MODERN DATA ACQUISITION TECHNIQUES AND TECHNOLOGIES IN THE GENERAL CADASTRE

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Abstract: *This research aims to achieve the general cadaster with the help of modern data acquisition techniques and technologies, within the area of UAT Zavoi, where sector 25 is presented in this paper. The area of UAT is 39129 ha and consists of 83 sectors, and for the present work, the area studied is 19 ha and comprises 110 real estates. The cadaster is the unitary technical ensemble, essential for the technical, economic and legal situation, on a set of real estates, on a UAT (territorial administrative units), which is identified by a unique cadastral number and is registered in a land register, together constituting a cadastral register of real estate. Planimetric measurement were made with the total station Leica TS06 and the GNSS equipment Leica GS16. The ortho-photoplane corresponding to the studied area and the 3D model of the land was made with the help of UAV (unmanned aerial vehicle) technology, WingtraOne generation II drone and aerial image processing were carried out with the help of the Pix4D program. Recently, in addition to drones dedicated to photogrammetry, drones have also emerged capable of using LIDAR devices that can create high accuracy point clouds. To acquire ground point clouds, the research also used mobile MMS (Mobile Mapping System) backpack scanning equipment, which contains a reality capture sensor platform. 5x4 megapixel cameras are installed for the best possible image coverage. Captured georeferenced images are combined and used to navigate and color the dot cloud. The visualization and alignment of the points clouds was achieved with the help of Pegasus Manager and the data processing and obtaining information related to constructions, roads, bridges, property limits and other elements of detail was carried out with the Cyclone program.*

Keywords: *UAV, Land Survey, Ortho-photoplane, GPS, Cadastre*

INTRODUCTION

The purpose of this paper is to use new techniques and state-of-the-art technologies in order to achieve a general cadastre, where the time of measurement and the accuracy of measurements is especially important in the realization of cadastral plans. The technique of measuring distance and angles in the past was done using theodolite, but modern measurements today use the latest technologies, recalling: Total stations, satellite technologies, UAV (RESOP, J.P et all, 2019) and LiDAR technique (DI STEFANO, F. et all, 2021; ŞMULEAC, A. et all, 2015). The information obtained in the field can be transferred in different formats such as: DXF, FBK, ASCII, SPF, E57, LAS, PTX (ABDELHAFIZ, A, 2009; DE ANTERO, K. et all, 2016; HERBAN, I.S. et all, 2014; RILEY, P. et all, 2006; SAVU, A. et all, 2009; ŞMULEAC, A. et all, 2019).

The use of satellite systems increases the speed of data collection in the field and the information received by satellite is taken directly with the dedicated programs. The GNSS (Global Navigation Satellite systems) system typically includes GPS (Global Positioning System), GLONASS (Russia) and GALILEO (Europe) satellites.

The WingtraOne Generation II equipment is a UAV-type device that has been used to make orthophotoplane and obtain 3D maps in conformity with national regulations. The 2D and 3D data (CALIN, M, et all, 2015; QIU, Q. et all, 2021) merge allows it to modelling more precise 3D objects in the field. The formats required for the orthophotoplan include the TIN and DEM (HERBEI, M. Et all, 2013) formats, as well as the of the point clouds. For the processing of the data achieved, Pix4D was necessary, data that can be exported to Google Earth.

Point clouds were obtained from the ground using MMS technology, Leica Pegasus, which is used for 360-degree images. Position and altitude were achieved from GNSS data and IMU data using the RTK (Real Time Kinematic) integration algorithm. The accuracy of point clouds and the efficiency of 3D information is 2-4 cm. LiDAR is the fundamental sensor for measuring information in the 3D environment. This mobile mapping system utilizes the SLAM algorithm (STRASDAT, H. et all, 2010; ȘMULEAC, A, et all, 2020), capturing photos and recording ground data. The measurements and post-processing was operated in the Pegasus Manager program, and the data was subsequently processed in the Cyclone program.

