Research Journal of Agricultural Science, 56 (4), 2024; ISSN: 2668-926X

MODERN TECHNIQUES AND TECHNOLOGIES FOR DATA ACQUISITION AND PROCESSING USED IN THE GENERAL CADASTRE OF CRISENI, SATU MARE COUNTY

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Abstract: *The topographic-cadastral measurements conducted in this study focus on all field and calculation operations necessary for representing the earth's surface on a plan or map, in a specific cartographic projection and at a designated topographic scale. The general cadastre is a unified and mandatory system for technical, economic, and legal records that identifies, registers, and describes all land areas on topographic maps and cadastral plans, regardless of use or ownership, across the entire country. This article aims to illustrate and test the proposed model, evaluating the data accuracy regarding predictive measurements for topographic surveys conducted in Crișeni, UAT Cridorolț, Satu Mare County. The area was analyzed using mobile scanning with the Leica Pegasus: Backpack equipment, combined with two GNSS devices, the Leica GS 14 and the Leica GS 08 Plus. In developing the general cadastre for this administrative-territorial unit, modern technology was also employed—specifically UAV technology, which enables high-accuracy surface measurements with reduced work time. The data collected from the flight were downloaded and subsequently post-processed using specialized software: Pix4D Mapper. The results obtained are stored in digital format, and after export, are saved as .dxf files, allowing access in either digital or analog form through the AutoCAD processing program. The generated orthophotoplan is exported in .ecw file format. Using the Leica Pegasus equipment, the data are stored digitally and subsequently undergo post-processing with the Pegasus Manager software, while the point cloud processing is carried out using Cyclone software. In this case, processing resulted in the delineation of property street fronts and existing structures on the terrain. GNSS equipment was used to perform detailed topographic measurements.*

Key words: *Topographic Measurements, Leica Pegasus, UAV, Crișeni*

INTRODUCTION

This work aims to track the stages of systematic registration within the locality of Crișeni, Satu Mare County, as it represents an essential process for the organization and management of real estate properties. The use of modern technologies significantly contributes to improving the accuracy and efficiency of this process (Popescu et al., 2015).

The cadastral system refers to the unified and mandatory system of technical, economic, and legal records through which the identification, registration, and representation on cadastral maps of all property units are carried out, regardless of their purpose or owner, across the entire country.

It was necessary to collect field data in order to determine the coordinates of each property (land or building) and to create an accurate cadastral map (Șmuleac et al., 2015).

To shorten the study time for this area, state-of-the-art technologies were used, acquired through both traditional and modern methods, so that, in the end, we could achieve the most precise results (Barliba et al., 2013).

During World War II and the Cold War, UAV technology improved significantly. Although in the past it was primarily used for military applications such as reconnaissance, surveillance of national interests, and maritime monitoring, over time it proved to be useful in engineering measurements. Subsequently, it began to be regarded as a standard research tool for acquiring detailed images of areas of interest and creating detailed 3D models and orthophotos.

Mobile mapping technology has revolutionized the mapping and management of our area of interest, providing precise data, quick results, and significant time and cost savings for the authorities and companies involved in managing these critical infrastructures.

Leica Pegasus: Backpack is a high-performance mobile mapping solution developed by Leica Geosystems, which uses a combination of advanced sensors, including a LiDAR laser scanning system, allowing for the collection of highly precise topographic data essential for creating detailed 3D maps and analyzing environmental structures.

Precise measurements can be made using GNSS technology, GPS (RTK), alongside modern drone technologies and geodetic data processing (Șmuleac et al., 2020).

MATERIALS AND METHODS

Topographic-cadastral measurements play an important role (Leu et al., 2022; in topographic and cadastral activities, which may include field measurements (in both undeveloped and urbanized areas), mapping property boundaries, measuring infrastructure elements (roads, utility networks, buildings, etc.), as well as preparing detailed plans and maps.

