APPLICATION OF UAV TECHNOLOGY (DRONES) IN FOREST CADASTRE

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Abstract: *In the 21st century, technologies are not on the spot, as in all areas in cadastral activity, classical equipment is substituted by computer technologies equipped with different types of sensors that simplify the acquisition of field data and obtain Maps and cadastral plans.*

This article reflects the advantages of using unmanned aerial vehicles (UAV) in forest cadastral surveying. The advantage of UAV systems lies in their high flexibility and efficiency in capturing the surface of an area from a low flight altitude. In addition, further information such as orthoimages, elevation models and 3D objects can easily be gained from UAV images. The benefits of using UAVs in forest cadastral surveying and the new opportunities they offer for cadastral activity are impressive. Using photogrammetric materials obtained during flight with drone on Forest massif, CAD and GIS software develops extremely precise relief patterns. Elaboration of digital Orthophotoplans with high orientation accuracy, for the studied forestry area, using the materials obtained during the UAV survey, together with the resources of geographic information systems, allow the formation Structured information layers that can be overlapped. One of such layers overlapped an Orthophotoplan digital is the layer with cadastral boundaries. The results of this work are useful in the inventory of forest land, in land research, in clarifying land boundaries.

Key words*: UAVs, Surveying, Mapping, forest cadastre, drone.*

1. Introduction

The cadastral system is advantage both to the citizen having land properties as well as to the government in that:

1. The document evidence of land ownership as a cadastre provides legal security and reduces or eliminates the risk of grabbing the property of other.
2. Transactions of properties are easier, safer and faster.
3. Establishment of an orderly, efficient and equitable system for land or property.
4. The data from the cadastral system provides an inventory and monitoring of the existing land use towards determining the sustainable future land use, its implementation and management.
5. Once satellite based cadastral system is establishment throughout the country. It enables a considerable saving to the government for its updating and realistic implementation towards any changes in use of particular land.

In the context of contemporary cadastral mapping, UAVs are increasingly argued and demonstrated as tools able to generate accurate and georeferenced high-resolution imagery from which cadastral boundaries can be visually detected and manually delineated (Mumbone, et al 2015). To support this manual delineation, existing parcel boundary lines might be automatically superimposed, which could simplify and accelerate cadastral mapping. Except for (Pajares, 2015), cadastral mapping is not mentioned in review papers on application fields of UAVs (Yao, et al 2019). This might be due to the small number of case studies within this field, the often highly prescribed legal regulations relating to cadastral surveys, and the novelty of UAV in mapping generally. Nevertheless, all existing case studies underline the high potential of UAVs for cadastral mapping in both urban and rural contexts for developing and developed countries.

Cadastral mapping contributes to the creation of formal systems for registering and safeguarding land rights. Numerous studies have investigated cadastral mapping based on orthoimages derived from satellite imagery or aerial photography. The definition of boundary lines is often conducted in a collaborative process among members of the communities, governments and aid organizations.

It is well known that forests are highly dynamic ecosystems that are perpetually undergoing successional changes through growth and natural disturbance. The provision of accurate and up-to-date forest inventories is essential to facilitate data- driven, effective, and well-informed forest management scenar- ios as well as formulate effective forest policy. High up-front inventory costs, complexity in data acquisition, and ongoing uncertainty surrounding the future state and condition of forests due to climate change are principle motivators for enhancing and modernizing forest inventory frameworks globally. As with other resource management fields, the demand for, and expectations of, inventory quality and content have compounded. The inherent complexity of forest ecosystems incentivizes the argument that routine data acquisitions to update inventories are needed to capture and integrate these changes in order to increase knowledge of forest dynamics, improve forest stewardship, and ultimately provide data-driven justifications for forest and environmental policy.

Digital analysis of remotely sensed data ha become an important component of a wide range of land studies. However, due to the resolution of the former generation of sensors, the use of satellite images in the surveying field ha been limited.

A forest cadastre is a methodically arranged public inventory of data concerning properties within a certain country or district, based on a survey of their boundaries. Properties are identified by direct or indirect methodologies such as total stations or aerial photographies.

