

GeoTerrace-2026-025**Use of UAVs in Creating a Functional Zoning Plan for the Territory**

V. Sai, *L. Vynarchyk, N. Stupen, Yu. Surmach (*Lviv Polytechnic National University*)

SUMMARY

The study is devoted to organizational, technological, and legal aspects of the use of UAVs in topographic and geodetic works and the formation of urban planning documentation based on them. The main objective of the study was to justify the modern technology of using UAVs in topographic and geodetic works to create a reliable cartographic basis that ensures the formation of a functional zoning plan for the territory. The article describes the features of using UAVs as one of the most effective tools for performing topographic and geodetic work and provides examples of the use of UAVs in field and office work. The importance of the master plan as a basis for the formation of a zoning plan for land use in accordance with current regulations is substantiated. The conclusion is made about the feasibility of using UAVs as an effective means of improving the quality of spatial planning of the territory.

Keywords: Unmanned aerial vehicles; Topographic and geodetic works; Orthophotoplan; Functional zoning plan; Master plan.

Corresponding Author: liliia.v.vynarchyk@lpnu.ua

Introduction

The use of UAVs in topographic and geodetic work allows for high-precision measurements of large areas in a minimum amount of time. This is particularly important for updating the cartographic basis of settlements and territorial communities for the purpose of further planning their spatial development (Kalych et al., 2022; Medvedskyi et al., 2024).

Attention is paid to the topographic and geodetic master plan, which is the basis for spatial planning. The master plan provides an accurate cartographic representation of the territory, including land boundaries, terrain relief, existing buildings, and infrastructure. On its basis, a functional zoning plan for the territory is developed, which determines the spatial organization of the territory in accordance with its natural conditions and socio-economic potential (Zakon, 2011; Hubar et al., 2020).

Method and Theory

The research was conducted in a settlement located in the Rivne region. After agreeing on the boundaries of the work to create a functional zoning plan for the territory, it was created in electronic form. The boundary was created taking into account the terrain and its characteristics, and it was also expanded to cover a larger area.



Figure 1. Boundary of the work site

Subsequently, its electronic version was used to create a flight route for an unmanned aerial vehicle to optimize the process of orthophoto plan shooting. The territory has a large area (89 hectares) where it is impossible to conduct a single drone flight due to its physical limitations in battery life. The technical characteristics of the drone allow it to fly for no more than 15-20 minutes on a single battery. Thus, only 10-15 hectares can be photographed under ideal conditions, so this territory was subsequently divided into equal parts, which can be photographed using a single fully charged battery.

Results

A total of 13 separate areas were created for drone flights (Figure 2). Each of them was converted to KML format using the Digitals program. Based on the flights, an orthophoto plan was created, which is used for topographic and geodetic surveying at a scale of 1:2000. The data obtained consists of 3,196 individual photographs in JPG format. Using landmark placement technology, the model was linked to the coordinate system. The landmarks themselves were successfully placed throughout the entire area where the survey was conducted. In this case, the landmarks serve as both control and reference points. When calculating the coordinates of control points, only reprojection errors are taken into account, not measured coordinates, which makes it possible to evaluate the accuracy of the model independently of external data. whereas for reference points, both measured coordinates and reprojection are taken into account, which provides a more accurate position of the point in space and allows errors in the source data to be detected.

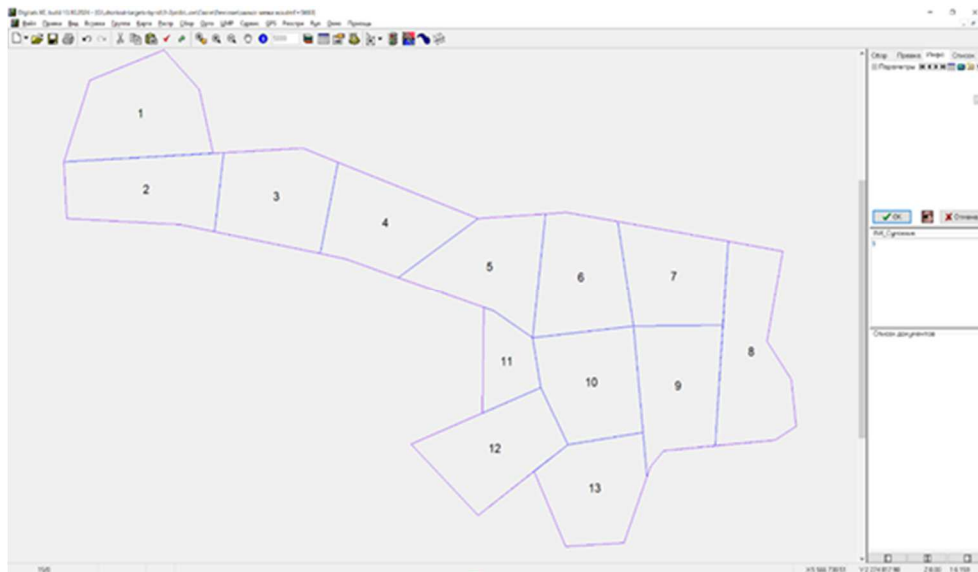


Figure 2. Optimization of flight paths by dividing the territory into 13 sections