The case study was conducted in the locality of Crișeni, Satu Mare County, Romania. It is a rural commune, located in the historical region of Transylvania, and is part of the Satu Mare Metropolitan Area, being relatively close to the county capital, the city of Satu Mare.

The topography of the locality of Crișeni, in Satu Mare County, is characterized by a flat plain area, situated within the depression of the Someș Plain. It lies in a hilly plain region, with fertile agricultural land and a well-defined hydrographic network, due to its proximity to the Someș River and its tributaries (figure 1).

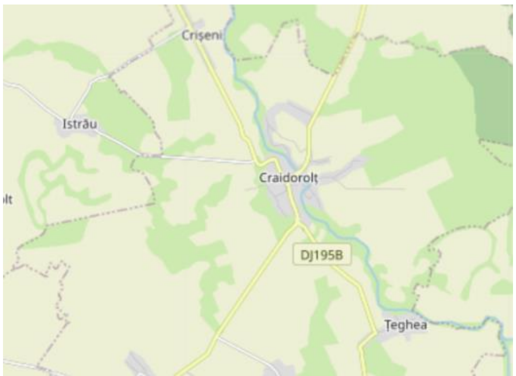

Fig. 1. Location of the study area

Crișeni is a small locality, but rich in history, tradition, and rural life, with an economy based on agriculture and a close-knit community. Although it is not a large urban center, Crișeni plays an important role in the rural life of Satu Mare County, being a place where traditions and customs are preserved with great care (Pascalau et al., 2020; Șmuleac et al., 2017, 2020).

The detailed topographic-cadastral measurements in this work were carried out for the purpose of creating the general cadastre for the locality of Crișeni (Popescu et al., 2016).

In order to accurately capture the stages that form the basis of the final results, certain steps were followed, including recognizing the terrain and establishing strategic points to begin the topographic measurements, as well as consulting the topographic-cadastral plans provided by the local council and the OCPI (National Agency for Cadastral and Land Registration).

The workflow began with scanning the area of interest to establish the street frontages.

As the Master Base, we used the Leica Pegasus Backpack equipment, which recorded Rinex data at one-second intervals throughout the scanning process (Pascalau et al., 2021).

The Leica Pegasus Backpack was used to capture detailed geospatial information, including the delineation of properties and structures, as well as the creation of detailed plans.

The Leica Pegasus Backpack is a portable system that combines two Velodyne VLP-16 linear scanners (one vertical and one horizontal), along with five cameras for texture data, an integrated GNSS/INS system using Novatel SPAN technology, batteries, and the control unit (Leica Pegasus Backpack, 2017, figure 2 and 3). It is capable of determining 600,000 points per second, with a maximum range of 50-75 meters left to right. During data acquisition, a rugged tablet displays video from the cameras, profiles from the two linear scanners, and a diagnostic tool with information about the GNSS and INS sensors (Șmuleac et al., 2017; Casian et al., 2019).

Fig. 2. Leica Pegasus Backpack Equipment

Fig. 3. WingtraOne drone

Post-processing daqta is carried out in two main stages: first, GNSS and INS data are integrated to calculate the MMS trajectory (the position and rotation of the SPAN platform) as a starting solution, and later, optimization is performed by considering the 3D profiles from both linear scanners (Herbei et al., 2013, 2018; Mita et al., 2020).

This method, often referred to as 3D object scanning or 3D laser scanning, is used to quickly capture the shapes of objects, buildings, and landscapes.

From a topographic-cadastral perspective, the terrain recognition was carried out using UAV technology. Thus, properties within the built-up area of the locality were digitized according to their use, taking fences into account. For this equipment as well, a base station was used to obtain Rinex data throughout the flight (Lmuleac et al., 2019).

For the particular case of our study, we used the WingtraOne Generation II drone.

The WingtraOne is equipped with high-resolution Sony cameras or professional multispectral cameras from Micasense. The cameras can be easily swapped in the field, making the same drone suitable for different applications. Using the intuitive flight planning software and fully autonomous flight operations, surveyors can capture georeferenced aerial images with virtually no piloting skills required (Pascalau et al., 2020).

