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THE USE OF UNMANNED AERIAL VEHICLES FOR ESTIMATING MARKET REAL-ESTATE VALUE

The Purpose. The problem of applying unmanned aerial vehicles for real estate estimations has become important with the development of modern methods of distance sensing of residential areas. For several decades aerial photography has been an effective tool for performing geodetic survey, geophysical studies, and various types of monitoring. Modern technology used in creating topographic and cadastral plans is based on using digital data of aerial photography [Burshtynska H., Stankewych S., 2013]. However, the cost of airplanes and helicopters used in applying the local large-scale survey is costly. The alternative solution is applying unmanned aerial vehicles (UAVs) for real estate estimation. **The Methodology.** The methodology is based on the necessity of utilizing UAVs for estimation of the market real estate value. Creating large-scale plans of rural areas on the basis of data obtained from UAVs is required for projecting gain plans [Glotov V, Korduba Yu, 2011; Glotov V, Gunina A., 2014]. This is related to the land accounting and setting boundaries in a particular region. This previous sentence is duplicated in paragraph below "In Practical Significance so it is best not repeated in 2 times. UAV aerial photography has additional advantages in comparison with traditional and space photography. **The Results.** The investigations show the importance of UAV application for real estate estimation. The course of using UAVs is to obtain photos with certain characteristics. Aerial photography is known as a distance sensing technology and economically justified method of collecting spatial information, as the basis for creating cadastral plans and maps, three-dimensional models of the relief and the territory [Glotov V, Tserklevych A. et al., 2014]. It can also be used for estimation of the market value of real estate. **Scientific Innovation.** The research connected to the use of UAVs for estimation the market of the real estate value has been done for the first time. This article proves that at the time of collection and analysis of basic data in order to improve the quality of raw materials reliability, as well as for rapid and precise geometric characteristics of the studied object and selecting similar objects to the estimative that unmanned aerial devices should be used. **The Practical Significance.** The UAV application for the estimation of market real estate value is of high economic efficiency. As the result the determination of geometric characteristics is cheaper compared to traditional surveying methods. UAV photography has additional advantages in comparison to traditional methods, particularly the possibility of obtaining high accuracy images (one point per centimeter) in the territory. It gives the possibility to make detailed photos of small objects and small areas when there is no value or technical possibility to do it by using other methods as in urban conditions. The other advantages of UAV photography are its mobility; high efficiency; and the environmental purity of flights.

Keywords: UAV, estimation of the real estate, distance sensing, aerial photography.

Introduction

The increasing human activity impact on the ecosystem of the Earth requires new methods of sustainable management of natural resources at different levels.

At present the important tasks are based on aerospace information, using innovative processing technologies in their application. Today the dominative means of obtaining information is space photography using special photo equipment. This

gives an opportunity to get high quality pictures covering large areas of the Earth's surface.

Space and aerial photography data are widely used for mapping, cartography, for deciding tasks in various fields of science and technology and for Geo-Information Systems (GIS). The amount of mapping and GIS products is increasing each year and new fields for their application have been appearing.

For effective mapping and monitoring of the environment state and commercial organization of the developed countries, and the creation of new

space complexes use a variety of photo techniques. The number of countries which make aerial photography is increasing and their users are informed with the help of the Internet. The features of space photography for the last decades are to get photos of high spatial resolution (<1 m), increasing spectral distinction of photo-systems, and making hyperspectral photography.

Scientific character images are used which have been obtained in optical range and in radio range for distance sensing in the last decade. There has been a real revolution in interpreting images possibilities. Today space and aerial photography are widely used. Visual, visual-electronic, television, infra-red, laser, and radio locative images are also applied in the practice.

The proper territory management and management of the world's natural resources is an important task today. It can't be fulfilled without data processes on the Earth's surface and phenomena of natural and anthropogenic character which has taken place. Modern trends in planning human activities require appropriate information and continuous monitoring to predict the dynamics of changes [Burshtynska H., Stankewicz S., 2013].

