

CORRECTION OF ERRORS DETECTED IN THE CADASTRAL MAPS OF SETTLEMENTS IN THE REPUBLIC OF ARMENIA USING ORTHOPHOTOPLANS

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Correction of inaccuracies and errors found in cadastral maps of communities and settlements of the Republic of Armenia using orthophoto floor plans (using the example of the Solak community). The article considers the issue of adjusting and modernizing cadastral maps, the key graphic document of the state registration system of real estate. Considering the inaccuracies and errors accumulated in the maps over the past 20 years, this study analyzes the legal and technical bases for their correction in accordance with the requirements of Articles 3 and 14 of the RA Law “On State Registration of Rights to Property” (application and coding of a unified geodetic coordinate system). This study details the process of detecting and correcting errors using modern orthophoto floor plans and space images at the district and community levels. This study defines the main terms and concepts related to the topic and reveals the phased features of field and office work in cadastral mapping. The prerequisites for creating maps and the modern technological innovations used for their final implementation are shown.

Keywords: *cadastral map, real estate unit, cadastral plan, orthophotomap, error correction*

Introduction

According to Article 3 of the Law of the Republic of Armenia on State Registration of Rights to Property, the main principles and objectives of state registration include:

- 1) recognition, guarantee, and protection of property rights and registered restrictions;
- 2) creation and maintenance of an information system on property rights, restrictions, cadastral valuation, and registration data;
- 3) ensuring the availability, objectivity, continuity, and consistency of property-related data;
- 4) establishing conditions necessary for the development of the real estate market.

Among the principal documents of the state registration system defined in Article 12 of the same law are:

- the unified register of state registration of rights and restrictions over property;
- the cadastral map (plan);
- the cadastral file prepared for each real estate unit.

Particular importance is given to linking land parcels, buildings, structures, and other immovable property objects represented in cadastral maps to the unified geodetic coordinate system of the Republic of Armenia, as well as to assigning cadastral codes established by the Government.

By Decision No. 698-N (April 29, 2021), the Government of the Republic of Armenia approved the procedure for correcting errors identified in cadastral maps. According to this procedure, orthophoto plans produced or approved by the Cadastre Committee are treated as thematic layers of cadastral data after the relevant boundary correction projects are transferred to territorial subdivisions.

The correction of cadastral district boundaries is carried out based on 1:2000 scale cadastral plans derived from orthophoto maps with 10...20 *cm* spatial accuracy. These materials enable the adjustment of administrative boundaries, cadastral districts, and real estate unit boundaries within permissible accuracy limits.

Baseline data recorded in urban planning, land management, and land allocation documents, as well as coordinate data obtained from plans prepared by certified specialists, are subject to updating during the correction process.

This study analyzes the mechanisms of error detection and correction in cadastral maps, using the Solak community in the Kotayk region as a case study.

Materials and Methods

Cadastral surveys are conducted using the following methods:

- tachymetric survey (electronic total stations),
- GNSS (GPS) satellite positioning,
- combined methods integrating aerial and satellite imagery with field measurements.

Depending on field conditions and the configuration of survey networks, linear intersection and polar methods are primarily applied.

When merging survey data from different areas, the allowable positional error must not exceed 0.3 *mm* at map scale.

All cadastral survey outputs must include the date of fieldwork completion, ensuring that mapped data accurately reflects ground conditions at that time.

Results and Discussion

Cadastral survey materials-namely cadastral maps and plans-represent reduced and generalized depictions of terrain at appropriate scales using conventional symbols. These materials display all real estate units regardless of ownership form, including their location, boundaries, area, type, as well as networks of above-ground and underground utilities and other relevant data.

Cadastral maps and plans constitute one of the main components of the state real estate registration system. They are used for the registration of property rights, valuation, formation of the tax base for land and property taxes, and for the management of a multipurpose cadastre.