MATERIALS AND METHODS

Zăvoi commune (figure 1) is a commune in Caras-Severin, located in the mountain area and plain in S-V Romania (ȘMULEAC, L. Et all, 2017), its area being 396km^2 the villages belonging to this commune are: Voislova, Valea Bistrei, Zăvoi, 23 August, Măru, Magura, Poiana Mărului.

Topographic elevations were achieved by combining both standard and modern technology. In the framework of the project of realization of the General Cadastre, the ruins of a palace were found in 2009, which is supposed to have been built by the Roman legionaries for the Emperor Traian in 101.https://ro.wikipedia.org/wiki/Comuna_Z%C4%83voi,_Cara%C8%99-Severin)

Fig. 1 – UAT Zăvoi

WingtraOne Gen II:

The unique WingtraOne GEN II feature set allows you to minimize flight time and longer working time, whether it is another field project or for data analysis at the office (Figure 2).

It provides effective flight with fixed wings at a speed of 16 m/s (36 mph) for a maximum of 59 minutes per flight for high coverage. It features a 42 MP camera that can fly higher than the 20 MP cameras, so you can capture a larger area with more detail. Thanks to the high-precision PPK GNSS receiver on the board, there will be no need to determine ground control points (GCP). Only three checkpoints can be used to check the quality of your map. High-quality optics mean reliably reconstructing the map even with smaller overlaps. This means more ground coverage on the flight line and maximum coverage per flight.

Faster data collection (QIU, Q. et all, 2021) and extensive coverage mean fewer people on the field for less time, decreasing the human-hour cost associated with data collection.

Fig. 2 - WingtraOne Generation II, UAT Zavoi, Poiana Mărului, Caras-Severin, the use of this technology brought to the realization of the orthophotoplane in the studied area.

Fig. 3 - Comparison of two best VTOL aircraft for topography

Leica Pegasus Backpack:

The Leica Pegasus Backpack (Figure 4) is a highly ergonomic reality capture sensor platform that combines five cameras that offer a fully calibrated 360-degree view and two LiDAR sensors (VLP-16) with an ultra-light carbon fiber chassis. It enables LiDAR points to be obtained both indoors (PURE SLAM method) and indoors or outdoors (FUSED SLAM method) at a level of accuracy that is authoritative and professional (STRASDAT, H. et all, 2010).

This mobile mapping solution (Figure 5) is designed for fast and regular capturing of reality. It is fully portable, allowing it to be checked as baggage if a flight is desired.

The navigation system (INS) is equipped with GNSS and IMU sensors, absolute altitude and outdoor positioning are achieved by GNSS, while the GNSS positioning inside is based on IMU and SLAM.

Fig. 4 - Equipment Leica Pegasus Backpack, Zăvoi Commune

Fig. 5 – Leica Pegasus Backpack together with the GNSS reference station Leica 1200, UAT Zavoi, Poiana Mărului, Caras-Severin

Pegasus Manager Program:

It is a reality capture software for mobile mapping (THRUN, S. et all, 2008) processing, analyzing and extracting functions from point clouds and images acquired by Leica Pegasus mobile mapping systems. Precise mission planning, data processing, automatic function extraction, integrated quality reporting and online publishing make Leica Pegasus Manager a unique, efficient work program for high-precision deliveries. Optionally, Leica Pegasus Manager allows the publication of JetStream files and Cyclone users can combine multi-sensor projects into a single file and for the most efficient collaboration.

MapFactory Program:

It is the complete solution for the Leica Pegasus sensor platform, which covers the end-to-end workflow, from data collection to function extraction. The intuitive interface combined with efficient workflow and semi-automated feature extractions allow for fast data acquisition from the project.

Inertial Explorer Program:

It is a product developed by NovAtel to maximize GNSS and INS performance, thus ensuring the required position, speed and altitude in this work. Close integration between GNSS and IMU data provides precise solutions. IE produces appropriate results data such as: Mobile cartography, aerial topography and hydrographic. IMU data can be processed from Gyro fiber optic (FOG) or ring laser (RLG) IMUs, as well as from low-quality sensor technology such as micro mechanical electrical systems (MEMS).