The WingtraOne VTOL mapping drone is capable of performing rapid topographic flights over vast and hard-to-reach areas, providing reliable maps with unparalleled resolution and accuracy.

The images obtained from flights with the WingtraOne can be processed using most of the well-known photogrammetry software to create high-precision orthophotos and 3D models.

For mapping drones, the transition from helicopter mode to airplane mode perfectly matches the coverage and high speeds typical of topographic drones with fixed wings. To land, the WingtraOne transitions back to helicopter mode and descends vertically.

After completing the scanning and flight, we proceeded with detail measurements. For all properties, RTK-determined control points were collected using GNSS equipment. These points verify the graphic representations made using the orthophoto map generated from the drone flight (Paunescu et al., 2020); Popescu et al., 2019).

In this case, we used two GPS devices, one being the Leica GS 08 Plus and the other the Leica GS 16 (figure 4 and 5).

Fig. 4. GPS Leica GS08 Plus

Fig. 5. GPS Leica GS 16

The Leica GS 08 Plus is a high-precision GPS system manufactured by Leica Geosystems, used for geodetic, topographic, and mapping measurements.

This system is based on GNSS (Global Navigation Satellite System) technology, which allows precise position measurements using signals from GPS satellites as well as from other satellite constellations, such as GLONASS, Galileo, or BeiDou (Lalu et al., 2020).

With two teams of engineers on-site for detail measurements, we also used the Leica GS 16 GPS, which is another high-precision system that offers a range of improvements over previous models, including enhanced performance, flexibility, and ease of use.

RESULTS AND DISCUSSIONS

The practical part focuses on the general cadastre in the administrative-territorial unit (UAT) Craidorolt, Satu Mare County, a cooperated area, but with various challenges in identifying property owners and property documents.

For the "cooperated areas," as is the case with ours, Property Titles (TPs) were issued after the dissolution of the cooperatives, and the people were restored to possession based on a document issued by the local council (certificate), which certifies the ownership of the land by the individuals.

The first step in carrying out the general cadastre work is informing the citizens about the commencement of the systematic registration of properties.

To start the information campaign regarding the administrative-territorial unit Craidorolt, Satu Mare County, informative materials (leaflets, posters) were printed, distributed, and published according to the format provided by the "ANCPI" (National Agency for Cadastral and Land Registration).

To support the local information campaign, the service provider, together with the Craidorolt local council, promoted the campaign by sending informative and convocatory letters, as well as advertising materials.

The next step involved measurements, which were carried out using a series of advanced equipment to ensure the accuracy and precision of the data collected.

The presence of property owners during these measurements was essential to ensure the correctness of the data and to clarify any discrepancies regarding property boundaries.

After the measurements are completed, the process of data processing begins, along with comparing them to the data obtained from the drone flights conducted by the service provider. This step is essential to ensure the coherence and accuracy of the collected data.

During this process, any discrepancies between the ground measurements and the aerial images captured by the drone are checked. Any discrepancies identified are analyzed and corrected afterward to ensure data consistency (Smuleac et al., 2020).

Additionally, the collected data is compared with existing cadastral plans. At this stage, a detailed verification is carried out to ensure that all properties are correctly identified and that property boundaries are well defined.

Data acquisition was performed using the Leica Pegasus: Backpack equipment, along with the GNSS equipment, used as the Master Base, which recorded Rinex data throughout the scanning process (figure 6 and 7).