The initial data for cadastral mapping include graphical and textual legal documents related to real estate, cartographic materials at scales of 1:500–1:25 000, urban planning and land development programs, master plans, and geodetic control point datasets [1, 2]. Cadastral mapping is carried out by qualified legal entities and may be produced in both paper and digital formats.

Cadastral surveying for state registration is conducted for each individual real estate unit. During registration, each unit is assigned a unique cadastral code consisting of numerical identifiers, which remains unchanged as long as the unit exists as a legal and physical entity. For properties that have not undergone state registration, including unauthorized constructions and illegally occupied land plots, provisional codes are assigned. For this purpose, the territory of the Republic of Armenia is divided into cadastral regions, communities, sectors, districts, and units.

Cadastral surveys are conducted using modern geodetic equipment, including electronic theodolites, GNSS (GPS) receivers, and laser distance meters.

Cadastral mapping of real estate in the Republic of Armenia began in 1998. Between 1998 and 2000, the cadastral base was created using local coordinate systems as well as SK-63 and SK-42 systems, while since 2001, the SK-42 coordinate system has been adopted as the standard [3]. Surveying during this period was performed using traditional terrestrial methods, including theodolite and tachometric surveys, as well as linear and angular intersection techniques.

During the first phase of cadastral mapping and registration, community boundaries were defined approximately. In subsequent phases, efforts were made to align administrative boundaries of communities and regions using topographic maps at scales of 1:10 000 and 1:25 000. However, this process did not fully eliminate initial errors, which persisted in the digitized cadastral maps.

Traditional surveying methods did not allow for high-precision representation of curved features or accurate calculation of polygon areas. Furthermore, the division of agricultural land in Armenia, carried out since 1991 by local land commissions, was based on Soviet-era land management maps (scales 1:5 000 and 1:10 000) and land balance records. These boundaries were later transferred to the field using low-accuracy measuring tools, resulting in significant discrepancies between allocated and actually used parcels.

These inaccuracies were later identified during cadastral mapping using modern geodetic technologies. Given the primary objective at that stage-initial registration of privatized land and issuance of ownership documents-it was decided to digitize existing land allocation data and create community-based cadastral maps, followed by the alignment of administrative boundaries in later stages.

This process began in 2004, which led to a number of deficiencies in digitized cadastral maps, including: mismatches between neighboring community boundaries, resulting in overlaps or gaps between parcels, errors arising from the transformation of maps created in different coordinate systems into a unified system.

To address these issues, both field and office-based corrections were undertaken. Community boundaries were adjusted using orthophoto maps at a scale of 1:10 000 and base topographic maps derived from satellite imagery with an accuracy of approximately one meter. However, the accuracy of these orthophoto maps is insufficient for fully correcting cadastral map errors.

As a result, due to existing inaccuracies in cadastral maps, applications submitted by citizens to territorial cadastral offices are often rejected or returned for correction during the registration of real estate floor plans approved by local authorities in Yerevan and other settlements [3].

The errors identified in cadastral maps can be classified into several main groups based on their nature and characteristics: positional errors, linear measurement errors, area discrepancies, errors in intended land use, ownership inconsistencies, certification issues, and layer mismatches. Table presents a detailed classification of these errors.

Table

The nature and content of the errors made in the cadastral map

No	Nature of the error
<i>1. Position (Location)</i>	
1.1	Not reflected in the map and cannot be reflected based on the existing registered data
1.2	The position cannot be determined with the incorrect coordinates and the existing data reflected on the map.
1.3	It is not reflected on the map and is returned with other properties based on the presented registration data.
1.4	It is reflected on the map and is returned with other properties based on the newly presented registration data.