RESULTS AND DISCUSSIONS

1. Use of the WintraOne UAV system in general cadastre

The use of UAV techniques and technologies used in the General Cadastre leads to the optimization of measurement methods through the allocated time and resources, compared to the classical ones, representing a whole process leading to the processing of the large volume of data (figure 6 and 7).

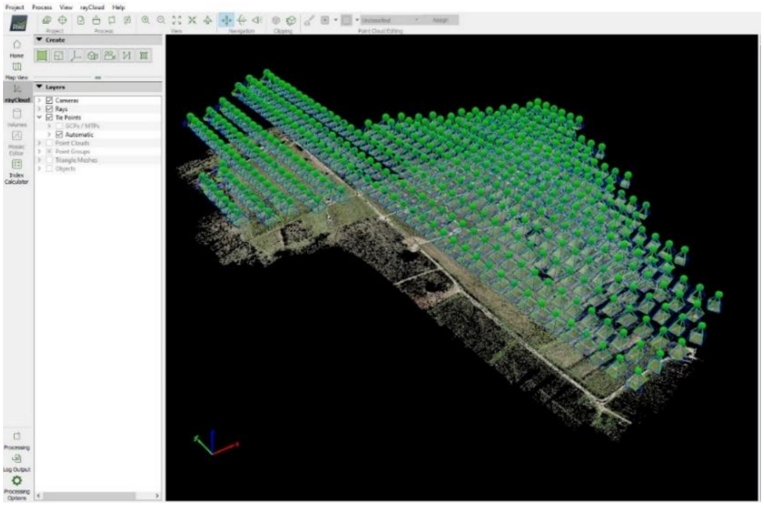

Fig. 6 – Data processing mode in the Pix4D program, in which we can observe the images superimposed above the cloud of dots. And then a complete picture of the Orthophotoplane.

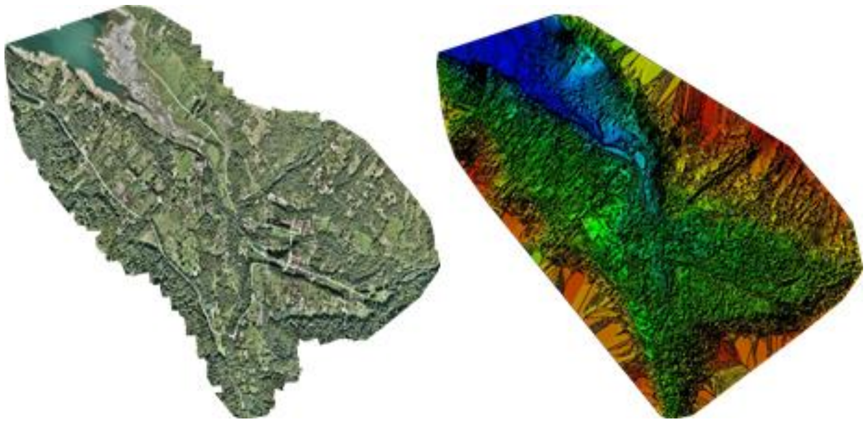

Fig. 7 – Obtained orthophotoplane and 3D model of DSM (Digital Surface Model)

In figure 7 shows the initial position of the image. The green line tracks the position of the images over time, starting at the large blue dot.

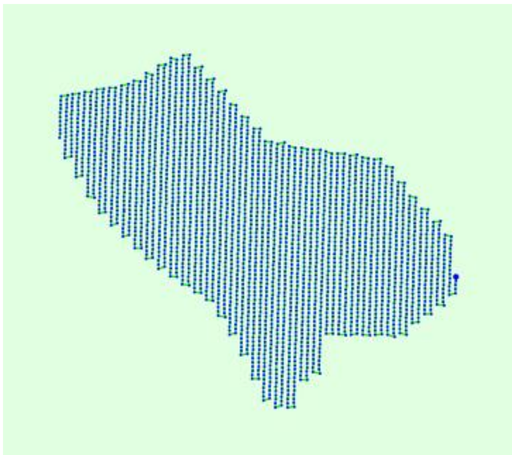

Fig. 8 - The green line follows the position of the images over time, starting at the large blue dot.

