

## POSSIBILITIES OF USING THE UAV PHOTOGRAMMETRY IN THE REALIZATION OF THE TOPO-CADASTRAL DOCUMENTATION

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**Abstract:** *The research presented in this paper took place in Resita City, Caras-Severin County, on an area of approximately 80 hectares for the realization of the graphic updating documentation in the Land Book. To accomplish this, a DJI Phantom 4 Pro UAV device was used together with a Leica Viva GS16 GNSS equipment. If initially the drones (UAV - Unmanned Aerial Vehicle) were manufactured and used exclusively in the field of defense, their cost amounting to several millions of dollars, today there are many variants on the market, including small and cheap drones, which can be controlled with the smartphone and can be successfully used in photogrammetry. In the last decade, the use of unmanned aerial vehicles has become increasingly popular for a wide range of disciplines and scientific applications, given that drones can be technical means for: surveillance of high-speed areas; monitoring of forests and natural phenomena that occur in them; damage assessment after certain natural disasters; observing and alerting the authorities about the victims of unfortunate events; observing and evaluating the growth and harvesting of agricultural products in the field of agriculture; filming and observing certain races and artistic or sporting events, etc. Currently, many photogrammetric mapping methods have used drones to retrieve and record data about objects on earth. This is because the drone use the Global Navigation Satellite System (GNSS) and Inertial Measurement Unit (IMU) for air metering and is more efficient and cheaper compared to the chartering of a plane, it also allows flying over difficult areas and significantly reduces the execution time of the work. From a technical and technological point of view, in the cadastral domain, in the last decades, there has been a remarkable progress. From theodolite, used to measure horizontal and vertical angular directions, to the total station, at present, the ground surface can be "scanned" and measured with non-pilot aircraft, commonly referred to as drones. The use of UAV in geospatial science is currently in high demand due to its relatively easy operation and relatively affordable cost compared to satellite systems, especially high resolution images. One of the benefits of using drones is to take aerial photos that are then processed for mapping so that they can be used to support spatial data acquisition.*

**Keywords:** *UAV, GNSS, Photogrammetry, Land Book, Caras-Severin County*

### INTRODUCTION

The last decade has seen a rapid development in the use of unmanned aerial vehicles (UAVs) to obtain spatial information on the Earth's surface. The use of UAV equipment is ideal for the acquisition of research data at resolutions from 0.5 to 2 cm. Software used for processing reconstruction and monitoring data can vary in price from the most expensive to the ones obtained as Open Source, thus obtaining data at high resolutions (MILOŠRUSNÁK ET ALL, 2017).

Compared to satellite or photogrammetric analyzes with traditional crew, UAV flight plans offer a high operational variety in terms of costs, time and repeatability (NEX, F.; REMONDINO, F., 2014; HERBEI, M. V., ET ALL., 2016). For this reason, UAVs are considered to be complementary to traditional remote sensing platforms (HERBEI, M. V. ET ALL., 2016), being able to replace some measurements that must be purchased by human crew aircraft. Given the economic and functional side, we can say that in relation to the retail market, it is in

development, both for commercial producers and for civil applications of UAV [HAARBRINK, R.B., 2012; SMULEAC, A., ET ALL., 2012; ŞMULEAC, A. ET ALL., 2017). Drones are today a valuable source of data for inspections, surveillance, mapping and 3D modeling issues. Since UAVs can be considered as a low-cost alternative to classical aerial photogrammetry, new applications are introduced in the short and near field. Rotary or fixed-wing UAVs, capable of purchasing photogrammetric data with digital or SLR cameras, can fly in manual, semi-automatic and autonomous modes. Following a typical photogrammetric workflow, 3D results can be produced such as surface or field digital models, contours, textured 3D models, vector information, etc., even on large surfaces (FRANCESCO NEX, FABIO REMONDINO, 2014).

A UAV platform can be used to study small urban areas, when national regulations permit, for cartographic and cadastral applications. These images have a very high resolution if the flights are made at a height of 100-200 m above the ground (M. SIMON ET ALL., 2018). Very large overlays are recommended to reduce the isolated areas and to obtain a more complete and detailed DSM. A sufficient number of GCPs is required to make geographical references of the processed images as part of the package and point cloud adjustment; the number of GCPs varies depending on the size of the image block and the complexity of the interviewed area. The quality of the point clouds obtained is usually very high (up to a few centimeters), and these data can thus be used for further analysis and feature extraction.