2. Materials and methods

The principal use of UAVs in the forestry cadastre is currently for the production of high resolution orthomosaics. An orthomosaic is a photogrammetrically orthorectified image produced from many single images to provide a seamless mosaic dataset which has been corrected for geometric distortions.

Obtaining good quality images is the key to obtaining high quality orthomosaic outputs. Even ‘prosumer’ drones now support good quality cameras but mission planning and an understanding of the photogrammetric process is also key.

The purpose of this paper is to present a modern alternative (Herbei and Sala, 2015) to classical topography for forestry cadastral map. This is much faster and with an increased accuracy both in accessible places and in areas with unsafe conditions for the human factor.

At the same time, this method offers the possibility of collecting at the same time a much larger number of details in the field, compared to an ordinary measurement.

The drone used in this study was the PHANTOM 4 ADVANCED (www.dji.com), with the GPS and GLONASS systems incorporated. Based on the images taken, a mosaic of them was made in order to obtain an orthophotoplan.

Orthophotoplan in digital format is a scale aerophotogrammetric product, which photographically represents a portion of the earth's surface. The images taken with the drone are in the WGS 1984 system, which is why the orthophotoplan georeferencing resulted in the MOLDREF99 system was required (Begov Ungur et. Al, 2016). This georeferencing is done based on control points (Filip et al., 2015) (GROUND CONTROL POINTS - GCP), points measured on the ground and which are also found in images taken from drones. For this purpose, 15 targets were used, located on the ground throughout the area of interest. These targets were measured using GNSS technology, namely CHC® M6 GNSS.

Figure 1. PHANTOM 4

Figure 2. System GNSS

Also, in order to process the data acquired from the field, the following software was used:

- MissionPlanner - for drone flight planning;
- AGISOFT PHOTOSCAN - for processing images from drones and creating orthophotoplan (https://www.geoscan.aero/ru/software/agisoft/metashape_pro);
- CHC Gematics Office - for processing GNSS measurements of ground targets;
- MapInfo - for georeferencing, based on the measured GPS points, of the resulting orthophotoplan.

3. Results and discussions

This article discusses the possibility of compiling a cadastral plan for a forest plot based on existing cartographic materials in the database of the cadastral office using ORTOPHOTOPLAN obtained using UAVs.

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Once the original images are uploaded, processing software (in our case Photoscan) reads the basic camera geometry (focal length and dimensions of sensor) from the EXIF header of the image files and performs a procedure referred to as photo alignment. Photo alignment produces relative camera exposure coordinates, a camera calibration for each and every image as well as a "sparse point cloud. For low accuracy requirements this may be all that is required to build a model if the final product does not have to be referenced to some spatial reference frame. However, the process of determining the camera exposure positions is significantly accelerated if approximate positions are introduced into the photo alignment procedure. Typically, these approximate positions are obtained from the stand-alone navigation GPS receiver mounted on board the UAV. However, if the product is to be accurately geo-referenced to a defined coordinate system (e.g. WGS84/MR99), then GCPs need to be provided. Align photo on agisoft shown in (Figure 2).

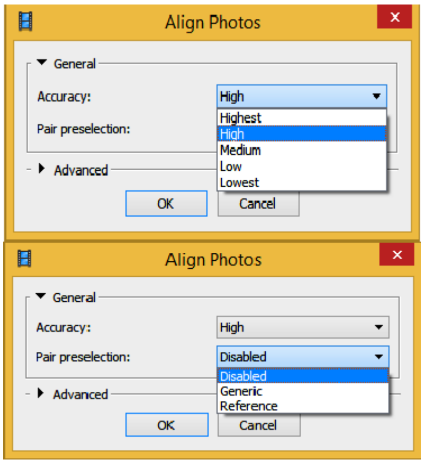

Figure 2. Agisoft align photo button

For accurate geo-referencing, the absolute coordinates of GCPs should be measured to an accuracy equivalent to the GSD of the imagery. GCPs are measured quite simply by identifying each GCP target in every photo on which it appears and centering a flag on each of those locations. With forward and lateral overlaps of 80% and 70%, a single GCP can appear on as many as 10-16 different photos. These measurements are used to compute linear transformation parameters to transform the model from an arbitrary local system to the spatial reference framework of the GCPs. The software does an error analysis and displays the results enabling the user to identify and eliminate any blunders. After this step, the sparse point cloud is re- transformed for optimum positioning in the coordinate system of the GCPs and the camera positions are adjusted accordingly. The only manual task in the entire workflow is the observation of the GCP image coordinates in each photo in which they appear.

