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Review / Pregledni znanstveni članak

# A New Way of Cadastral Map Collection Improvement in Slovakia

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*ABSTRACT. There are several techniques for the maintenance of cadastral operates in Slovakia. One of them is the cadastral operate renewal. The process of renewal is much needed because the quality of cadastral maps is not satisfying. Only one method is usable today – the cadastral operate renewal by a new mapping. The mapping is not popular worldwide in the present, but in Slovakia, there are problems with the non-numerical maps as well as with some of the numerical ones, which also have to be dealt with. However, in case of the numerical cadastral maps with local shifts this process would be ineffective, so a new way of their renewal was proposed – Renewal by Correction. The main principle of this process is a transformation of the part of the map with local shifts to the correct position. The main aim of this paper is to propose a formal process of the Renewal by Correction. First, the criteria for the use of the Renewal by Correction were proposed. In the next part, all the formal steps of the process were described.*

*Keywords: vector cadastral map, renewal, transformation, formal process.*

## 1. Introduction

In Slovakia, the documentation of the cadastre consists of cadastral operates, which are managed per cadastral unit. The main elements of a cadastral operate are the graphical part with surveying information and the descriptive part. Cadastral operates also include the deed collection, summary data on the land, the parcel book and the railway book. The cadastral map is one of the most important components of the graphical part. The descriptive information file includes information on real estates and rights to them, on owners and other authorized persons as well as on geographic names. Some of this information is recorded in the deed of ownership (Act no. 162/1995 Coll., Decree no. 461/2009 Coll.).

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There are currently five main techniques of the cadastre for the maintenance of a cadastral operate, which are:

- creation of a cadastral operate,
- updating of a cadastral operate (keeping it up-to-date),
- cadastral operate renewal (reworking of a part of a cadastral operate),
- correction of errors in a cadastral operate,
- data revision in a cadastral operate (control of the up-to-dateness, accuracy and integrity, solution proposal).

Each of the techniques has its own particular purpose. They have existed in various forms since the establishment of the cadastre.

The cadastre of real estate in Slovakia originated in 1848 when the serfdom was abandoned. In this period, the first tools for the ownership recording were established – the land book and land cadastre. In the 170 years of the existence of the cadastre in Slovakia, a heterogeneous collection of maps has been created, which needs to be renewed.

However, low precision and inconsistencies in the cadastral maps and cadastral database are not a problem only in Slovakia, but also in other countries (Kaufmann et al. 2009, Lisec and Navratil 2014, Mika 2018, Popov 2019). In Slovakia, more than half of the cadastral maps are of a graphical non-numerical origin, their precision does not meet today's requirements, and their renewal is needed urgently. Recently, a new process for refinement of the non-numerical maps has been proposed, which is conducted along with the implementation of numerical results of measurements into the non-numerical maps (Hudecová et al. 2016, Lesňák et al. 2021). Several ways for the renewal of older, mainly graphical cadastral maps were also proposed in other countries with similar problems (Berková 2011, Siejka et al. 2015, Moharić et al. 2017, Taszakowski et al. 2018, Zrinjski et al. 2019). However, the only reliable way of renewal of the non-numerical maps is a new cadastral mapping, which produces a new numerical map with a satisfying level of precision.

## 2. Types of cadastral maps in Slovakia

There are several types of cadastral maps in the cadastral map collection. Their quality depends on their origin, the way of measurement, coordinate system, cartographic projection and the method of their updating and reworking (Horňanský et al. 2014). Nowadays all the maps are managed in the digital vector form, and thus they are called vector cadastral maps (VCM). One part of them (52%) consists of vector cadastral maps non-numerical (VCMnn), and the other part (48%) comprises vector cadastral maps numerical (VCMn).

### 2.1. Vector cadastral maps non-numerical

The vector cadastral maps non-numerical were created as a graphical result of the non-numerical measurement. They were produced in the period from

1850 to 1927. There were three historical Hungarian coordinate systems used for these maps – non-projectional system, stereographic system and cylindrical system. Most of these maps were made in the stereographic system, which used the stereographic cartographic projection. The plane table method was mainly used for the measurement of detailed points. This method is non-numerical, which means that the coordinates of points were not determined and recorded, and the only result of the measurement was a graphical map. The maps were repeatedly modified and re-drawn, so their quality decreased with time. In recent years, the maps in the analogue form have been scanned, transformed into the Unified Trigonometric Cadastral Network (UTCN) coordinate system, which is nowadays obligatory for the cadastre, and reworked into the vector form. However, the transformation between the historical coordinate systems and the UTCN system has not been precise due to the lack of identical points known in both systems, so the precision of these maps in regard to the UTCN system is sometimes not better than 5 m (Čada 2001).