2. Linear dimensions	
2.1	The linear dimensions on the map differ from those of the orthophoto plans.
2.2	The linear dimensions on the map differ from the recorded measurements and cannot be verified with the orthophoto plan.
2.3	The linear dimensions on the map differ from the orthophoto plans and the registered dimensions.
2.4	The linear dimensions on the map differ from the dimensions of the orthophoto plans, but correspond to the registered dimensions.
2.5	The linear dimensions on the map are divided into parts according to the administrative boundaries of the community compared to the registered property dimensions.
3. Area	
3.1	The area on the map is smaller than the registered area and does not correspond to the area of the orthophoto plan.
3.2	The area on the map is smaller than the registered area, but corresponds to the area of the orthophoto map.
3.3	The area on the map is smaller than the registered area, but it is not possible to determine the area using the orthophoto map.
3.4	The area on the map is larger than the registered area and does not correspond to the area of the orthophoto map.
3.5	The area on the map is larger than the registered area, but corresponds to the area of the orthophoto map.
3.6	The area on the map is larger than the registered area, but it is not possible to determine the area using the orthophoto map.
3.7	The area on the map corresponds to the registered area, but differs from the orthophoto map.
4. Target and/or functional significance	
4.1	The target and/or functional significance of the land plot in the map differs from the transfer decision, but corresponds to the registration.
4.2	The target and/or functional significance of the land plot in the map corresponds to the transfer decision, but differs from the registration.
4.3	The target and/or functional significance of the land plot in the map differs from both the transfer decision and the registration.
4.4	The target and/or functional significance of the land plot in the map differs from the main layout / zoning project / and the registration.
4.5	The intended and/or functional significance of the land plot on the map differs from the main layout (zoning project), but corresponds to the registration.
5. Ownership	
5.1	The form of ownership of the land plot is indicated as community on the map and in the transfer decision, but is registered in the name of a citizen or legal entity.
5.2	The form of ownership of the land plot is indicated as state on the map and in the transfer decision, but is registered in the name of a citizen or legal entity.
5.3	The form of ownership of the land plot is indicated as state on the map, but there is no such thing in the transfer decision, and it is registered in the name of a citizen or legal entity.
5.4	The form of ownership of the land plot is indicated as community on the map, but there is no such thing in the transfer decision, and it is registered in the name of a citizen or legal entity.
5.5	The ownership form of the land plot is indicated on the map as belonging to a citizen or legal entity, but there is no registration.
6. Certificate	
6.1	The area of the land plot on the map differs from the area specified in the certificate, which has resulted from rounding the number.
6.2	The cadastral code of the land plot on the map differs from that specified in the certificate.
6.3	The cadastral code of the land plot is not specified in the certificate.
6.4	The functional significance of the building in the certificate does not correspond to the intended and functional purposes of the land plot.

6.5	The area of the building in the new certificate is smaller than the area specified in the previous certificate, which resulted from recalculation based on internal dimensions instead of external dimensions.
7. Identification	
7.1	The coordinates and linear dimensions of the breakpoints of the intended and functional purpose/land use layer in the map differ from those of the property form layer and/or the real estate layer.
7.2	There are several identical layers in the map; for example, the property layer can be both community and state, etc.

Adjustments of community administrative boundaries in cadastral maps are carried out based on a written request from the respective community leader, taking into account boundary descriptions and orthophoto plans defined by the Law of the Republic of Armenia on “*Administrative Division of the Republic of Armenia*” (hereinafter referred to as *the Law*).

Administrative boundaries of communities, or their separate sections, are adjusted in accordance with the descriptions established by the Law and with the mutual consent of neighboring community authorities. Boundaries agreed upon prior to the adoption of the current regulation are also considered valid if they comply with the provisions of the Law [4].

If, during the adjustment process, it becomes evident that the proposed boundary does not conform to the descriptions defined in the Law, the agreed data from neighboring community authorities is submitted by the Cadastre Committee to the Ministry of Territorial Administration and Infrastructure for initiating amendments to the Law. The adjustment of the respective cadastral map section is carried out only after such amendments are adopted.