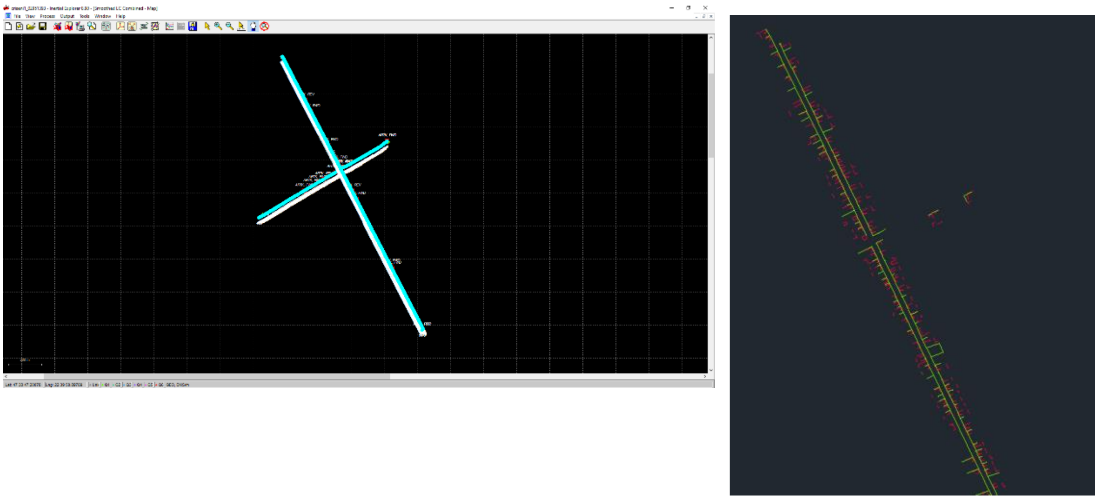

Fig. 6. Scanning with the Backpack

Fig. 7. Streets subject to the scanning process

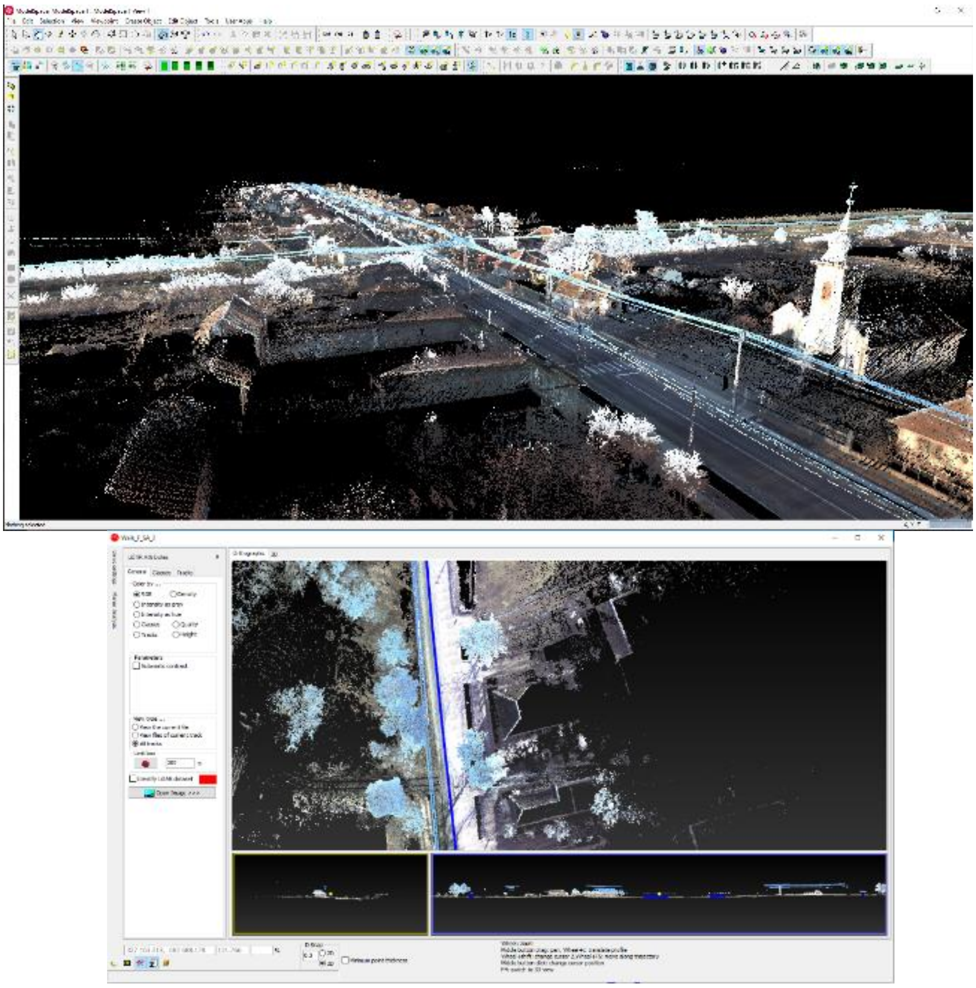

Fig. 8. Obtaining the point cloud

After obtaining the 3D point cloud (figure 8) from the processing, the project was uploaded into the Leica Cyclone software, from which all the tracked elements were extracted.

The software allows us to segment the data based on specific objectives or areas of interest. This can include identifying and separating terrain, buildings, trees, or other objects.

Once we extracted the relevant data, Cyclone allows us to export the processed data in different formats, such as geospatial file formats or formats compatible with other applications. Since we continued working in AutoCAD, the exported file was in DXF format.

The processing was carried out using Pegasus Manager software, and the accuracy verification was performed using NovAtel Inertial Explorer software.

Pegasus Manager is specialized in managing and processing data collected during mobile mapping data acquisition, such as LiDAR scans and photographic images.

The software provides a wide range of tools to ensure that the collected data is transformed into valuable information for the planning and management of road infrastructure points or other types of projects.