Along the non-numerical maps, there are also results of newer numerical measurements from the updating procedures. In most of the maps, these numerical results are located in a separate file. In about 20% of them, the results are implemented into the non-numerical maps. Recently the numerical results has been added also into the rest of the non-numerical maps by the land surveying department. Moreover, a new methodology for this reworking has been proposed (Lesňák et al. 2021).

## 2.2. Vector cadastral maps numerical

The second group of cadastral maps consists of the vector cadastral maps numerical (VCMn). The creation of the numerical cadastral maps began in 1927 with the arrival of a new coordinate system – the UTCN system, use of which has been obligatory for the purpose of cadastre until now. In the cadastral mapping, numerical methods of measurement were used, such as the polar method and the orthogonal method. For the creation of some maps, mainly in the rural or forest areas, the aerial photogrammetry was also used. All these methods resulted in coordinates of detailed points, which were recorded along with the measured parameters, such as angles or lengths. If the map was damaged, and it could not be used anymore, the renewal was done using the recorded coordinates of points, so the map did not lose quality over time. When the position of a point in the map is determined nowadays, the positional deviation between the measurement and the original position of the point in the map should be no more than 0.24 m (Gašincová et al. 2014). However, in some cases there were mistakes made during the original cadastral mapping, mainly during the building of a detailed geodetic control network for the measurement. These mistakes were discovered only at the end of 2000s thanks to the availability of the new GNSS technology, which was independent of the old geodetic controls (Hudecová and Kyseľ 2020). Since 2013, a new way of updating these maps has been applied, where the points measured using the GNSS technology are stored in a new POINTS layer, and the new points are then transformed to the shifted map using a local transformation (Decree no. 461/2009 Coll., Guideline

no. 9/2013). Even when the cadastral map does not meet the requirements for the precision of points and includes some local shifts, in most cases these local shifts are systematic, which means that the direction and size of the shift are similar in all the points in a delimited area, so the relative quality of the map is high. A new mapping is thus not necessary, but instead of it, a new process for the correction of these local shifts in VCMns needs to be proposed in order to achieve an effective homogenization of the cadastral map collection.

## 3. Renewal by Correction

The numerical cadastral maps were created using precise surveying methods, but in a big part of them, there are local shifts, which reduce the quality of these maps. The cause of the local shifts is unknown, but it is assumed that they are a result of mistakes made during the original mapping (Hudecová and Kyseľ 2020). In most cases, these local shifts are systematic, which means that at least the relative quality of the map is satisfying. A whole new cadastral mapping would be thus ineffective for these maps, so a new way of their renewal was proposed, called Renewal by Correction (RbC). The technical part of this process is very simple, and its main principle is a transformation of the shifted map to the most probable correct position using a GNSS measurement (Kyseľ 2021). However, the whole process would not include only the correction of the map itself, but there have to be other formal steps. The main aim of this paper is to propose formal procedures for the RbC process, so it can be implemented into the surveying practice.

According to the data, which were provided by the Office of Geodesy, Cartography and Cadastre of the Slovak Republic (OGCC SR), approximately 42% of all VCMns include the POINTS layer (Fig. 1).