The offset between the initial positions (blue dots) and the calculated positions (green dots) of the image, as well as the offset between the initial GCP positions (blue crosses) and their calculated positions (green crosses) (XY plane), the front view (XZ plane) and the side view (YZ plane) are shown in Figure 9. Red dots indicate disabled or uncalibrated images. Dark green ellipses indicate the absolute uncertainty of the position of the package block adjustment result.

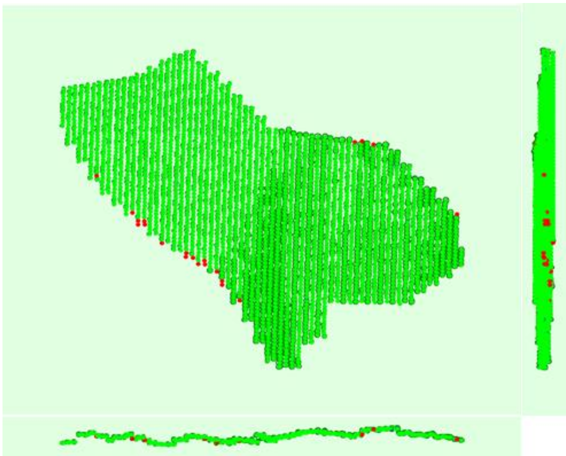

Fig. 9 - Image calculated using the GCP control points.

The positions of the calculated images with links between the matching images are shown in Figure 10. Link darkness indicates the number of matching 2D key points between images and light links indicate weak links and require manual link points or multiple images.

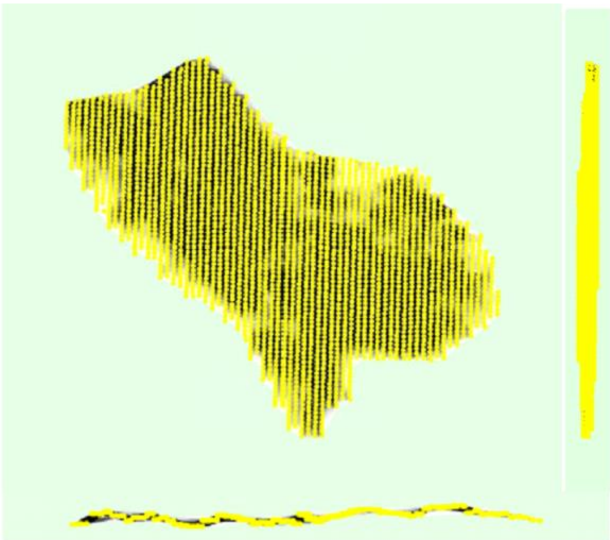

Fig. 10 - Calculated image positions with links between the appropriate images

1. Using the Leica Pegasus Backpack mobile LiDAR scanning system in general cadastre.

3D scanning is one of the newest measurement methods in the domain of topography and allows detailed analysis of the elements in the field through the complexity of the cloud of points obtained.

As the world's population grows and global changes in construction and infrastructure become faster, the need to document this growth and change is growing. Referring to image capture sensor systems, this new concept outlines how surveying professionals come to understand and shape the world. The Leica Pegasus backpack was invented as part of this generation of new sensory systems for capturing wearable sensors in response to growing global changes. PRISMA Group was the first company to use the Pegasus backpack: Backpack in its recent infrastructure project.

The acquisition of LiDAR data (DI STEFANO et all, 2021; ȘMULEAC, A. et all, 2020) was carried out using the Leica Pegasus backpack, which is a portable mobile mapping system, in which a GNSS receiver and an inertial navigation system (IMS) is combined with a dual laser scanner and five digital cameras. The Leica Backpack Pegasus package is able to make quick and good decisions in emergency situations, thanks to quick access to accurate data on reality (localities, tunnels, passages, mining galleries, bridges, etc.

