Use of UAVs for land inventory

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SUMMARY

By means of a land inventory, it is determined that: the actual location of land parcels, address errors have been eliminated; duplicated parcels of land have been identified as a result of changes in cadaster numbers, division and consolidation of land parcels; Discrepancies between the boundaries of land parcels according to documents and real boundaries on the ground; other information needed for the customer.

Keywords: UAV, land inventory legislation, photogrammetry, aerial photography
Introduction

The inventory of land, which is being carried out as one of the types of land management work, began in the first stages of modern land reform in Ukraine. At the same time, the political and legal aspects of the execution of one type of technical work have undergone significant changes at various historical stages of land reform: from the injection of a separate land parcel to a continuous one, within the borders of the whole country. But most of the policy decisions taken on land inventories were never fully implemented.

Methods of investigation

At the legislative level, it is established that «Land inventory is carried out for the purpose of establishing the location of land-management objects, their boundaries, size, legal status, identification of land which is not used, is not irrational ...» (Law, 2003). The objective is noble and responsible, but the law does not regulate the requirements for actual land inventory work.

A review of land inventory legislation, in particular with regard to the accuracy of field and desk work, reveals a number of conflicting requirements. Thus, one of the first normative acts (order, 1993) has established that the «average square error in determining coordinates of corners of borders and land-use signs must not exceed 0.10 m». Subsequently, (Order, 1997) the interpretation has been changed, «the margin of error of the points of the survey justification of the inter-ground signs relative to the nearest points of the State Geodetic Network must not exceed 0.10 m». At the same time, the land area needed to be calculated to the precision of 1 sq. m. As this was not possible, more recent legislation (Decree 2012; 2019) states that at the time of the land inventory, the land area is defined to 1 sq. m, taking into account the margin of error in the scale of the plan, when the coordinates of the boundary turning point are determined to within 0.01 m."

In the current phase of land reform, in view of previous shortcomings, the State is giving increased attention to the issue of land inventory. Without going into more detailed analysis of the legal regulations (this is public information for interested persons), the results of actual work on the inventory of land at specific sites are given below, regardless of their name, the problems identified are very similar.

Although it has been considerably delayed, it has been realized that land inventories can only be as positive as possible if they are comprehensive. It is advisable to establish that the minimum objects of land inventory may be: a housing block, individual fields or areas of agricultural land, forest areas, nature reserves, etc. This approach will contribute to a more accurate and reliable identification of the location of specific land-use objects and to the identification of erroneous data (here we do not dwell on the causes) The results of previous years' work and the prompt introduction of corresponding changes in State land cadaster data.

Regulated (regulatory) techniques for the technical and technological maintenance of land inventories (field and desk work) have long been obsolete. The (Order 1998) Instruction does not even contain a reference to unmanned aerial vehicles (UAVs) in setting the requirements for aerial topography surveys. This is in spite of the fact that the law (law, 1999) provides that: «In carrying out topographic-geodetic and cartographic work, it shall be ensured that the requirements of the normative-technical documentation ... as well as the introduction of progressive technologies and methods of organizing surveying, geodetic and cartographic production». That is, the operators of the works, applying the latest technologies, provide significantly higher accuracy and reliability of the results of the work, and, equally important, significantly shorten the time and reduce their cost, are formally violators. Such a disgrace at the level of regulations should be corrected as soon as possible. There is a need to improve (considerably simplify) the procedure for making changes (essentially correcting errors in previous work) in the information already available in the State Land Cadaster. Financial and administrative penalties may be required for perpetrators if errors of fault are subsequently found to have occurred.
The results of the actual work on land inventory are given below. For aerial photography of the area used modern UAV FLIRT «Cetus», specially developed for high-precision aerial photography and remote sensing. The above-mentioned UAV is equipped with SONY Alpha 7RM2 camera, full-size 42-megapixel camera mounted on a stabilized gyroscope frame, resolution of images up to 3 cm/pixel. A geodesic GPS receiver L1 / L2 is mounted on board the UAV.

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In order to assess the accuracy of aerial photography, a plan-altitude study is being prepared with the marking of the points of the backbone network. As a result, the average accuracy of the coordinates of the points in the plan is at most 10 cm. The resolution of the received orthophotos does not exceed 5 cm / pixel.

The points of the State Geodetic Network (drawing of the reference coordinates and elevations (if any) of the GGS points from the Geodetic Data Bank were provided in accordance with the established procedure) were used to create the planning and altitude base. The processing of the collected information was carried out on the servers of the System Solutions network and on the own computer equipment using the software complex Geosystem Delta/Digitals. The coordinates of the survey points of the geodetic base were defined in the world coordinate system WGS84 (World Geodetic System 1984) with the possibility of transfer to the state coordinate system (SC63 or USK2000).

As a result of the field work carried out, photographs of the terrain were obtained, which were processed in camera conditions with the help of special photogrammetry programs, and the installation and orthophotos of the facility was made.

![Figure 1 Orthophotos resulting from image processing](image)
To construct a digital relief model (CMR), the Agisoft PhotoScan program classifies points of dense cloud in manual and automatic modes.

The classification of points in a dense cloud is possible in two modes: automatic and manual. The automatic classification procedure consists of two steps. In the first step, a dense cloud of points is divided into cells of a certain size. The point with the lowest height is defined for each cell. The result of triangulation of these points is a relief model in the first approximation.

In the second stage, a point satisfying the following conditions is added to the «ground points» class: 1) it is removed no more than a certain distance from the relief model obtained in the first stage, and 2) the angle between the approximate relief model and the lines connecting this point to the points, previously included in the «land points» class, less than a certain value. The second stage of the procedure is repeated until all points have been checked for belonging to the class of «points of land».

**Figure 2.** Agisoft PhotoScan working digital relief model.

**Recommendations and conclusions**

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Figure 3 Consolidated inventory plan fragment. The boundaries of land parcels are indicated in black in accordance with the documents certifying real rights to land parcel and the State Land Cadaster; red in the form of the boundaries of land parcels according to the results of the land inventory.

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