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THE USE OF UAV AND GNSS TECHNOLOGY FOR THE PERFORMANCE OF SYSTEMATIC REGISTRATION WORKS

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Abstract

Systematic cadastre represents the registration in the land register of all buildings that belong to a TAU. In order for the field part to have a shorter duration and greater efficiency, it was chosen to make a flight with the WingtraOne GEN II drone, which represents one of the best performing drones, for better precision when georeferencing the images they used in the field "ground control points" for which the coordinates were determined with the help of GPS. AutoCAD and Agisoft programs were used to process the data obtained from the field, later vectorisation and identification of small problems appeared on the orthophoto plan. These works were carried out for the registration of buildings in the integrated cadastre and land register system.

The purpose of this work consisted in the acquisition of data for the realization of the systematic cadastre for a very large number of existing buildings in the localities that are part of the TAU Giroc. This was also marked by the difficulty of taking the data from the field and processing them, due to the high degree of coverage in the inside of the urbane area with buildings and vegetation.

Key words: *Agisoft, AutoCAD, drone, GNSS, GPS, systematic cadastre*

INTRODUCTION

Systematic registration represents "the process by which the real situation of all buildings located on the territory of Romania is translated into a unified computer system, with the aim of effectively managing the information regarding them" (Popescu, 2015).

The procedure and stages of the systematic registration works are provided in the Regulation of reception and registration in the cadastre and land register records (Order 600/2023) based on Law number 7/1996 on the cadastre and real estate advertising and the Regulation of July 9, 2014 on approval, reception and storage in the cadastre records and functional book.

The information regarding the buildings on the territory of Romania, which is translated into the IT system, is of a legal, economic and technical nature.

The economic information is determined based on the technical elements of the real estate, with the aim of establishing a real tax value for it.

The legal information has in mind "the identification of the owners/possessors of all buildings, as well as the registration in the land register of property rights and/or other real rights, based on the translative or constitutive acts of rights" (Popescu et al., 2015).

The process regarding the systematic registration is carried out at the level of the villages, by cadastral sectors.

In order to carry out systematic cadastre works and to collect the necessary data from the field, it is necessary to use modern technologies with high precision, such as Global Navigation Satellite System (GNSS) and unmanned aerial vehicle (UAV) (Popescu et al., 2020).

Taking data from the field with these technologies is done in an optimal time and on fairly large surfaces.

MATERIALS AND METHODS

The Trimble R8 GNSS receiver and the WingtraOne GEN II drone were used to perform the work.

The Trimble R8 GNSS receiver offers the necessary features and benefits in a single flexible and scalable system so that we can build a system perfectly adapted to ongoing projects (Figure 1). As requirements change, the Trimble R8 can be further configured to significantly increase field productivity, featuring 72 channels and 440-channel Trimble Maxwell™ 6 chips.

Figure 1: GNSS Trimble R8 receiver (https://ts-geosystems.com/product/trimble-r8-rtk-gps/)

The GPS measurements were performed using the kinematic method.
The kinematic method RTK (Real-Time Kinematic position) implies the movement of a receiver during the observation period, while a receiver remains fixed on the known point.
The principle of positioning by the kinematic method is based on the fact that, first of all, a few points with known coordinates are occupied on which data is collected from satellites (it is necessary that the number of visible satellites be as high as possible) during a few minutes. Through this method, the vector between the stationary receiver (base) and the mobile one (rover) is established, with a precision of the order of two to three centimeters.

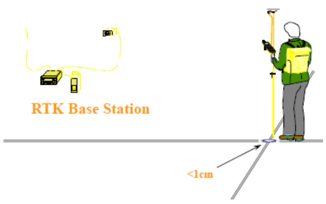

Figure 2. Kinematic method RTK (Guidelines for RTK/RTN GNSS Surveying)