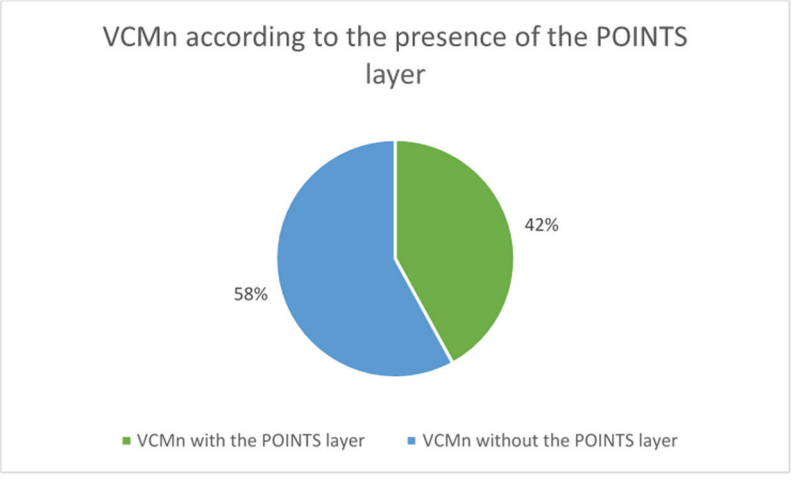


Fig. 1. *VCMns according to the presence of the POINTS layer (source: OGCC SR).*

However, that does not mean that there are no other maps with local shifts. The presence of local shifts is assessed only by the presence of the POINTS layer in a VCMn. The objects in the POINTS layer are created solely during the updating of a VCMn. If there were no updating measurements performed in the area with local shifts, there is currently no other way to find them. The number of maps with local shifts can thus be incomplete, but generally it is assumed that most of the maps with local shifts include the POINTS layer, so the number is more or less reliable. Fig. 2 shows the distribution of the VCMns with the POINTS layer according to the original cadastral mapping campaign.

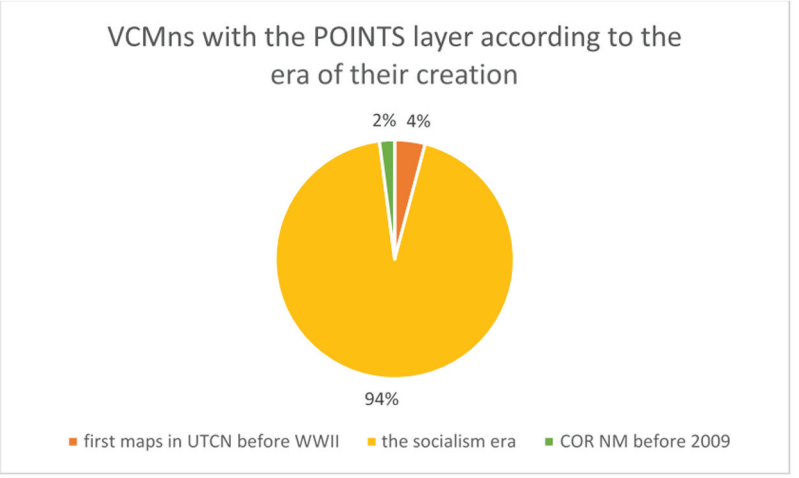


Fig. 2. *VCMns with the POINTS layer according to the mapping campaign (source: OGCC SR).*

Most of these maps with local shifts originate in the socialism era with the Technical-Economic Mapping campaign and the Basic Large-Scale Map creation campaign. In this period, the mapping was conducted in a hurry, and in some cases geodetic controls with a practically unknown precision were used to fasten the whole process. For some maps, the aerial photogrammetry was used, which could also be the cause of the local shifts. Only a few maps with local shifts were created in the oldest numerical mapping campaign before the WWII. The interesting fact is that a number of maps from the newest cadastral operate renewal by a new mapping (COR NM) campaign also include the POINTS layer, but all of these maps were created before 2009 when the terrestrial methods were used. After 2009, when the GNSS technology became compulsory for the cadastral mapping, no cadastral maps have been created which would include local shifts. Fig. 3 shows the distribution of VCMns with the POINTS layer according to the extent of the objects in this layer.

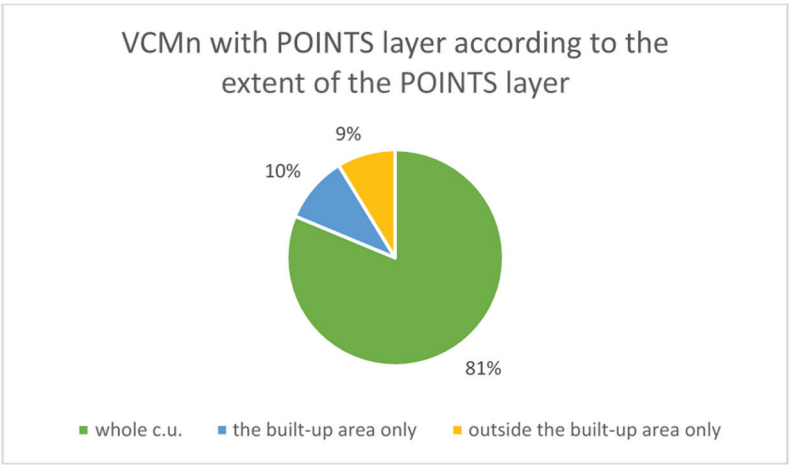


Fig. 3. *VCMns with the POINTS layer according to its extent (source: OGCC SR).*

In most of the maps, the objects are present both inside and outside the built-up areas. In the other 20%, the objects are present either only in the built-up area or only outside the built-up area. Fig. 4 shows the distribution of VCMns according to the number of objects in the POINTS layer.