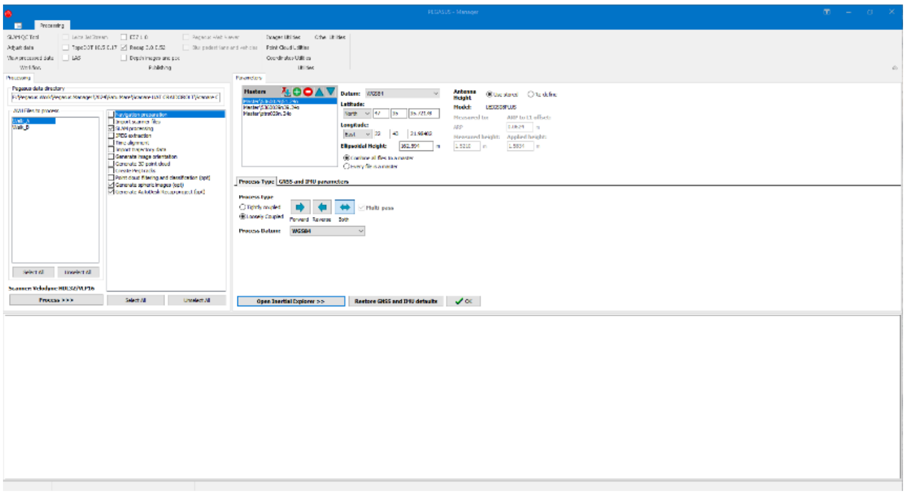

Fig. 9. The interface of the Pegasus Manager software

NovAtel Inertial Explorer is a software specialized in collecting trajectories and analyzing inertial data obtained during mobile data collection, such as data from the Leica Pegasus Backpack equipment (figure 9).

Trajectory correction is an essential step in data processing to obtain accurate and consistent data.

In the images above, quality control can be observed following the measurements. Since it was properly calibrated, there were no errors, and the parameters were suitable for scanning.

After completing the measurements and comparing them with the cadastral plans, the next step is the process of identifying the property titles and cadastral documents, through which the localization of the deeds is carried out, meaning the old land registry books.

Based on the measurements and land registry books, the following information was recorded on the plan: the owner's name from the Land Book (CF), the name of the possessor, the area as per the documents, the land use category, the Land Book number, the topographic number, and whether the property is fenced or unfenced.

