. Nevertheless, one can state, that any point, situated on the boundary line and received from raster map, should also, after transformation, be situated, on the measured in the field boundary line, done by means of any two points being on it.

In this case, it seems to be essential, that one should perform such transformation, where not only „normal“ control points will be received but also some additional conditions will be taking into account. These conditions „force“ position of boundary point (being on cadastral map, of coordinates given in local, cadastral reference system) exactly on the boundary line determined by means of two points (which coordinates are given in the national reference system), measured while field survey. Of course, such presumed conditions may be more than one. They may be added to any kind of transformation. Such a method may also be used, for example, in case of the lack of control points. Moreover, obtained results seem to be more correctly than these, obtained through traditional methods of transformation.

4 Problem of usefulness estimation of former Austrian cadastral documentation

Surveyors are many a time in a doubt, when they want to use former Austrian cadastral documentation, especially cadastral maps. As it was mentioned earlier, they were prepared on the base of plane table field survey.

Thus, there is a need to create a simple method serving for estimation of cadastral quality documentation and for possibilities of its application for various surveying works. It would be very advisable if such estimation could be expressed by means of number – coefficient of cadastral documentation usefulness.

Coefficient of Austrian cadastral documentation usefulness, 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,
- coefficient itself should be expressed by means of such formula, which makes it impossible to throw away documentation suitable for future use.

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: „may former Austrian cadastral documentation (especially cadastral maps) be suitable for application or not, while contemporary surveying works“. It is really crucial question, sometimes.

Coefficient should be the function of cadastral parcel area related to existing (in grounds and buildings register) parcel area. They differs each other sometimes. Coefficient should also be the function of quality of parcel boundary points and, at least, the function of changes, made within a parcel in the past. All mentioned here problems have been presented in detail in [4].

5 Conclusion

In some contemporary surveying works, connected with real estate boundary, it is necessary to apply old cadastral documentation, sometimes. It is especially important because of the fact, that range of ownership determination needs thorough analysis, of all possible sources. One of them is cadastral map.

Former Austrian cadastral documentation, especially cadastral map, may be fully applicated to these surveying-legal processes, where real estate boundary plays a very important role, by means of suitable methods and modern techniques of its use. These processes are, first of all: delimitations, divisions and assemblages. One can also mention such processes as grounds and building register modernization⁴ and receiving data for the needs of IACS system, where cadastral map, is also very useful.

The crucial moment, while using these maps, is their suitable transformation to obligatory field reference system. One should also add, that the way of using them to the needs of delimitations and divisions will differ from the way of using them for grounds and buildings register modernization and for receiving information for IACS needs.

Thus, on the base of [4] one can mention some rules of using old Austrian cadastral maps. Here they are:

- the most important process, necessary while cadastral maps using, is correct and accurate transformation, made through suitable transformation methods,
- transformation of the part of cadastral map, for real estate delimitation or division, should be made on the base of measured control points, which position had been not changed for years; they are: „three boundary strips“, corners of buildings, and others,
- while delimitation one shouldn't use for transformation control points located near boundary line, being an object of survey,
- the best transformation method, suitable for real estate delimitation or division is affine transformation; one can also use then additional conditions for points, being located on boundary line, measured in the field,
- transformation should be made in some variants, and as a final result one should take result expressed by the least transformation error,
- as a criterion of quality fitting-in map, one should take into account (except transformation error) also other factors influenced on boundary changes through years, like: land use, relief and so on.

In turn, the most important rules which surveyor should follow, while grounds and buildings register modernization and while obtaining information for IACS purposes are as follows:

- cadastral maps transformation should be made in two stages,
- the first stage depends on map transformation on the base of „zoll dividing lines“ within local map reference system,
- the second stage depends on transformation from local map reference system to obligatory field reference system, on the base of such control points as „three boundary strips“, expressed by means of coordinates, coming from existing surveying files or from direct field surveys,
- while the first stage one should use affine transformation as giving the best results, and possible least deformations in the middle of the map,
- while the second stage one should use conformal transformation, does not change „parcels structure“, obtained through the first stage. One should also pay attention to scale coefficient, which should be close to „1.0000“ value.

Using described rules one may obtain accuracy of position boundary points not more than 0,3 m (in case of delimitations and divisions) and in case of grounds and buildings register modernization and obtaining information for IACS – some 0,6 m (the first stage of transformation). Taking into consideration, that discussed map was created in 1:2880 scale, obtained errors seem to be very small.

⁴ As it was mentioned earlier, real estate cadastre has been created in Poland, through this process.

Even though, that limit error is taken as double value, results are also very satisfied. Undoubtly, there is no possibility to obtain such results by means of other methods. This method is also very useful for correct determination of boundary line.

Presented in the paper all problems and proposals, may be applied not only in described surveying-legal processes, but also within other processes, where real estate boundary plays an important role.

Authors strongly believe that former Austrian cadastral documentation will serve properly for these works, especially for grounds and buildings register modernization, up to its successfully end.

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