The reference receiver transmits its phase and code measurements to the mobile receiver. The biggest advantage is that it measures points without them being visible to each other (Figure 2).
Using RTK, the position can be determined in a few seconds with centimeter precision at a distance of up to 50 km from the reference station.
Determining the coordinates using RTK takes a few seconds, as long as there is a radio link with the reference station, and an optimal opening to the sky.
Due to its ease of use, versatility, centimetres accuracy and reliability, RTK has become the standard for surveyors.
Complex works are processed at the office with specialized software.
WingtraOne GEN II drone (Figure 3) which has the advantage of: flying at 16 m/s (36 mph) for up to 59 minutes per flight for high coverage, at the same time WingtraOne can fly higher than drones limited to 20MP cameras so it can capture more field and more detail with each shot and a larger area per flight, high-quality optics mean it can reliably reconstruct the map even with smaller overlays, the system offers a safe and efficient mapping from constant altitudes even in the most mountainous areas, thanks to global field models or your own custom elevation data.
With WingtraOne data acquisition is much faster than with other tools, even for large areas. Can collect data up to 2x faster than other fixed wing drones and up to 8x faster than multicopter drones. (https://www.dronezone.ro/).
Thanks to years of continuous improvements, the WingtraOne drone consistently delivers high-resolution and accurate data, featuring GSD up to 0.7 cm/px (0.3 in/px) and absolute horizontal accuracy up to 1 cm (0. 4 inches).

Figure 3: WingtraOne GEN II drone (https://www.es2-inc.com/uas-mapping)

Mission Planner (Figure 4) was used to perform the flight mission, which represents a ground control station for the plane, helicopter and rover. It is only compatible with Windows. The mission planner can be used as a configuration utility or as a dynamic control add-on for the autonomous vehicle. Mission Planer is useful for Monitor the status of your vehicle during operation: record telemetry logs that contain much more information than on-board autopilot logs, view and analyze telemetry logs and operate the vehicle in FPV (first person view).

Figure 4. Interface presentation of Mission Planner (https://ardupilot.org/planner/)

Agisoft software (Figure 5) was used to process the images, they represent a state-of-the-art software solution, with photogrammetry based on the central part of the software engine designed to the absolute limits, while the entire system is designed to generate specific results for this field which is based on automatic learning techniques for post-processing and analysis tasks (https://roexpertcad.ro/services/mapare-geografica/).

Figure 5: Agisoft software

The software enables the processing of images from RGB or multispectral cameras, including multi-camera systems, in dense point clouds, textured polygonal models, real georeferenced orthomosaics and DSM/DTM.
Additional post-processing allows the removal of shadows and texture artifacts, the calculation of vegetation indices and the extraction of information for action maps of agricultural equipment, the automatic classification of dense point clouds, etc.

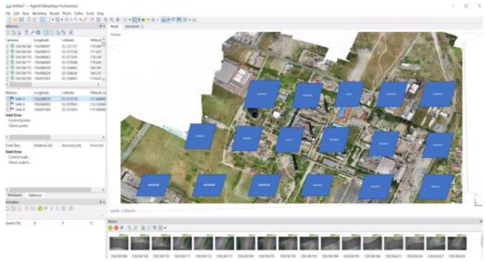

Figure 6: How to process images in Agisoft

Based on the last generation technology developed by Agisoft, Metashape (Figure 6) allows very fast processing, while providing very precise results for both aerial and close-up photography (up to 3 cm for aerial photography and up to 1 mm for the approach).

RESULTS AND DISCUSSIONS

In order to be able to start the systematic cadastre works within the Giroc TAU, it was necessary in the first stage to collect data from the field. This stage was carried out by marking the control points on the ground, in order to be able to align the images obtained in the 1970 Stereographic projection, in order to process the data in the AutoCAD computer environment. Terrestrial landmarks were materialized on the ground with the help of targets visible from the air. They were represented with neon orange color, to be easily visible on the ground, at the time of data processing.
The landmarks were placed in free areas, with high visibility in areas where constructions and vegetation did not represent an impediment to viewing the landmarks from the air.
The equidistance between the landmarks was 300 m.
The markings were placed and anchored as best as possible during the measurements in order not to introduce errors.

Figure 7. Marking control points on the ground

In this situation, 16 ground control points were used, as can be seen in figure 8.