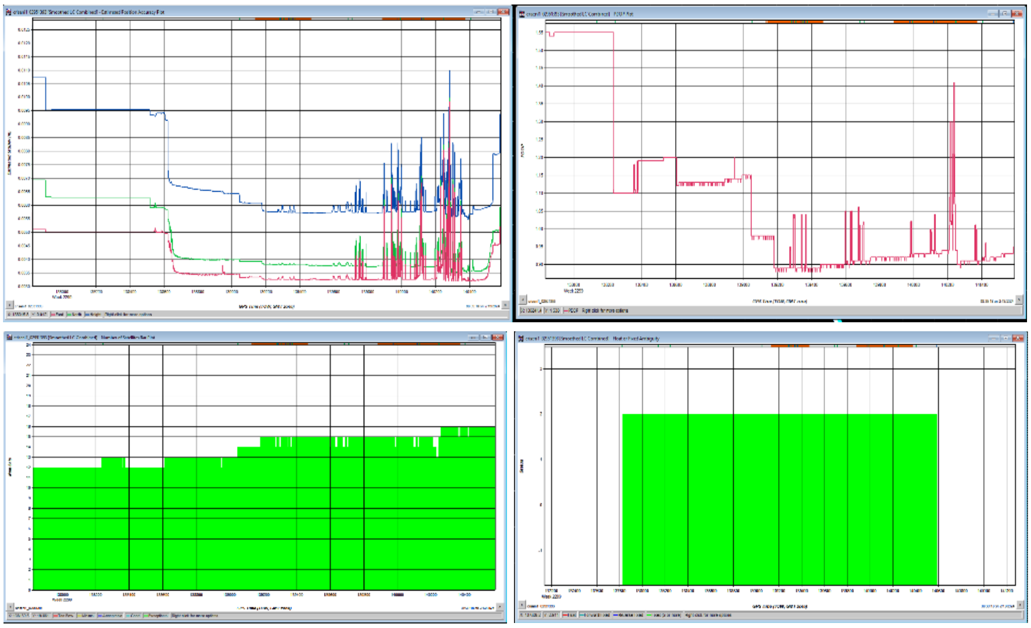

Fig. 10. Quality Control

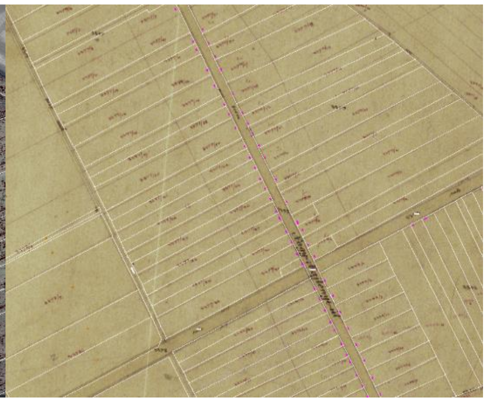

Fig. 11. Cadastral Plan Fig. 12. Topographic Plan

After introducing the parceling into Mapsys, topological errors were corrected to avoid overlaps between properties or gaps. Topological errors were corrected for each layer individually in order to generate the cgxml files (figure 10).

The next step is to make the entries in the C.G. program. Through this program, cgxml files are generated, meaning new converted land books. A "first step" to reach this stage is assigning an ID to each property in a sector.

The IDs are numbers, usually consisting of at least four digits, which help us keep track of the properties in the sector more easily. Each property receives a unique ID, which differentiates it. These IDs do not repeat and, at the end of the process, they are transformed into a land book number ("CF"). The second step is creating projects for entering the IDs into the C.G. program. After entering the data from Mapsys, each ID will be processed individually in the "property" section of the C.G. program, where the owner, the document number and date, the concluding number, the type of document, the issuing authority, the registration type, the type of right, and the method of acquisition, the share type, and any relevant notes (if applicable) will be recorded.