The Purpose

In the process of development of modern methods of distance sensing of the residential territories, the problem of applying unmanned aerial vehicles for real estate estimation has become actual. Aerial photography has been decided as an effective tool for conducting geodetic survey, geophysical studies, and various types of monitoring for the last period. Modern technologies for creating topographic and cadastral plans are based on using digital data of aerial photography [Burshtynska H., Stankewicz S., 2013]. However, the cost of airplanes and helicopters applying for local large-scale survey is high. The alternative solution is applying of UAV for real-estate estimation.

Methodology

Especially rapidly in recent decades, the method based on non-contact electromagnetic spectrum signal registration has developed and is applied in the Earth's surface imaging. It is called distance Earth sensing. The result of the distance sensing is obtaining natural characteristics of the Earth's surface. Exact details include the geological

structure, water supplies of surface and underground water-stores, type of soils, vegetation, fauna, and climatic and atmospheric features. Under the model of distance sensing we understand the system of receiving and converting input signals of the electromagnetic spectrum for the output once. They form images of set point data of objects on the territory. The main element of this aerial photography system model uses a special device for converting input data to output once. It is part of an aerial photography complex.

The current practice of distance sensing is based on the data obtained by television, visual-electronic, infra-red, laser, radio-heating, or locative systems by traditional-photography systems. The distance Earth sensing (DES) allows obtaining details of the earth's surface objects, phenomena and processes that occur on the surface or near it, in the atmosphere, soil and water, without direct contact with the object.

This method is based on the relative connection between the object properties and their images or set-point data obtained by applying electromagnetic waves of different lengths. Thus, distance sensing is based on non-contact registration of electromagnetic radiation of the Earth surface at different spectrums. The results of distance sensing are aerial and space photographs, and output data based on photography systems.

The efficiency analysis of aerial photography analysis and their interpretation are determined by the content and DES data listed due to thematic tasks. Aerial photography is formed by the registration of electromagnetic radiation which is reflected or generated by Earth formations or artificial (anthropogeny) objects. Different objects have different spectral distance energetic reflective characteristics and are different in geometric size, shape and nature of its activity in time and in space. All these features of DES objects must be taken into consideration when selecting aerial systems, which make photographs.

At present, distance sensing methods help to decide different thematic tasks successfully [Mylchev M., 2003; Burshtynska H., Stankevich S., 2013], exactly:

1) monitoring global atmospheric changes: surface temperature measurement determining the atmosphere conditions, cloud cover observations, research of "greenhouse effect";

2) mineral and energy resources (oil, natural gas, coal) searching;

3) topographical mapping, creating and renewing maps, building new digital relief models, monitoring of urban expansion;

4) analysis of agricultural lands, determination and identification of crops, crop prediction, analysis of agricultural potential, monitoring of soil and pastures conditions;

5) observation of coast zones and oceans of water resources, measuring the thickness of ice and snow layer and determination of water equivalent, and sources of water pollution;

6) monitoring of forest conditions, and determination the types of trees and species that dominate in the estimation of wood materials and wood storage;

7) monitoring of emergency situations in order to prevent them, to control and estimate flood, fire and earthquake effects;

8) defensive observations must determine military state, military industry and engineering facilities. They include monitoring the border territory, monitoring the troop movement.

Distance sensing data processing is carried out for the purpose of determination of objects or situations and their set position. Since the physical properties of objects are different and universal methods of photography, cannot be applied. That's why various means of distance sensing are applied.

Taking into account the importance of physical photography phenomena, all means of distances in Earth Sensing can be roughly classified by:

- the types of media photo equipment;
- the special range of distance Earth sensing work;
- means for receiving distance sensing data;
- distinguishing the data .

It is considered appropriately to improve the efficiency and reliability of distance sensing methods applied at the preparatory step of vast estimation of real estate in inhabited places. It is perspective to use unmanned aerial vehicles (UAV) for this purpose.