In the next step of the image processing workflow the software uses the optimized sparse point cloud and improved camera positions to generate a dense point cloud of the project area (see Figure 3). The generation of the dense point cloud usually takes the longest time of all the processing steps.

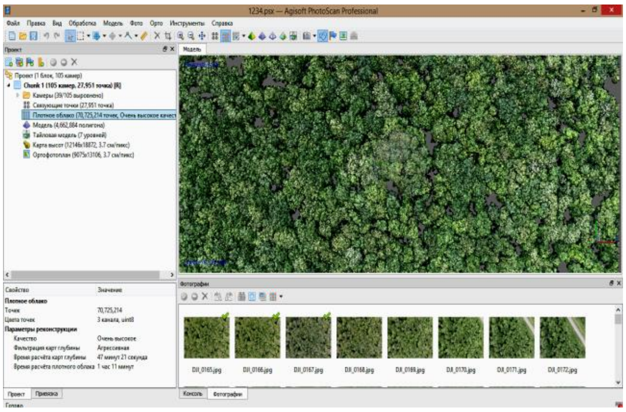

Figure 3. Dense Point Cloud

From this point it is relatively simple, although time consuming, to generate a surface model in the form of a triangulated irregular network (TIN) (see Figure 4) as well as a texture atlas that is used to create a true color orthophoto.

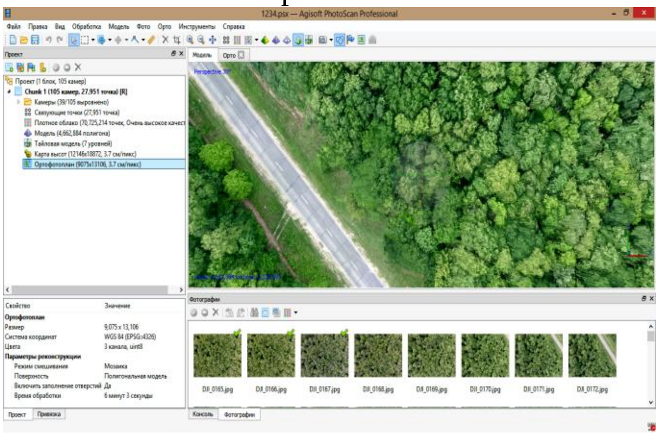

Figure 4. Orthophoto

Orthophotomap, is only an image of the territory. Overlapping plans is done using MapInfo. MapInfo - software with which they work in the cadastral offices of the Republic of Moldova. All graphic and accompanying information is stored in the format * .TAB, suitable for MapInfo. Thus, by superimposing a digital cadastral plan on orthophoto, it is easier to complete the task of developing a cadastral plan.

Next, we compare ORTOPHOTO with the forestry plan for forest management and the cadastral plan using the example of the forest Alazan (see Figure 5).

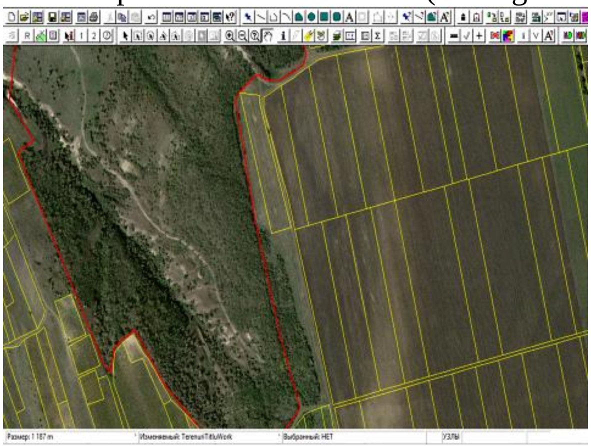

Figure 5. Forestry Cadastral Plan

The overlay of orthophoto and cadastral plans is done in order to identify the cadastral object. This process allows and greatly facilitates the work in the field of cadastre, namely updating and updating the cadastral plan. Often the content of the orthophotoplane does not match the graphics of the cadastral plan.