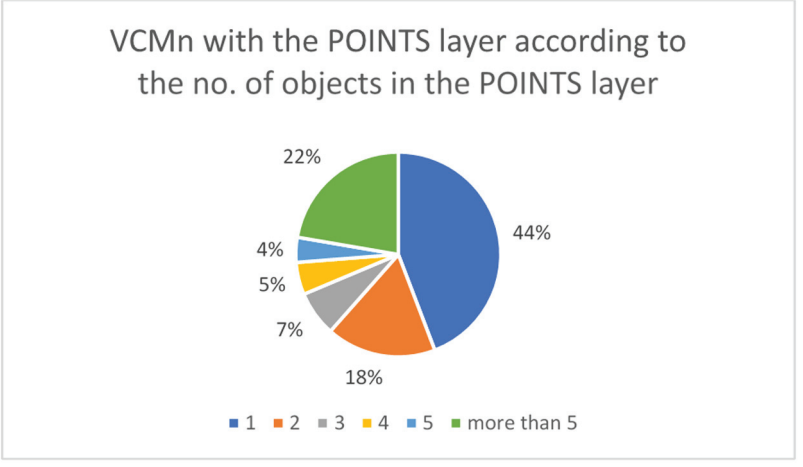


Fig. 4. *VCMns with the POINTS layer according to the number of objects (source: OGCC SR).*

In more than 75% of them, there are no more than 5 objects in the POINTS layer. This could mean that the local shifts are present in the map, but alternatively the objects in the POINTS layer could result from a mistake of a land surveyor during the updating measurement. Generally, if there are more than

5 objects in the POINTS layer, there are local shifts in the map, which need to be corrected. This means that approximately 10% of all numerical VCMs include the local shifts and have to be renewed.

## 4. The formal process of Renewal by Correction

The whole process would be executed by the local cadastral authority – the Cadastral Department of the District Office. For various tasks throughout the process, a private land surveying company could be contracted. The formal RbC process proposed has five main phases:

1. Preliminary procedures,
2. Additional measurement in the field,
3. Creation of a new graphic and descriptive part of the cadastral operate,
4. Reclamation procedures,
5. Declaration of validity of the renewed cadastral operate.

The phase 2 would be used only if needed. If there are enough points in the POINTS layer, and their configuration is satisfying, the phase of the measurement in the field is skipped.

### 4.1. Preliminary procedures

The main aim of the preliminary procedures proposed is to prepare the documentation for the person carrying out the renewal and to officially start the process.

#### 4.1.1. Choice of a suitable VCM

The proposed preliminary procedures start with the choice of a VCMn suitable for the execution of the RbC process. The cadastral authority assesses the number and configuration of points in the POINTS layer and decides on the need for an additional measurement with the GNSS method.

The main criterium for the applicability of RbC is the presence of local shifts. This criterium can be assessed automatically by the presence of the POINTS layer. The practical experience showed that the RbC process could be reliably conducted with approximately 0.5% of all points in a particular cadastral unit.

The next criterium is the number and configuration of the points in the POINTS layer, which could be used either as identical or check points in the RbC process.

The cadastral map with local shifts has to be divided into the smallest possible blocks, borders of which should be publicly-owned land parcels, such as streets or water streams.

Inside every block, there should be at least 15 points determined using the GNSS technology. However, the configuration of these points is also very important. The points should be evenly distributed along the perimeter of the block. If there are points also in the middle of the block, it is a big advantage, but it is not necessary. Fig. 5 shows the ideal configuration of identical points (red circle) and check points (green square) inside a block delimited by publicly-owned streets.

Fig. 5. *Ideal configuration of identical points (red circle) and check points (green square).*

According to the proposal, if there are not enough points in the POINTS layer which would meet these criteria, the cadastral authority decides to conduct an additional measurement using the GNSS technology. The cadastral authority also assesses:

- if the POINTS layer will be added in the near future on the basis of the updating measurements,
- if the extent of the additional measurement is not too large.

However, the criteria regarding the number and configuration of points determined using the GNSS technology cannot be assessed automatically, but a visual assessment by a human has to be conducted. If the VCMn meets all these criteria, the RbC process can be started.