The final stage of data processing includes the generation of orthophotoplanes, mosaics, raster images, TIN and DEM formats as well as the generation of point clouds. The combination of 2D and 3D data allows the classification of points and their filtering for precise modeling and modeling of objects. At the end of the post-processing of UAV aerial data, topographic models will be generated, exporting the data in different formats, including Google Earth, which can then be processed and viewed with other special programs.

The purpose of this research is to realize the graphics of the buildings included in the flight plan based on the resulting orthophotoplan. These contours of the buildings were made in AutoCAD following the import of the orthophotoplan from the study area and the vectorization of the property and building boundaries (M. SIMON ET ALL., 2017).

## **MATERIALS AND METHODS**

The researches presented in this work were carried out in Reşiţa Municipality, the residence of Caraş-Severin county, located in the southwest of Romania, in the northwestern part of the county, on the middle course of the Bârzava river (figure 1). Resita is the oldest steel center in Romania. The city has a simple form being mainly located on the hills and their valleys, following the route crossed by the river Bârzava, which comes from Văliug, from the east of the city of the Semenic Mountains. Thus, the main road also follows the route formed by the river Bârzava between the valleys.

Historically, the town is attested from the fifteenth century by the name of Rechyoka and Rechycha. Archaeological researches have found traces of this Neolithic, Dacian and Roman period in this space. It is mentioned in 1673 with the name Reszinitza, whose inhabitants paid taxes to the Timişorara pass, and in the years 1690 - 1700, the sources remind it as depending on the Bocşei District together with other localities in Bârzavei Valley (<https://ro.wikipedia.org/wiki/Reşiţa>).

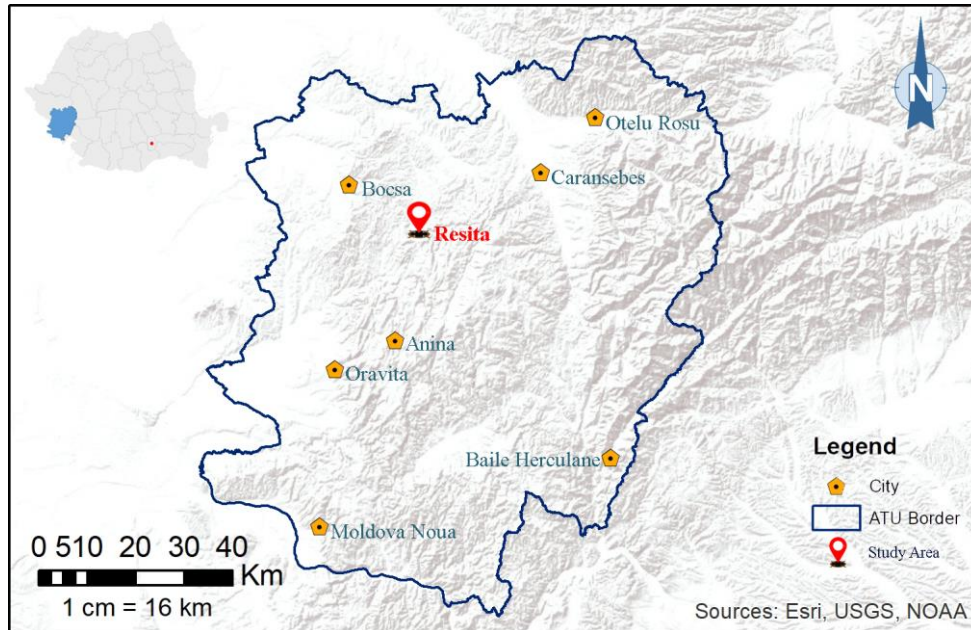


Figure. 1 – The studied area

The working methodology underlying this study is summarized in Figure 2.