The Leica Pegasus Backpack is a sensor platform for capturing reality. A highly ergonomic design combines five cameras that offer a fully calibrated 360-degree view and two LiDAR profiles with an ultra-light carbon fiber chassis. It allows for external and efficient documentation inside or outside, at a level of precision that is authoritative and professional. Each laser has an aperture of +/- 15 degrees vertically and 360 degrees horizontally (figure 11).

Figure 12 shows post-processing of point clouds using the Cyclone program by creating desired lines/polylines.

Fig. 11 – Backpack components for capturing the surrounding reality with speed and ease.

For the correct collection of RiNNEX data, the Master Station (Figure 5) was switched on 10 minutes before the initialization of the backpack (Leica Pegasus Backpack) and turned off 10 minutes after the LiDAR data collection was completed. Ground control points were determined directly in the field with the GPS equipment from Leica GS 08 Plus, points that were used to verify and realign the LiDAR point clouds collected with the Leica Pegasus Backpack. The control points were also imported into the Pegasus Manager to check the quality of the recording data and the trajectory of the scanned objectives (Figure 12 and 13).

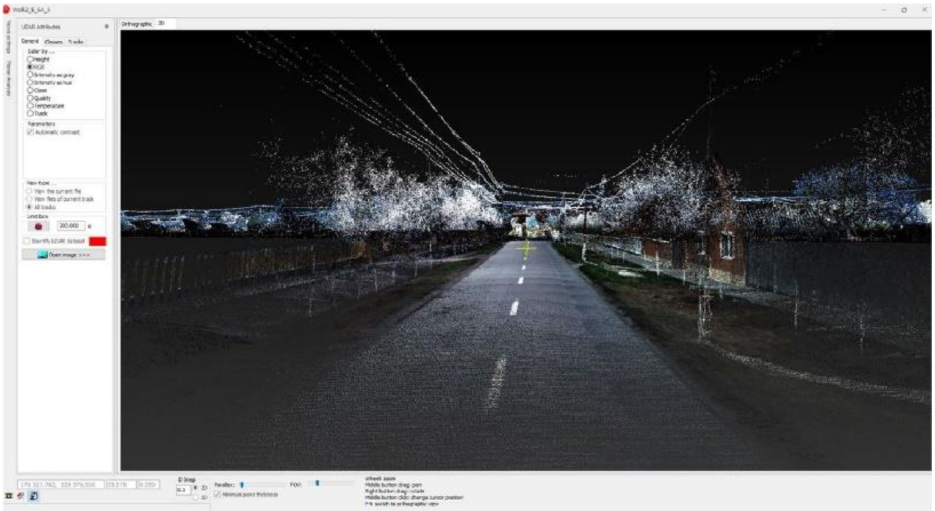

Fig. 12 – Post-processing of point clouds in the Cyclone program

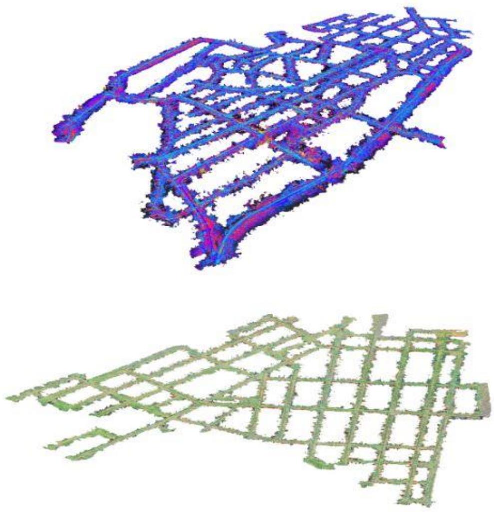

Fig. 13 – Presentation of the 3D LiDAR points for the collected data, UAT Zăvoi

The distribution graph (BEILICCI, E. et all, 2017; ŞMULEAC, L. et all, 2014, 2020) of the control points is represented in Figure 14, representing the exact position as well as the poor or better quality of the signal received by the backpack, illustrated later on in different colors and in Figure 15 is presented the estimate of the position, symbolizing the margin of error of each point, as well as the measurement time.