#### 4.1.2. Announcement of the process of Renewal by Correction

The proposed process of renewal begins with the Announcement of the RbC start, which is sent to the local municipal office no later than 30 days before the works start. As there can be some field works and measurements, the start of the process also needs to be announced publicly, and the announcement has to be available on the website of the OGCC SR.

#### 4.1.3. Control of the state of cadastral documentation and preparation of basic documents

The cadastral authority prepares the basic documents for the person carrying out the RbC, which are mainly the valid VCMn, documentation on the origin of the map, surveying sketches documentation and descriptive files of the cadastral documentation. The cadastral authority also establishes an accompanying record, in which all the important matters relating to the process will be recorded. During the preparation of the documents, the compliance of the VCMn with the descriptive part of the documentation is verified, and all the updates of the VCMn are executed. In this phase, a preliminary perimeter of renewal is specified, which will be particularized after the homogeneity analysis.

#### 4.1.4. Additional measurement in the field

According to the formal procedure proposed, the phase of the additional measurement is executed only if the cadastral authority decides that it is needed and useful. During this phase, a new measurement is conducted using the GNSS technology with a precision according to the valid legislation (Decree no. 461/2009). It is preferred to minimize entering the private properties and the cooperation with landowners. However, if the cooperation with the owners is necessary, they are notified no later than three days before the date of the measurement.

### 4.2. Creation of a new graphic and descriptive part of the cadastral operate

This phase is the most important part of the RbC process, during which the renewal itself is conducted, and a new VCMn is produced. The works start with receiving all the basic documentation. The technical part of the renewal has three main phases – the homogeneity analysis, the transformation, and the final control.

#### 4.2.1. Homogeneity analysis

The homogeneity analysis includes the determination of the definitive renewal perimeter. The area suitable for the RbC process is divided into the smallest possible blocks. The borders of these blocks should consist of publicly-owned

parcels because after the transformation, the local shifts would burden these border parcels, and their areas could be changed. If these parcels are for example streets which are publicly owned and which delimit blocks of buildings, the changes in the areas after the transformation could be compensated reciprocally. After the division of the area included in the RbC in the preliminary procedures into blocks, the parameters of local shifts are calculated in each block and then compared with each other. The result of the homogeneity analysis is:

- in each block, a condition has to be fulfilled that the positional deviations do not meet the requirements given by the regulations, and the map is homogeneous (Decree no. 461/2009, Hudecová and Kyseľ 2020),
- if some blocks have similar parameters of local shifts, they can be joined into a larger block and renewed together,
- if the map is qualified as inhomogeneous inside a particular block, this block cannot be a part of the RbC perimeter.

#### 4.2.2. Transformation and final control

After the homogeneity analysis, the number of usable blocks and the parameters of local shifts in them are known. The VCMn is transformed through the 2D linear conformal transformation without the scale change using the identical points determined by the GNSS technology. The last step of the renewal is the final control, where the parameters of local shifts are calculated on a set of check points, also determined using the GNSS technology. During the final control, the positional deviations should meet the requirements in all the check points. When the technical renewal of the VCM is successful, the cadastral authority determines the date of the end of the renewal, which is recorded in the accompanying record. On this date, all the updating documents, which were delivered after the start of the RbC process, are incorporated into the cadastral operate, and the final renewed VCMn is produced.

The cooperation of land surveyors and the person carrying out the RbC.

The land surveyor producing the updating documentation in the period between the start of the process and the end date has to contact the cadastral authority and alternatively the contracted land surveyor producing the new parts of the cadastral operate. The land surveyor has to also fully utilize the interim results of the renewal, if they are already produced.

#### 4.2.3. Analysis and correction of parcel areas

The next step of the proposed process consists in an analysis of the areas of those parcels which are part of the boundaries between the blocks. Due to the transformation, the areas of these parcels could change. This analysis consists of a calculation of differences "$d_P$" between the parcel areas in the renewed VCMn and the parcel areas in the deed of ownership and a comparison of these differences with the maximum allowed difference "$U_P$", calculated according to

the decree (Decree no. 461/2009). A comparison document with these values is created for this purpose. If the difference "$d_P$" is lower or equal to the "$U_P$" value, the value in the deed of ownership remains without any change. However, if the "$d_P$" value exceeds "$U_P$", first the correctness of the parcel area determination is verified. If no mistake is found, the parcel area in the deed of ownership has to be corrected. For this purpose, the technique of correction of errors in the cadastral operate can be used (Guideline no. 1/2022). The documentation used for the correction of parcel areas would be the simplified survey sketch documentation, which would include the parcel areas summary and the XML file for the updating of the descriptive part. The areas of parcels inside the transformed blocks do not have to be analysed because the transformation, which is used for the RbC process, is without the scale change, so the shape and area of parcels are kept unchanged.