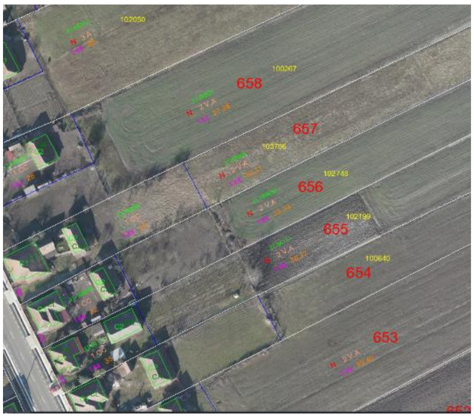

Fig. 13. Writing down the plan the informations from the CF

In the case of some property owners, it was necessary to obtain a possession certificate, as they did not have ownership documents. To resolve this situation, a list was created with all the owners who required the issuance of a possession certificate. This list was sent to the local government, which was responsible for verifying and issuing the possession certificates. The local government issued these certificates only to individuals who had cared for the land and had paid the corresponding taxes on time.

After completing the registrations, the final step is to generate the "CGXML" files and upload them, along with the Property Data Sheets, to the "ANCPI - E-terra" platform (figure 13).

For the launch of the second advertising campaign related to the administrative-territorial unit of Crișeni, Satu Mare County, informational materials (brochures, posters) were printed, distributed, and made public according to the format provided by ANCPI.

The contractor promoted the project’s objectives by displaying the campaign posters in all local points of interest, such as cultural centers, schools, medical dispensaries, and bulletin boards. The local residents accepted the invitations and showed up in large numbers at the cultural center in Craidorolt to review the published documentation.

The request to contest the information in the technical documents can be submitted within 60 days from the date of their publication and must be accompanied by supporting property documents. These requests can also be submitted through the electronic platform of the National Agency for Cadastre and Land Registration (ANCPI).

The receipt, registration, and resolution of requests are the responsibility of the commission designated by the Cadastre and Land Registration Office (OCPI).

Rectification requests are resolved through a report (process verbal), which will be communicated to the involved parties in accordance with the provisions of the Civil Procedure Code.

The contractor updates the final cadastral documents based on the information received from the "resolution commission" of the contestations, including the minutes of contestation resolutions, the contestations, and the associated supporting documents. In addition, the contractor "integrates the solutions" adopted by the commission into the work and updates the land books that have undergone modifications since the beginning of the publication of the project. All updates made are transmitted in digital format to the Cadastre and Land Registration Office (OCPI).

After the updates are completed, if the work submitted to the OCPI no longer presents technical deficiencies, it informs the contractor that the work is compliant and requests the submission of the documents in analog format. This stage is concluded with the transmission of the "quantitative and qualitative reception report" to the purchaser and contractor, following which the acceptance report is issued.

The Cadastre Office proceeds with the opening of new land books based on the final cadastral documents and the associated documents, in accordance with the regulations authorized by the director of ANCPI. After these are opened, the Cadastre Office hands over the new land books along with the cadastral plans to the representatives of the municipality, for distribution to the involved parties.

CONCLUSIONS

The completion of the general cadastre involves a series of important steps and aspects. This work requires the integration of engineering skills, advanced legal knowledge, the use of information technology, and database management.

Traditional topographic surveys were used in the past to collect the necessary field data, but mobile mapping technologies have become an attractive option in this regard, offering a range of advantages in terms of efficiency, accuracy, and savings in time and resources.

At the same time, we believe that systematic cadastral works cannot fully resolve all the existing issues in the cadastral field, but they can significantly contribute to normalizing the cadastral situation within a Local Administrative Unit, with any remaining issues falling under the jurisdiction of civil courts.

The completion of the technical systematic cadastre works will lead to the opening of new land books, thus replacing the old cadastral records with updated documents.

The implementation of the systematic cadastre allows for the organization of land for various operations such as land consolidations, decommissioning, expropriations, or corrections, benefiting from an up-to-date database.

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