GIS plays a key role in the spatial analysis of the data obtained, as it allows for the automation of point cloud processing, data clustering, and integration into cadastral and urban planning systems. Normals to points in the formed cloud are calculated using the approximate plane method, which is based on the analysis of the local environment in combination with depth maps. The color information of each point is assigned according to the brightness values of the pixels in the photographs corresponding to the relevant area. The use of GIS in the process of creating digital terrain models significantly improves the accuracy of spatial analysis, as it provides automated processing of large geodata arrays, which is critical for cadastral and urban planning work.

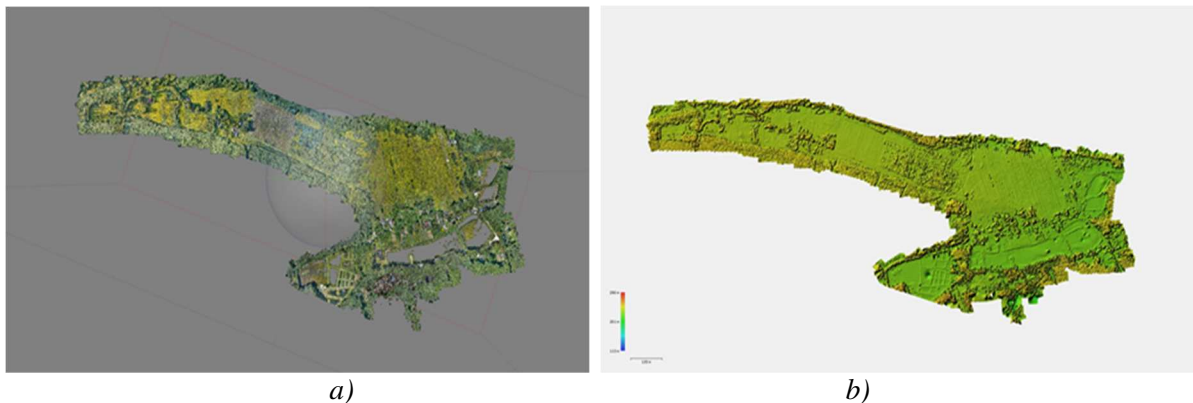


Figure 3. Image of the dense cloud obtained after processing (a) and the result of the constructed digital terrain model (b)

Thanks to this structure, the digital terrain model becomes the basis for a wide range of geoinformation analysis, spatial planning, monitoring of terrain changes, and modeling of natural or man-made processes. The final product of photogrammetric processing is an orthophoto plan, which combines high spatial accuracy and analytical value.

The result of comprehensive processing of spatial and graphic data obtained on the basis of an orthophoto plan and field measurements is a topographic-geodetic master plan (Figure 4). It is an integral part of land management, cadastral documentation, or urban development projects. It provides accurate spatial visualization of the territory and all its infrastructure objects, taking into account the relief, boundaries of land plots, and their functional purpose. It is the cartographic basis for creating a functional zoning plan for the territory, on which all further analytical, legal, and planning processes are based.