The phase of creation of a new graphical and descriptive part of the cadastral operate results in a new vector cadastral map numerical in the VGI format and an updated descriptive part in the FUVI format. Other results include the parcel area comparison document and the documentation for the correction of parcel areas. All these documents are delivered to the local cadastral authority.

### 4.3. Reclamation procedures

The areas of some land parcels can change during the Renewal by Correction process. The parcel area is stated in the deed of ownership, so the landowners have to be given an opportunity to file a reclamation. This opportunity should be given in the next phase – the reclamation procedures. According to the proposal, before the start of these procedures, the local cadastral authority prepares a new cadastral operate and executes the changes resulting from the correction of local shifts in the deeds of ownership. The changes are made on the basis of the area comparison document and the error correction documentation. The new cadastral operate is then publicly presented through the local municipality, no later than 30 days after its production. The start of the reclamation procedures has to be announced by the municipality in the usual manner (e.g. by a public notice or by an announcement in the local public address system). The owners who do not have a permanent address in the municipality have to be notified by a letter. The local municipality also has to prepare a suitable space for the presentation of the cadastral operate. The new cadastral operate is then displayed for at least three days.

After the presentation of the new cadastral operate, the landowners and other entitled persons can file a reclamation in the oral or written form. Simple reclamations, where only an explanation is needed without making any changes in the cadastral operate, can be solved orally. The reclamation is recorded in the summary document. If the reclamation is legitimate, and the operate can be corrected without any additional investigation or measurement, the changes are immediately recorded in the summary document. In case an additional investigation or measurement is necessary, it is conducted after the end of the reclamation procedures. If a cooperation with landowners is needed, they are

notified no later than three days before the investigation. After the execution of all reclamations, the local cadastral authority implements all the changes recorded in the summary document in the cadastral operate. At the end of the reclamation procedures phase, a protocol is produced by the cadastral authority with the summary data about the procedure.

### 4.4. Declaration of validity of the renewed cadastral operate

The final phase of the proposed RbC process is the declaration of validity of the renewed cadastral operate. The validity is declared by the local cadastral authority no later than 15 days after the end of the reclamation procedures if all the reclamations were solved. The cadastral authority also asks the OGGC SR to publish the declaration of validity of the renewed cadastral operate on its website. On the date of the declaration, the original cadastral operate becomes invalid, and the data in the new cadastral operate become dependable and binding. If the area of the cadastral unit is changed by the RbC process, the cadastral authority produces the documentation for the purpose of making changes in the register of administrative units as well as the summary of the municipality and cadastral unit areas.

## 5. The cadastral operate after the Renewal by Correction

The result of the RbC process is a renewed VCMn, which is the basic document for the updating measurements and staking-out of parcel borders. The new VCMn would be provided to the land surveyors via the web portals of the land surveying department. The original VCMn with local shifts would be also stored in the cadastral archive but no longer used as a valid cadastral map. If it was necessary, the older surveying sketch documentation and staking-out sketches would be provided from the archive of the local CDDO, but only if not older than 2013, when the POINTS layer was established. The older documentation would not be allowed to be used because of the local shifts. However, on specific occasions, e.g. for staking-out of parcel borders or for the investigation and solution of arguments between neighbours, the original VCMn, the original cadastral mapping documentation and the older updating and staking-out documentation could be provided by the local CDDO.

### 5.1. Quality of the detailed points after the Renewal by Correction

After the transformation, a problem could arise in connection to the quality of points in the VCM. Nowadays, there are five quality codes "T" of a detailed point in the map, which are determined by its origin and precision, defined by the mean coordinate error "$m_{xy}$" (Decree no. 461/2009). In the older numerical maps, there are mostly points with the quality code T = 3 or T = 4 in the rural or forest areas. After 2009, when the GNSS measurement became compulsory, the points have been determined with the quality code T = 1 (determined by