Unlike terrestrial surveying methods, including tacheometric photography and measurement with GPS-receivers, UAVs allow to fulfill quickly and economically aerial photography of small areas in order to create cadastral survey and orthophotomaps.

In the article [Burshtynska H., Stankewich S., 2013, Trubnikov G., 2009] the aspects of UAV applying complexes in order to conduct various types of monitoring are considered. These systems are used for renewing and précising geospatial information.

The obtained photographs are imposed on the digital territory model and then the data can be used to measure distances and area determination which is required for overlaying other information.

Media aerospace photographic equipment can be installed on airplanes, helicopters, gliders, hang-gliders, unmanned aerial vehicles, aircraft (airships and balloons), and spacecraft, and also on satellites of the Earth and other planets, orbit stations, and interplanetary apparatus.

Significant technological effect of aerial photography is due to the use of GPS-receivers, which have been installed on the board of the craft and connected to photo-equipment. It provides the definition of linear elements of exterior orientation. If the set of photo complex includes inertial navigation system, the angular elements of exterior orientation photos can be determined (EOP). The definition of EOP gives the possibility to take off altitude planned reference.

Unmanned aerial vehicles are all widely used for aerial photography as a cheap alternative choice in comparison with traditional ones from aircraft, helicopters, gliders and space satellites. In addition to high economic efficiency it is cheaper, and UAVs have the following additional advantages comparing to traditional aerial photography:

- low altitude done at altitudes of 10 to 200 m in order to obtain ultrahigh differentiation (numbers and parts of centimeters) on the territory;
- the set-point makes detailed photo of small objects and small areas possible, where it is unprofitable or technically difficult to make it applying other methods in urban conditions;
- mobility whereby it does not need specially prepared airfields or takeoff platforms, UAVs are easily transported by cars and some can be carried on in a hand. The procedure of permission and coordination of flights is not complicated;
- high efficiency allows the whole cycle of photography to obtaining results in several hours;
- environmental purity of flights means that low-power petrol or noiseless electrical engines are used with no impact on the environment.

Depending on the take-off weight and the flight distance, UAVs are divided into micro categories. See Table 1.

The main characteristics of some modern UAVs [According to Burshtynska H., Stankewicz S., 2013] are presented at Table 2.

Table 1

Take-off weight and the flight distance

Type of UAV	Weight kg	Distance km
micro/mini	5	10 to 40
light	5–50	25 to 70
light of medium	50–100	70 to 150
medium	100–300	150 to 1000
moderate	300–500	70 to 300
heave of medium	500+	300 to 1000
Heave	1500+	1500 +

Table 2

The Basic Features of UAVs Used in Aerial Photography

Features	Proteus	Altair	Hermes 450	Irkut-2M	Irkut-10	Irkut-200	Irkut-850	Strepet
Take-off weight, kg	2180	1120	450	3	8,5	200	860	200
Payload, kg	315	120	150	0,5	1,5	50	200	50
Moving	460	210	130	85	110	170	270	160
Ceiling, m	19800	7800	6100	3000	3000	5000	9000	6000
Distance, km	2700	2600	800	20	70	200	200	300
The maximum duration of the flight, in hours	18	32	20	1,5	2,5	12	12	16

Standard aerial photography equipment on UAVs include as a rule a digital or video camera which sometimes are set on a gyro-stabilized platform with an infrared camera or scanner. Sometimes UAV is equipped with laser distance measuring scanners and medium and heavy UAVs have radio locative stations with synthetic aerial aperture (SAA).

In UAVs and digital stereo-photogrammetric methods are more effective than other surveying methods in conducting large topographical surveys. Using UAVs which are equipped with appropriate means for aerial photography, is much cheaper than land complex processing methods which are conducted for a long term. One more advantage of surveying methods is the possibility to reflect the state of the territory in just several photographs. The reason is easy access to the territory with extreme conditions or to private land-plots.