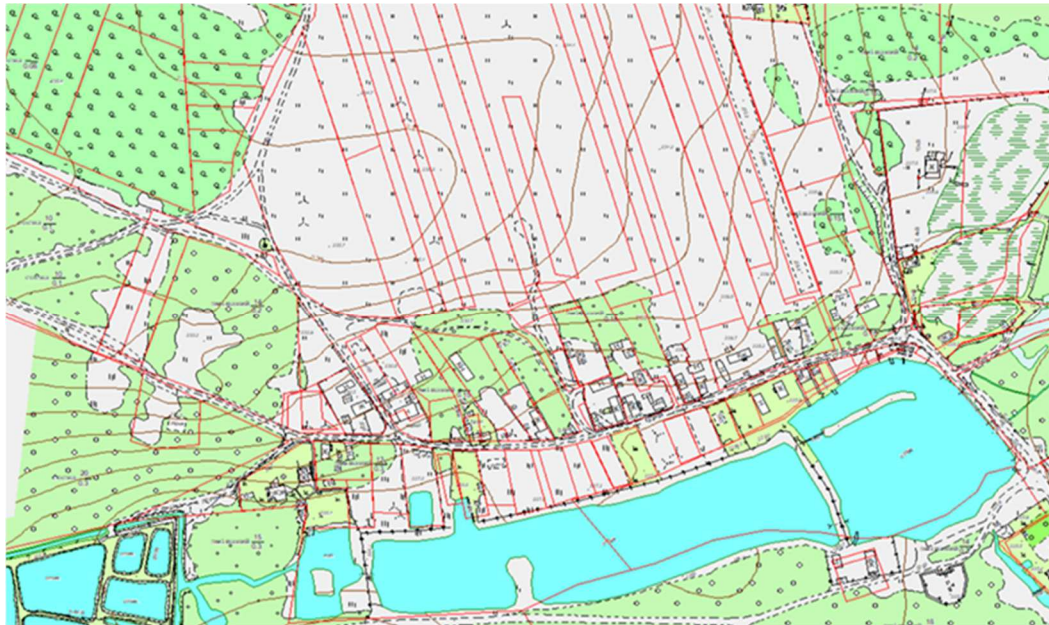


Figure 4. *Topographic and geodetic master plan of the settlement*

The master plan of a settlement is the main type of urban planning documentation that defines the long-term strategy for planning and developing the territory (DBN, 2021). It integrates the results of field geodetic measurements and a digital terrain model, reflects land use classification, and thus serves as the initial stage in the formation of a functional zoning plan for the territory.

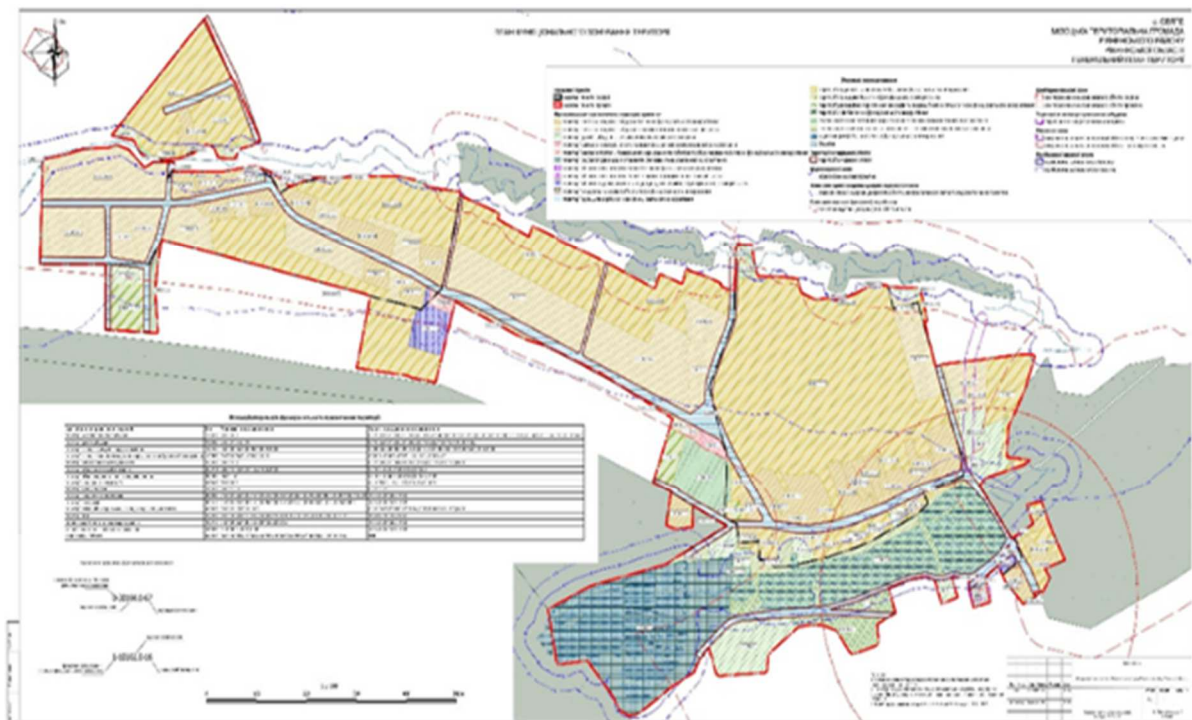


Figure 5. *Functional zoning plan for the territory*

The functional zoning plan (Figure 5) performs the task of spatial organization of the territory in accordance with its legal status, natural conditions, and socio-economic potential. The zoning process involves conducting a spatial analysis of the master plan, visually marking the boundaries of the relevant zones on a cartographic basis, and compiling a corresponding explanatory note describing the characteristics of each functional zone, its purpose, and planning conditions (DBN, 2017; Jach et al., 2023).

Conclusions

The study proved that aerial photography using unmanned aerial vehicles, as well as the creation of digital terrain models and three-dimensional visualizations, significantly change approaches to the collection and analysis of geospatial data. The materials obtained are highly accurate, suitable for geoinformation modeling, and allow for the effective identification of spatial patterns, assessment of terrain, and planning of territory structure. This, in turn, creates a basis for informed decision-making regarding land use, infrastructure placement, zoning, and environmental protection.

Special attention was paid to the zoning plan structure, which is a key tool for the rational use of land resources and optimization of urban planning. The study examined innovative approaches, in particular the use of UAVs as a method of increasing mapping accuracy and improving geospatial analysis. The data obtained confirm that the use of UAVs significantly increases the detail and relevance of cadastral information, contributing to the formation of a modern model of land resource management.

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