measurement) or T = 2 (taken from other documentation). All the points in the POINTS layer have the quality code T = 1. The quality code T = 5 is used only in non-numerical maps. However, all these quality codes used in numerical maps are defined as either determined by a direct measurement or taken from other documentation. For the points whose position was determined by a transformation in the RbC process a new quality code T = 6 should be established. It is proposed that this quality code be defined as "a numerically determined point in the UTCN system, originally with terrestrial methods, after the transformation in the Renewal by Correction process", and the mean coordinate error of this quality code be 0.14 m, same as for the quality code T = 3. That is because most of the points in the original VCMn had quality code T = 3. This means that if a new measurement is performed in a point with the new quality code T = 6, the positional deviation should not exceed the value 0.24 m. However, in individual cases, which are assumed to be very rare, the positional deviation could exceed this value. In such cases, there should exist a possibility to correct the position of a point with the code quality T = 6 during an updating measurement without using the "classic" technique of error correction in the cadastral operate. In case of points which were a part of the POINTS layer, the position from the POINTS layer would be adapted, and these points would be given the quality code T = 1 in the renewed VCMn. It is proposed that the POINTS layer be removed after the RbC process. If there were some points with the quality code T = 1 embedded into the map inside the transformed block, these points would not be subject to the transformation, and their position would be preserved. The original point numbers would be kept after the transformation, only their quality code would be changed to T = 6.

According to the proposed procedure, if a new measurement is conducted, the positional deviation between the position of a point in the map and the position determined by the new measurement should be less than 0.24 m in case of transformed points with the new quality code T = 6 and less than 0.14 m in case of points with the quality code T = 1 which were part of the POINTS layer before the RbC process. These conditions should be fulfilled for all the points covered by the Renewal by Correction. The precision of the renewed VCMn should be satisfying for the updating measurements as well as the staking-out of parcel borders.

## 5.2. The amendment of legislation

The Renewal by Correction is not only a technical but also formal process, during which the ownership and other rights to the real estate could be affected. This means that only a technical instruction is not enough, and it would be also necessary to amend the existing cadastral act and its decree to include this process. This amendment would have to go through a full legislative process.

## 6. Conclusions

In the past, several methods of cadastral operate renewal were applied in Slovakia. However, nowadays only one of them is used in practice – the cadastral operate renewal by a new mapping. The cadastral map collection is currently not in a good condition (chap. 2). Even in the part of the map collection with the higher quality, there could be local shifts in many of the maps, which is indicated by the presence of the POINTS layer (chap. 3). However, the relative quality of these maps is high in most cases, so a complex new mapping process is not needed. A new way for the renewal of these maps was proposed – the Renewal by Correction, main principle of which is a transformation of the VCMn inside a delimited block. The technical part of the process was tested successfully several times. However, the Renewal by Correction would not include only the technical renewal of the map, but also some formal steps would be necessary. The main aim of this paper was to propose the criteria for the use of RbC and the formal process for the Renewal by Correction (chap. 4).

There were four main phases proposed for the process – preliminary procedures (chap. 4.1), creation of the new parts of the cadastral operate (chap. 4.2), reclamation procedures (chap. 4.3) and declaration of validity of the renewed cadastral operate (chap. 4.4). There is also an additional phase of the measurement in the field, which would be executed only if necessary. The execution practice was described for each of the phases. In the phase of production of a new SIF and DIF, there was also a brief description of the technical part. The way of the correction of parcel areas after the transformation and the quality of detailed points after the renewal were also mentioned. Finally, the way of using the renewed cadastral operate was described (chap. 5).

### References

Act No. 162/1995 Coll. on the cadastre of real estate and the entries of ownership and other rights to the real estate (the cadastral act) as amended.

Berková, A. (2011): Refinement of Cadastral Maps, Acta Montanistica Slovaca, 16, 242–248.

Čada, V. (2001): Využití geodetických základů stabilního katastru, historie vzniku a užití mílových tabulek, Geodetický a kartografický obzor, 47/89, 271–280.

Decree No. 461/2009 Coll. of the Office of Geodesy, Cartography and Cadastre of the Slovak Republic, implementing the Act No. 162/1995 Coll. on the real estate cadastre and the entries of ownership and other rights to the real estate (the cadastre act).

Gašincová, S., Gašinec, J., Weiss Kiraly, A. (2014): Legislative changes specifying the matters of survey sketch in the Slovak Republic, Acta Montanistica Slovaca, 19 (4), 207–220.

Guideline no. 9/2013 on the contents and form of files for updating the geodetic informations in the cadastral units with the vector cadastral map numerical (2013): Office of Geodesy, Cartography and Cadastre of Slovak Republic, Bratislava (in Slovak).