The project of the geometric plan will be drawn up in digital format, according to the Instruction regarding the elaboration and updating of the cadastral and, or geometric plans, and will contain the following information: a) the boundaries of the land; b) turning points; c) the scale on which the plan was printed; d) the MOLDREF99 coordinate system; e) the catalog of coordinates; f) the table with the dimensions of the terrain segments; g) the type of borders (fixed, general); h) graphic orientation of the plan; i) the technical characteristics of the land (type, mode of use, surface); j) the name of the company that executed the works; k) the date of drawing up the geometric plan; l) the name, forenames and signatures of the executor of the works and the person who verified the work (from the performer).

At the end of the elaboration of the project of the geometric plan, and of the technical file, the materials will be submitted to the local council for approval and signature.

The result of the work will represent the geometric plan of the real estate Alazani forest trunk elaborated in the MapInfo software represented in the following figure.

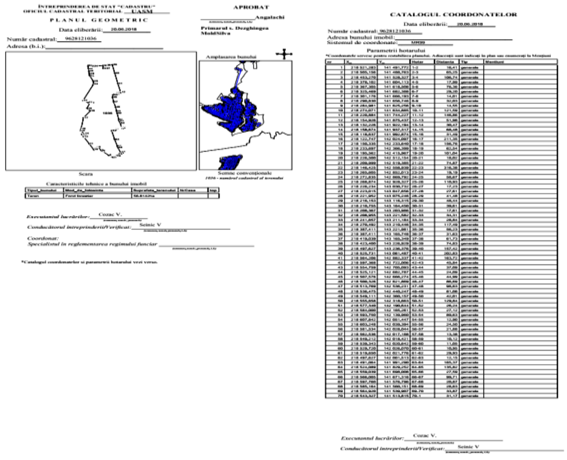

Figure 6. Project of the Geometric Plan

4. Conclusions

The UAV method with appropriate photogrammetric evaluation methods offers a great potential to gain information from the captured data that are useful for cadastral applications.

These derives from UAV measurements can present a great additional benefit to users of cadastral data, such as real estate agencies and insurance companies.

With further developments of specific system technology, the usability of UAV systems will increase in cadastral surveying.

In order to decrease the complexity of data processing the development of an efficient workflow for data analysis of the aerial images is needed. This includes appropriate software packages as well as reliable automation of image orientation and geometry measurement.

In the future, UAVs will be used where a need of high accuracy is required and fast data capturing is demanded. Therefore, the use of UAVs is an opportunity for cadastral surveying.

The tests carried out by several specialists in the field have convinced us even more that UAVs offer a radically new approach for spatial data mapping and acquisition.

This approach would enable individuals or small enterprises in developing countries to acquire mapping capacities which could deliver current spatial data at unprecedented resolutions. It also promises order of magnitude savings over conventional mapping approaches in terms of time and cost.

Initially, the only UAVs that were available for mapping work were large, expensive vehicles. Over the past 5 years, the cost and size of UAVs has dropped significantly, partly due to the strong open source and do-it-yourself culture (see http://diydrones.com/) that has arisen in this sector. UAVs, such as the one used in test, are now available at unit costs that are lower than conventional total station or GNSS rover prices. The real cost savings are in the increased technological efficiencies, the incremental approach to map production and the associated shortening of the supply chain (Anderson 2010; 2013).

The UAV is an incredibly useful tool for collecting data, but the key to successfully adopting UAVs in the forestry sector is to use that data effectively to reduce costs, increase accuracy and decrease risks.

The advantage of using the UAV technology as compared to classic cartographic materials used to develop and update technologies is obvious, namely for hard-to-reach or economically unprofitable landscapes. 3D images of high resolution and accuracy enlarge the areas of the UAV technology application.

The areas in which drones are applied are infinite. Currently drones can be successfully applied to determine the area of the forest funds, etc.

Advantages of the UAV technology:

- Efficiency;
- Enhancing the accuracy of topo-geodetic data;
- Developing and updating different types of maps and plans;
- Developing 3D models of localities;
- Developing digital models of land plots;
- Land monitoring and inventory;
- Detection of unauthorized constructions, etc.

5. Acknowledgements

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