Upon completion of boundary adjustment works, the draft cadastral map section-aligned with orthophoto plans-is provided to the community leader in both paper (Sample Form 1) and electronic (PDF) formats. It is also published on the official e-cadastre platform for public access [5].

Within 10 working days of receiving the documents, the community leader must submit written consent or objections, including feedback from neighboring communities. In case of disagreement, the Cadastre Committee prepares a revised draft and resubmits it for approval. If consensus is still not reached, the issue is referred to the commission established by the Decision No. 67-A of the Prime Minister of the Republic of Armenia (February 7, 2005) [6].

Until written agreements are obtained, land allocation within disputed or overlapping areas is suspended, and such areas are considered contested.

Land plots incorporated into community boundaries as a result of adjustments-previously located within former boundaries and not owned by individuals or legal entities-are classified as community property. These lands are transferred to communities by the state under the right of gratuitous ownership in accordance with relevant regulations [7].

Conversely, land plots that, by law, fall within community boundaries but were previously located outside them (within regional administrative boundaries) and are not privately owned are classified as state-owned lands.

Adjustments to cadastral district boundaries or locations are also carried out based on written requests from community leaders. These adjustments rely on orthophoto maps and align district boundaries with visible physical features such as roads, railways, streets, canals, drainage systems, and natural barriers (e.g., rivers, ravines, watersheds).

Such adjustments are performed while preserving, as much as possible, the original geometry, linear dimensions, and area of the districts.

After completing these adjustments, the updated cadastral map sections are submitted to the community leader in both paper (Sample Form 2) and electronic formats. The same approval procedure (10 working days, objections, revisions) applies.

Where district boundaries coincide with community administrative boundaries, adjustments are carried out following the same procedure.

The finalized administrative boundary maps are published on the Cadastre Committee's official website for a period of one month. If no objections are received from community leaders during this period, the adjustments are deemed approved.

Adjustments to agricultural land categories in cadastral maps are made in accordance with cadastral records and land fund accounting data, as well as the requirements of Government Decision No. 1066-N (September 17, 2009) [8].

Adjustments to the designated or functional use of registered land plots are carried out based on official registration documents. In cases of missing or inconsistent data, adjustments are made based on the functional use of registered buildings or information provided by the community leader.

If corrections to the base cadastral layer do not alter the designated purpose of a property unit or the land balance scheme, and valid legal documents exist, such corrections may be implemented without applying Government Decisions No. 1920-N and No. 1918-N (December 29, 2011) [8, 9].

Analysis of inaccuracies identified in cadastral plans highlights the need for systematic correction and updating of cadastral maps. This process is essential for clarifying property boundaries within a unified coordinate system, ensuring their legal validation and formalization.

The process of identifying and correcting cadastral map errors is illustrated through a case study of the Solak community in the Kotayk region (Fig. 1).

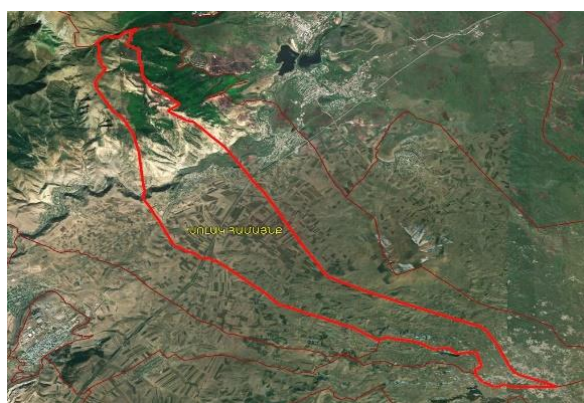


Fig. 1. The location of the Solak community in the Kotayk region of Armenia on the Google Earth browser platform

To perform the analysis, the cadastral map of the Solak community in the Kotayk region was overlaid onto the corresponding orthophoto plan. This comparison reveals that the directional deviation between the cadastral map and the orthophoto is consistent in magnitude across the entire community area (Fig. 2, 3).