Using aerial photography in aircraft is not as practical because it requires significant funding and this is why UAVs can make photography of distant areas with high accuracy and at a low cost. Thus using digital method can be applied to conduct a

large-scale topographic survey in-office conditions. Fig. 2 shows the structure of the UAV called Trimble UX-5.

Before starting to fly UAV it is necessary to select the territory of 50 × 120 m with a different grass or soil surface, in order to avoid a problem during the taking off and landing. Table 3 presents technical characteristics of UAV Called Trimble UX-5.

To conduct work on the objects in it is necessary to recognize the areas. It is best to first consider to include:

- buildings (numbers, material, number of floors, and size);
- street (name, covering material, width);
- power lines (PL);
- hydrography (depth, direction, flow velocity);
- vegetation (forest, meadows, woodlands, shrubs, grasslands).

To fulfill the process of creating a topographic survey and transforming pictures to a geodetic photogrammetric orientation model, building networks and other necessary basic control points are applied.

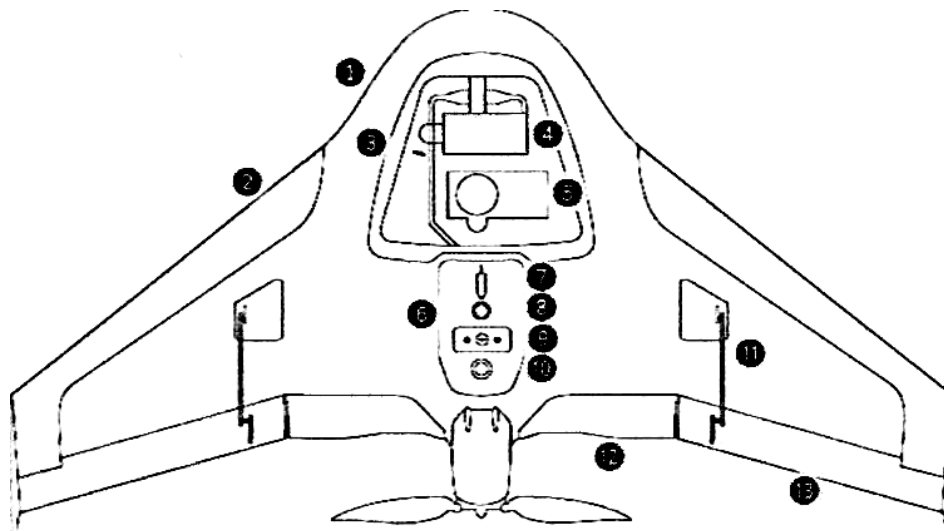


Fig. 1. Shows the types of unmanned aerial vehicles:
 a – Proteus; b – Altair,
 c – Hermes 450; d – Strepet;
 e – Irkut-200