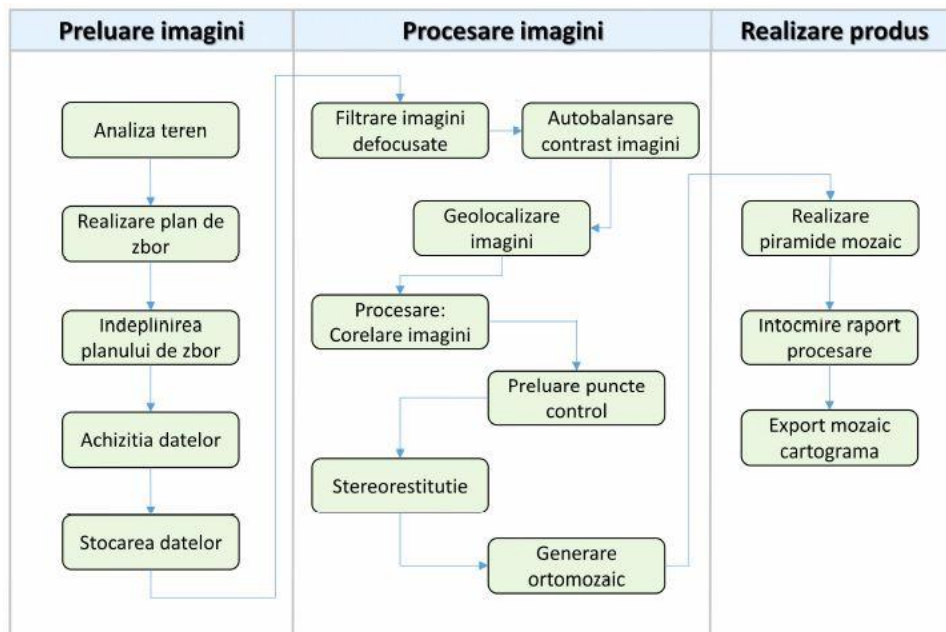


Figure. 2 – Working methodology

Following the exact determination of the objective to be measured, in the first stage a land recognition was made and the ground control points were established. These points were materialized in the field by targets with the size of 1m / 1m (figure 3).



Figure. 3 – Targets used (GCP)

The targets have a role in the georeferencing in the national stereographic projection system 1970 of the photogrammetric images, images that resulted from the drone flight.

For this study I used a number of 8 targets located on the area that I surfulated with the drone. Thus, they were determined at the coordinates of the 8 landmark targets on the ground using GNSS technology using the Geomax Zenith 20 GNSS system (ŞMULEAC, A. ET ALL., 2017; ŞMULEAC, L. ET ALL., 2017; <https://geomax-positioning.com/products/gnss>) (Figure 4) by connecting with the ROMPOS permanent station system.



Figure. 4 – GNSS Geomax Zenith 20

The drone used in this study was DJI Phantom 4 (<https://www.dji.com/phantom-4>), the drone in which the camera enters (with 4K shooting capacity and 12 megapixel images; image quality being influenced by camera sensor, optical parameters of the lens used and the stability of the aerophotography platform), GNSS, GPS and GLONASS positioning system (which allows the acquisition of images in the WGS 1984 system), propellers, smart battery, obstacle detection system (Figure 5).



Figure. 5 – DJI Phantom 4

The maximum flight altitude of the drone is up to 3 km, our flight being made at an altitude of 120 m. The flight was performed at this altitude, because the lower the flight height, the better the clarity of the images. At this altitude 335 photos were taken, all passing the quality test from 4 different flights to cover the entire area.

Aerophotography was performed when the sun's elevation angle was greater than 25 degrees, ie about 12 PM. The flight took place under maximum visibility conditions that did not affect the orthophoto rendering of the natural colors existing on the ground. These relevant details have not been omitted so that the obtained map does not have clouds or accentuated shadows.

## RESULTS AND DISCUSSIONS

The route that the drone follows is planned and established in advance, not neglecting the route established by the operator. The drone went in straight lines for the acquisition of photogrammetric images, which overlap longitudinally in proportion of 70% and transversely in proportion of 75% to ensure increased accuracy and to create the 3D model.

In the conducted flight, the drone surprised all the 8 targets marked on the ground that were later useful to us for the georeferencing of aerophotogrammetric images. The height must be constant, that is, once set, it must be kept until the end of the flight, otherwise errors will occur in the data processing and the realization of the orthofoplan. After the entire surface was covered (Figure 6), and the flight was completed, the drone returned exactly where it left off at the beginning of the flight (ŞMULEAC, A. ET ALL., 2015).