In the presented example, this deviation is clearly observed in three different sections of the community, where discrepancies between the mapped features and their actual positions are evident. After applying the necessary corrections, the map becomes properly aligned with the orthophoto imagery, resulting in correctly oriented representations (Fig. 4-6).



Fig. 2. Illustrates the deviation of the cadastral map from the actual spatial configuration [10, 11].



Fig. 3. The area N 1 depicted on the orthophoto plan after correction



Fig. 4. The area N2 depicted on the orthophoto map

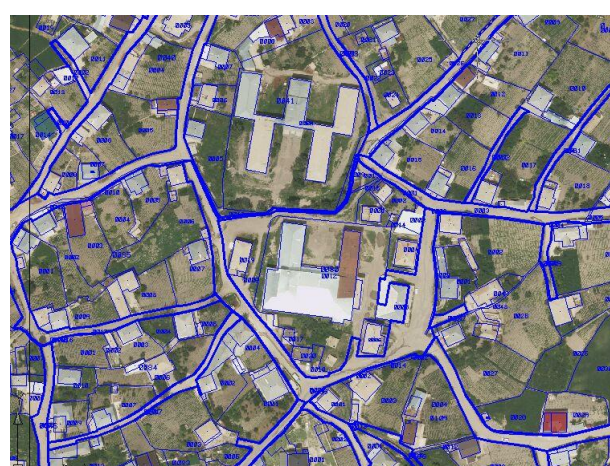


Fig. 5. Area N2 as shown on the orthophoto map after alianment



Fig. 6. The area N 3 depicted on the orthophoto plan



Fig. 7. The area N 3 depicted on the orthophoto plan

Analysis of the map shown in Fig. 7 indicates that approximately 90 % or more of the cadastral map is consistent with the orthophoto imagery; however, certain discrepancies still remain. These errors are highlighted in the areas marked with yellow frames.

Attempts to correct and fully align these sections with the natural features may lead to additional issues. Specifically, such adjustments may result in changes to the linear and areal parameters recorded in existing ownership certificates, which in turn could generate additional costs and potential disputes (Fig. 8, 9).

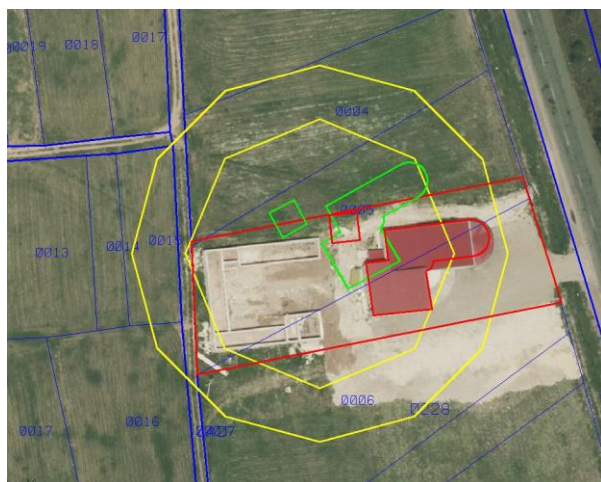


Fig. 8. The land plot and building on the cadastral map of the Solak community depicted on the orthophoto plan create conflicts



Fig. 9. Similar combinations on the community cadastral map

To implement comprehensive field measurements and utilize the resulting data, it is necessary to establish a working environment that meets modern technological requirements. The obtained geospatial database should be used for the transformation and correction of the cadastral map covering the entire territory of the Solak community. Fieldwork should be conducted using modern geodetic technologies, including GNSS satellite positioning systems and electronic total stations.

Conclusion

The principles governing cadastral mapping implementation, including the stages of field and office work, have been outlined. These principles describe the necessary prerequisites for cadastral map creation as well as the technological innovations applied in their final development.