Guideline no. 1/2022 on the correction of detailed points and parcel areas in the „C“ and „E“ register (2022): Office of Geodesy, Cartography and Cadastre of Slovak Republic, Bratislava (in Slovak).

Horňanský, I., Leitman, M., Ondrejička, E. (2014): Na ceste k homogenizácii katastrálneho mapového diela, Geodetický a kartografický obzor, 60/102 (9), 229–240.

Hudecová, Ľ., Kyseľ, P. (2020): Vector Cadastral Maps Numerical Homogeneity Analysis, Geodetski list, 74 (97), No. 1, 41–56.

Hudecová, Ľ., Nemcová, P., Geisse, R., Bajtala, M. (2016): Renewal of cadastral maps, Proceedings of 16th International Multidisciplinary Scientific GeoConference in Albena, Bulgaria, Book 2, Informatics, Geoinformatics and Remote Sensing, 511–518.

Kaufmann, J., Aleksić, I. R., Odalović, O. R. (2009): Real Estate Cadastre Development in Serbia, Geodetski list, 63 (86), No. 3, 243–254.

Kyseľ, P. (2021): Usage of “VCMt Precising” Application in Renewal by Correction, Advances in Architectural, Civil and Environmental Engineering, Proceedings, 195–203 (in Slovak).

Lesňák, M., Kubasák, T., Raškovič, V. (2021): Návrh tvorby vektorovej katastrálnej mapy implementovanej z vektorovej katastrálnej mapy nečíselnej transformovanej, Geodetický a kartografický obzor, 67/109, 21–29.

Lisec, A., Navratil, G. (2014): The Austrian land cadastre: from the earliest beginnings to the modern land information system, Geodetski vestnik, 58 (3), 482–516.

Mika, M. (2018): An analysis of possibilities for the establishment of a multipurpose and multidimensional cadastre in Poland, Land Use Policy, 77, 446–453.

Moharić, J., Katić, J., Šustić, A., Šantek, D. (2017) Improvement of Cadastral Maps of Graphic Survey, Geodetski list, 71 (94), No. 4, 339–360 (in Croatian).

Popov, A. (2019): Land Cadastre Development in Ukraine, Geodesy and Cartography, 45 (3), 126–136.

Raškovič, V., Muchová, Z., Petrovič, F. (2019): A new approach to the registration of buildings towards 3D land and property management in Slovakia, Sustainability (Switzerland), 11 (17), pp. 12.

Siejka, M., Ślusarski, M., Mika, M. (2015): Legal and Technical Aspects of Modernization of Land and Buildings Cadastre in Selected Area, Reports on Geodesy and Geoinformatics, 99, 44–53.

Taszakowski, J., Litwin, U., Doroż, A. (2018): Transformation of the Former Austrian Cadastre Map, Geomatics, Landmanagement and Landscape, 1, 55–67.

Zrinjski, M., Barković, Đ., Tupek, A., Smoković, E. (2019): Homogenization of the Cadastral Map of Cadastral Municipality Plomin in Croatia, Conference Proceedings, 7th International Conference Contemporary Achievements in Civil Engineering 2019, Bešević, M. T. (ed.), University of Novi Sad – Faculty of Civil Engineering Subotica, Subotica, 995–1004.

# Novi način poboljšanja zbirke katastarskih planova u Slovačkoj

*SAŽETAK. Postoji nekoliko tehnika za održavanje katastarskih operata u Slovačkoj. Jedna je od njih obnova katastarskih operata. Proces obnove prijeko je potreban jer kvaliteta katastarskih planova nije zadovoljavajuća. Danas se može primijeniti samo jedna metoda – obnova katastarskog operata novim kartiranjem. Kartiranje trenutno nije popularno širom svijeta, no u Slovačkoj postoje problemi s nenumeričkim planovima kao i s nekim numeričkim planovima koje je također potrebno obraditi. Međutim, u slučaju numeričkih katastarskih planova s lokalnim pomacima taj bi proces bio neučinkovit pa je zbog toga predložen novi način njihove obnove – obnavljanje pomoću ispravaka. Glavno je načelo tog procesa transformacija dijela plana s lokalnim pomacima u ispravan položaj. Glavni je cilj ovog rada predložiti formalni proces obnavljanja pomoću ispravaka. Najprije su predloženi kriteriji za primjenu obnavljanja pomoću ispravaka. U sljedećem su dijelu opisani svi formalni koraci procesa.*

*Ključne riječi: katastarski plan u vektorskom obliku, obnova, transformacija, formalni proces.*

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