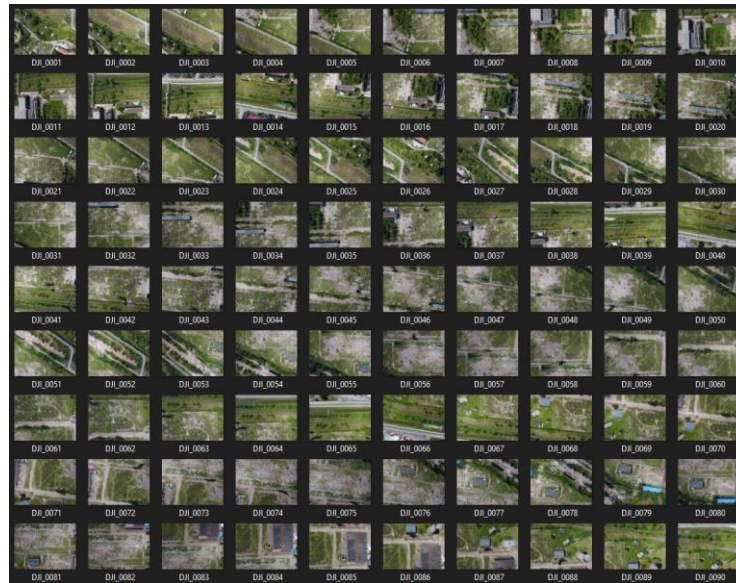


Figure. 6 – Pictures taken during the mission

The first stage of the office is the download of the raw data from the GPS, namely the ASCII file (figure 7) with the coordinates of the three control points that we will use for the geo-referencing of the orthophotoplan from the WGS '84 projection system into the Stereographic system. '70.

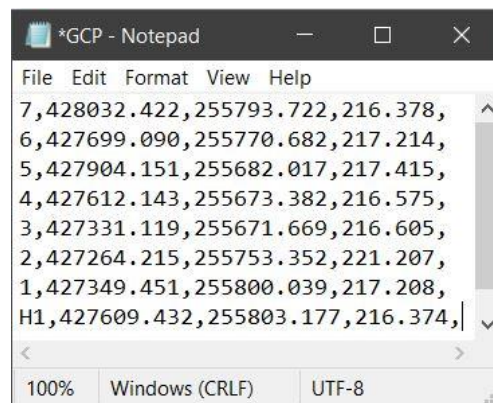


Figure. 7 – ASCII File

In the second stage the data were processed with the Agisoft PhotoScan software (<https://www.agisoft.com>). This data processing is done by determining the flight path of the drone. The stereoscopic view allows us to see an object from two different perspectives, such as aerial photography taken from different camera positions. Therefore, the result of data mapping using this drone can produce very high resolution images, it also produces a three-dimensional image of the recorded surface. Photo alignment is done to identify the points in each photo and to make the same matching process in two or more photos (Figure 8).

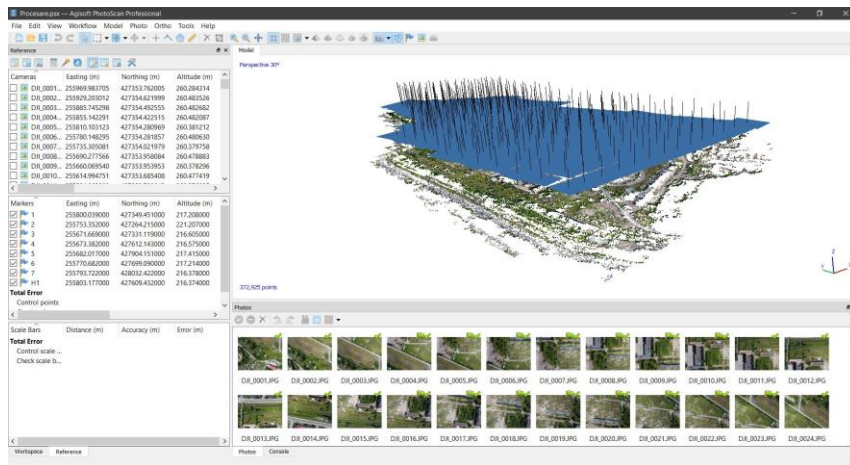


Figure. 8 – Image alignment

After I have done the alignment of the images, the part of introducing the coordinates of the control points and the georeferencing of the point cloud based on them (Figure 9).