Errors related to individual real estate units have been identified and corrected within the cadastral maps of communities in the Republic of Armenia, including adjustments to administrative boundaries and cadastral districts.

Using orthophoto maps, existing discrepancies and inaccuracies in real estate units have been detected and clarified within the cadastral maps of the Solak community in the Kotayk region of the Republic of Armenia.

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Սամվել Զալիբեկի Կրոյան*, Ժորա Սմբատի Մարգարյան, Նարեկ Սամվելի Կրոյան

Ճարտարապետության և շինարարության Հայաստանի ազգային համալսարան, ք. Երևան, ՀՀ

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Հոդվածում դիտարկվում են Հայաստանի Հանրապետության բնակավայրերի կադաստրային քարտեզներում հայտնաբերված սխալների ուղղումն օրթոֆոտոհատակագծերի կիրառմամբ (Սուլակ բնակավայրի օրինակով) և անշարժ գույքի պետական գրանցման համակարգի առանցքային գրաֆիկական փաստաթղթի՝ կադաստրային քարտեզների ճշգրտման և արդիականացման հիմնախնդիրները: Հաշվի առնելով վերջին 20 տարիների ընթացքում քարտեզներում կուտակված անճշտություններն ու սխալները, վերլուծվում են դրանց ուղղման իրավական և տեխնիկական հիմքերը՝ համաձայն «Գույքի նկատմամբ իրավունքների պետական գրանցման մասին» ՀՀ օրենքի 3-րդ և 14-րդ հոդվածների պահանջների (միասնական գեոդեզիական կոորդինատային համակարգի կիրառում և ծածկագրում): Մանրամասնվում է արդի օրթոֆոտոհատակագծերի և տիեզերական նկարների օգտագործմամբ սխալների հայտնաբերման ու սրբագրման գործընթացը թաղամասային և համայնքային մակարդակներում: Մանրամասնվում են թեմային առնչվող հիմնական տերմիններն ու հասկացությունները, ինչպես նաև բացահայտվում են կադաստրային քարտեզագրման դաշտային և գրասենյակային աշխատանքների փուլային առանձնահատկությունները: Ցույց են տրված քարտեզների ստեղծման նախապայմաններն ու դրանց վերջնական իրականացման համար կիրառվող ժամանակակից տեխնոլոգիական նորամուծությունները:

Բանալի բառեր. *կադաստրային քարտեզ, անշարժ գույքի միավոր, կադաստրային հատակագիծ, օրթոֆոտոքարտեզ, սխալի ուղղում*

ИСПРАВЛЕНИЕ ОШИБОК, ОБНАРУЖЕННЫХ НА КАДАСТРОВЫХ КАРТАХ НАСЕЛЕННЫХ ПУНКТОВ РА С ПОМОЩЬЮ ОРТОФОТОПЛАНОВ

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Коррекция ошибок, обнаруженных на кадастровых картах населенных пунктов Республики Армения, с использованием ортофотопланов (на примере населенного пункта Солак). В статье рассматривается вопрос корректировки и модернизации кадастровых карт, ключевого графического документа государственной системы регистрации недвижимости. С учетом неточностей и ошибок, накопленных на картах за последние 20 лет, в работе анализируются правовые и технические основания для их исправления в соответствии с требованиями статей 3 и 14 Закона РА «О государственной регистрации прав собственности» (применение и кодирование единой геодезической системы координат). В статье подробно описывается процесс выявления и исправления ошибок с использованием современных ортофотопланов и пространственных изображений на районном и общинном уровнях. В работе определены основные термины и понятия, относящиеся к теме, а также раскрыты поэтапные особенности полевых и офисных работ по кадастровому картографированию. Представлены предпосылки для создания карт и современные технологические новшества, используемые для их окончательной реализации.

Ключевые слова: кадастровая карта, объект недвижимости, кадастровый план, ортофотокарта, коррекция ошибок

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