Figure 8: Marker positioning mode

After the control points were materialized in the field, the coordinates of each point were determined by the GNSS method, stationing on each point, until the GPS receiver made all the corrections.
The planning of the flight mission was carried out, the stage in which the area and the flight route are entered in the drone's operating system. The software integrated into the drone system is Mission Planner, it comes bundled with all the drone's equipment, thus facilitating the entire process of photographing the studied area.
In the flight planning software, the operator defined the flight area, and drew up the plan that included the flight route with return positions. Depending on the planning parameters, the flight speed of the drone, the altitude of the flight, as well as the angle of the camera for the photography operation were calculated.
After accepting all the parameters, the drone started the flight mission respecting the selected area, from the initial take-off point.
The operator checks the entire process from the drone's console for added safety in accomplishing the mission.
At the end of the flight, in the office stage, the images from the drone were downloaded and the coordinates obtained with the GPS were processed in Stereo 70 coordinates.
Thus, the second stage was represented by downloading the coordinates of the control points on the ground and the representation in AutoCAD, as can be seen in figure 9.

Figure 9: Representation in AutoCAD of control points

The next stage consisted in processing the images and obtaining the mosaic of images with the help of the Agisoft program, steps for this stage were represented by:
After georeferencing the images, a cloud of points was created at different levels (Low, Medium, High, Highest).
The next step was georeferencing the images and creating the orthomosaic using this field model and the resulting photograms.
As a finished product, the orthophoto plan of the area of interest resulted, the orthophoto plan being exposed at High resolution level (Figure 10), this being followed by the vectorisation process that was carried out in AutoCAD.

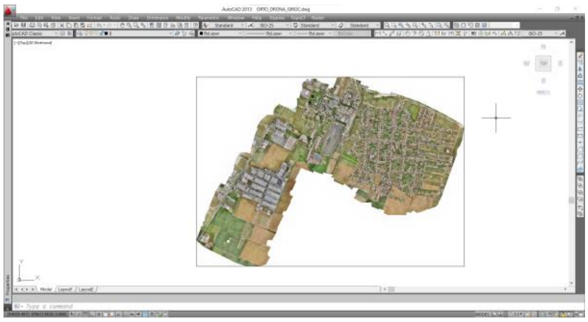

Figure 10. The orthophoto plan of the area of interest

After a more careful analysis of the orthophoto plan, it was found that there is a relative percentage of deformations of the images (Figure 11). The "aesthetic" problems appeared precisely because of this reason (interpolation of images on certain areas).

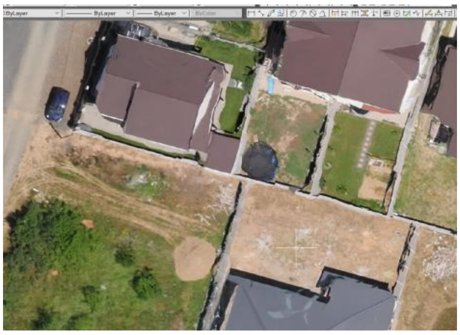

Figure 11: Exemple of „corrugation” of fences

When performing the photo interpretation and vectorisation of the orthophoto plan, the graphic database made available by the Timis Real Estate Cadastre and Publicity Office was also used as an extra help (Figure 12).

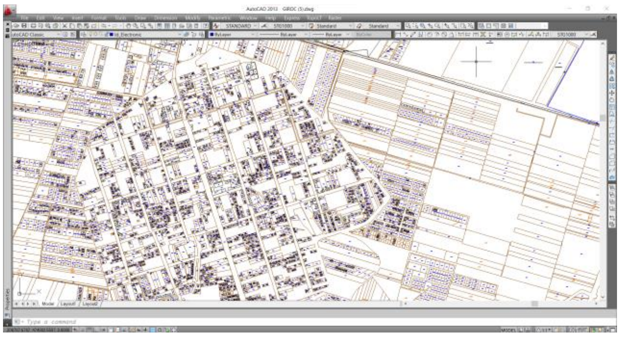

Figure 12. Graphic database

The two elements being overlayered, as can be seen in figure 13, were helpful in the vectorisation process of the constructions that did not have a graphic database.