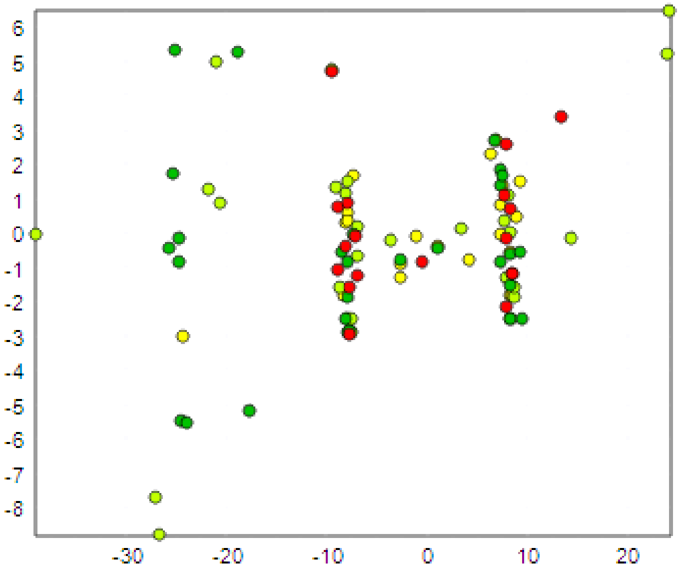

Fig. 14 – Distribution graph of control points

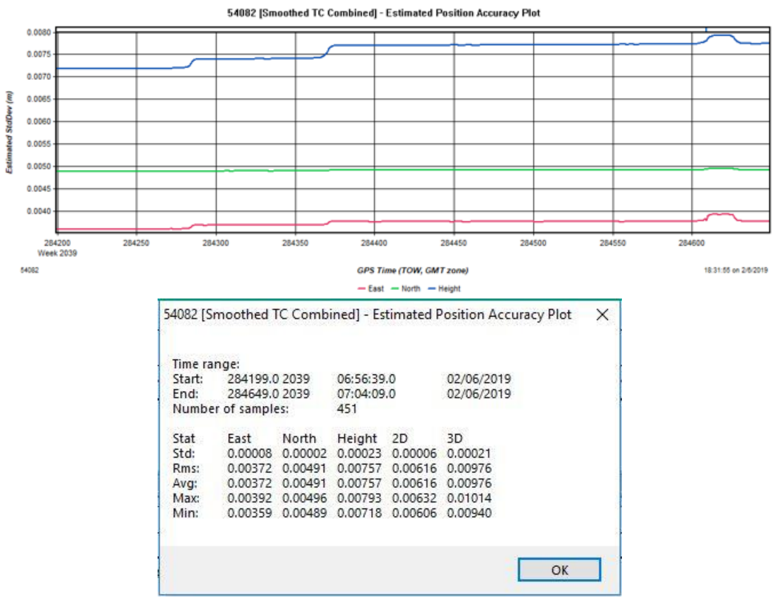

Fig. 15 – Estimated position and measurement time.

CONCLUSIONS

In conclusion, we can say that modern technology has improved the accuracy of the data collected for the general cadastre:

- The use of the Leica Pegasus Backpack and UAV technology, the WintrOne Gen II drone led to the achievement of fast and high quality results;

- By removing human controllers from the equation, these technologies have an even longer usage time.

- - drones have become important parts in all fields of activity: topography, precision agriculture, logistics infrastructure, natural disasters, monitoring, etc.;

- 3D scanner is equally important in road and rail systems, also used in underground measurements and in creating point clouds for scans.

Through the researches carried out, with the help of drone, detailed situation plans were obtained, which resulted in the building being built in the village of Valea Bistrei, within the Zăvoi UAT, Caras-Severin.

The coordinate systems used for drafting the situation plans and updating the land register data on the surrounding buildings and land were, the Stereographic reference System 1970 and the Black Sea 1975.

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