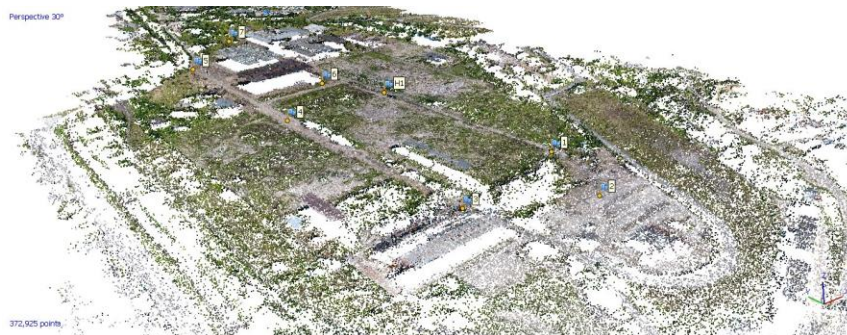


Figure. 9 – Georeferencing of control points

After completing the steps presented above, the 3D model of the studied area was shown in Figure 10.



Figure. 10 – Obtaining the model 3D

The locations of the rooms and the error estimates are shown in Figure 11. The altimetric error (Z) is represented by the color of the ellipse, and the planimetric error (X, Y) is represented by the shape of the ellipse.

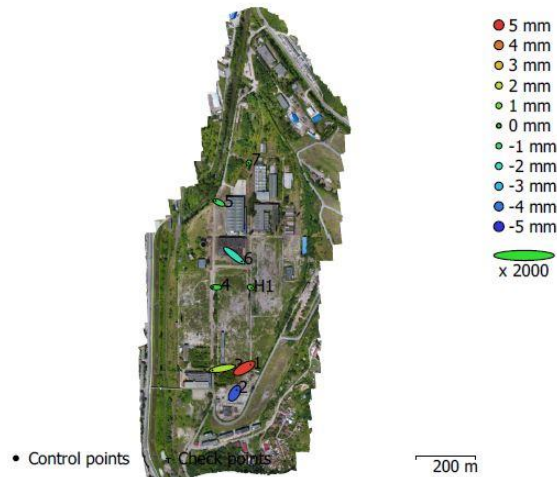


Fig. 3. GCP locations and error estimates.  
 Z error is represented by ellipse color. X,Y errors are represented by ellipse shape.  
 Estimated GCP locations are marked with a dot or crossing.

Count	X error (cm)	Y error (cm)	Z error (cm)	XY error (cm)	Total (cm)
8	1.76417	0.957302	0.251066	2.00717	2.02281

Table 3. Control points RMSE.  
 X - Easting, Y - Northing, Z - Altitude.

Figure. 11 – The locations of the control points and the estimated errors

After the georeferencing and processing specific to digital photogrammetry based on aerial images, different products can be generated, such as: DEM, DSM, DTM, or orthophoto (Figure 12).



Figure. 12 – Orthophoto of the studied area



After importing the orthophoto plan into AutoCAD, the property limits of the real estate in the studied area were vectored based on the extracts from the Land Book and the cadastral plans in the respective area (Figure 13).



Figure. 13 – Vectorization of property ownership limits

Once the vectorization of the buildings was completed, a final plan was obtained, following which the documentation of updating real estate data was drawn up for the 52 buildings identified in the study area (Figure 14).



Figure. 14 – Update of the study area

## CONCLUSIONS

In conclusion, we can say that the use of the drone is increasingly practiced both in foreign countries and in us in the country because it offers the possibility of the user to enter areas inaccessible, difficult or dangerous for human operators. Privind siguranța personalului, aceasta este asigurată prin efectuarea de măsurători de la o distanță sigură. Măsurătorile se fac în a non-invasive manner, drones leaving no traces or emissions of any kind, during or after measurements. The measurements are made in a short period of time and with a high temporal resolution.

Due to the low flight speed and the ability to plan, combined with a programmable flight path, areas of interest covering relatively large areas can be studied. The autopilot, perfectly integrated with the aircraft, can accurately comply with the pre-determined flight plan, controlling the room in such a way as to obtain the coverage of the entire studied surface.

Through the project of photographing the area studied with the help of modern technology (drone), situation plans of the respective area resulted from the demolition of certain buildings, also these plans that resulted in the Stereographic 70 system were used when drawing up the cadastral documentation in view updates in the land book of the land and related constructions. The accuracy of determining the plans with respect to the classical topographic methods is of the order of centimeters (ȘMULEAC, A. ET ALL., 2016; ȘMULEAC, L. ET ALL., 2016).

Also with the help of the plans resulting from the measurements with the help of drones, it is possible to determine the number of levels of the constructions, the type of roof (type of roof or roof), as well as the color and texture of the facades.

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