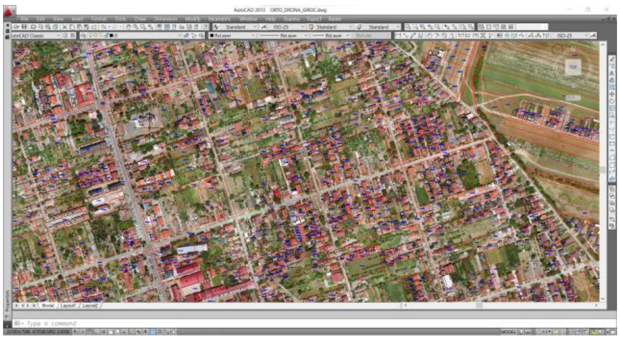

Figure 13. Overlayered of the graphic base over the orthophoto plan

For vectorisation, the points from the base, represented by the fence/post, were chosen, the stage represented in Figure 14, so if we had a slightly inclined fence, it represented an advantage to the operator, being able to establish more quickly the correct point that he must vectored.

Figure 14: Elaboration of the vectorisation of the orthophotoplan

For the vectorisation of a building, the operator looked for the posts and the direction between the posts that defined the outline of the building, even if the fence seemed to be wavy on certain portions (Figure 15).

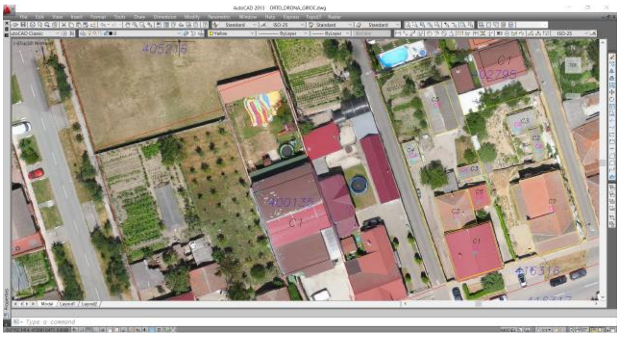

Figure 15. The vectorisation process of real estate

Also in this process, the identification of buildings without a database was also carried out, identifying the category of use and the height regime.

For the vectorisation of the buildings, the edge of the roofs according to Figure 16 was not used, but a minimum distance of 10-20 cm was kept from the edge, so that the wavy edge did not negatively influence the precision of the orthophoto plan and the vectorisation.

Figure 16: Model for realizing the vectorisation of constructions

These obtained materials provided effective help for obtaining the materials that led to the realization of: the measurement base for: Systematic Cadastre and/or General Cadastre.
In order to achieve this stage, more time and attention was needed, the greatest attention being allocated to overlaying contours, a situation that can be seen in figure 17.

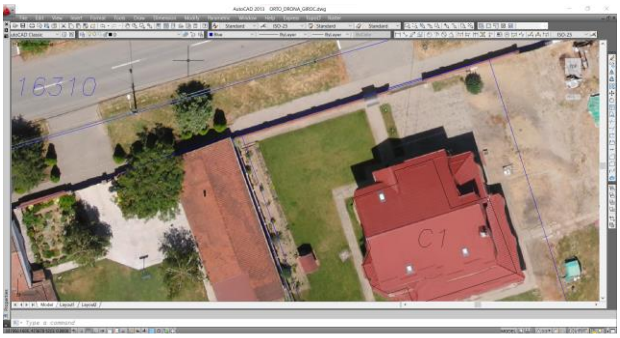

Figure 17. Real estate contour overlay

This operation was carried out on cadastral sectors (Figure18).

Figure 18. Vectorized cadastral sector

CONCLUSIONS

These works were necessary for the systematic registration of buildings within the radius of the Giroc TAU. The work presenting a real challenge due to the surface area of approximately 5200 ha and the large number of buildings that are in a continuous expansion, Giroc representing one of the largest TAUs in Timis county, this being the main reason why it was used UAV technology in collecting data from the field but also identifying certain elements from the field that could not be observed and it was difficult to access. The main advantage of using this technology was the shortening of the time for the field stage, thus reducing the number of work force that would have been necessary for the terrestrial measurements, also reducing the related costs.
Also, this method presents the problem of errors appeared during data processing, which lead to the loss of precision during vectorisation, for this reason interventions in the field are also necessary to be able to eliminate the errors. The most difficult and meticulous part of this work was represented by the office stage, which required a lot of work time in the vectorisation process, because the orthophoto plan presented certain deformation errors of property limits and buildings.
In conclusion, we can say that working with the drone offers, in addition to the identification of details in the field, an update of the orthophoto plan through detailed aerial images of the targeted area.
The need to prepare these types of works also arising from the identification of those details that were not included in the legal documents presented by the beneficiaries.

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