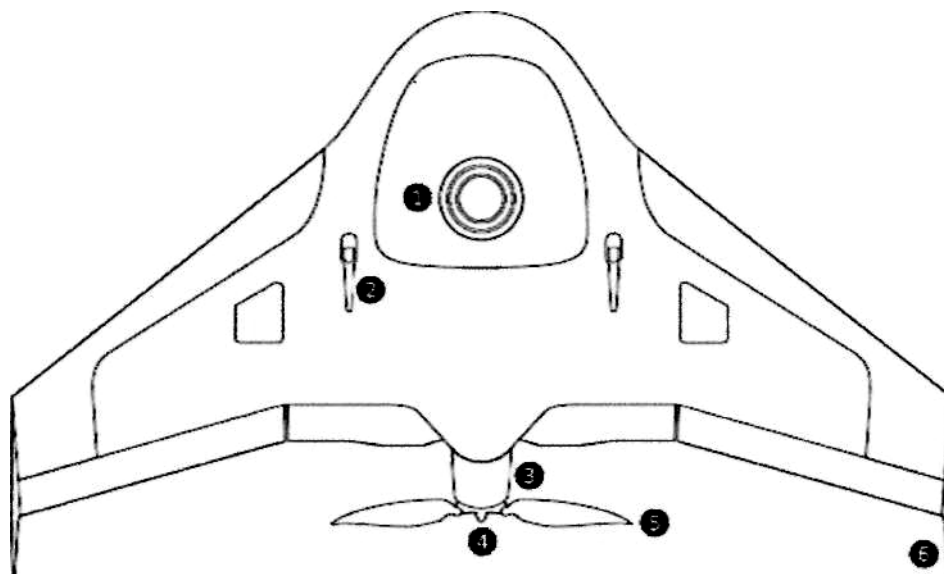
Table 3

Features of UAV Called Trimble UX-5

Weight	2.5 kg
Size	100 × 65 × 10 cm
The flight altitude distance:	75–750 m , cruising height: 150 m
Moving flight speed	80 km / h.
The maximum flight time	50 min.
Operating temperature range:	from -5 ° to 35 ° C
Resistance to weather conditions:	wind force up to 6 points, mist
Distance Control	above 5 km.
Glideslope angle	14 °
Attack angle	30 °
The average productivity (Quantity of scan area for one flight (about 30 min.)):	3.1 km ² (about 800 photos longitude overlap: 70 %; transverse: 80 %).
Photo quality (pixel size)	above 5 cm
DEP density (distance between points)	from 25 cm to 200 cm
Accuracy of surface modeling	On plane ± 5 cm, In altitude ± 10 cm
Calibrated digital camera	SONY NEX 5R



- | | |
|--------------------------------|---------------------------|
| 1 – fuselage of the aircraft | 8 – GPS aerial |
| 2 – front edge of the wing | 9 – mode button |
| 3 – compartment of the device | 10 – boot cable connector |
| 4 – Battery | 11 – Servomotor (aileron) |
| 5 – camera | 12 – fuselage aileron |
| 6 – electronic navigation unit | 13 – plane aileron |
| 7 – accelerator | |



- | | |
|------------------|---------------------|
| 1 – object glass | 4 – starting device |
| 2 – engine | 5 – propeller nut |
| 3 – propeller | 6 – winglets |

Fig. 2. The Structure of UAV Called Trimble UX-5

A basic control point is a point in the territory or any photographic object for which the spatial coordinates are given as “absolute” or “geodetic” coordinates set by geodesic methods and recognized with the help of aerial photographs. The combination of these points is a geodesic basis for cameral

photogrammetric work. If all three coordinates X, Y, Z are known, then the basic control point is called the planned altitude; if planned coordinates X, Y are determined it means that this point is basic point, but if only altitude Z is known, it means that this is basic altitude control point.

The process, which is held for setting number of basic control points out of field work is called connecting referencing to aerial photographs. Reference point objects are chosen with well-defined boundaries as a basic control point which is unmistakably recognized on the photographs (such as the corner of a building or fence, hatch of underground utilities, electric pole, ledge of concrete bridge, or clear crossroads).

In large-scale mapping, for example, to create a plan on the scale of 1 to 2000, it may be the corner of the house, the hatch of underground utilities, low pole, ledge of concrete bridge, clear crossroads and others objects. Thus the general requirement is the basic control point must be recognized in the picture with accuracy 0.1 mm of the created map scale. The basic control points cannot be selected on the steep slopes because this may cause errors in determining the altitude while the allowed error is not more than 1/10 of the altitude of the relief intersection for the created map.

When making project, the photogrammetric method is used for determining the location of the set points. With analog and analytical triangulation, set points are projected in a series located across the aerial photography route. Set points should be located if possible in the area of longitude triple overlap in the middle between the route floor.

In general, planned altitude connection (PAC) has 3 steps:

- 1) making a project;
- 2) determination and execution of set points;
- 3) field mapping.

To construct the PAC project it should be done in accordance with pictures based on the fact that on the printed aerial photograph the border points are determined. These serve as basic control points during stereo processing. Border points should be clearly defined at the picture located on the Earth's surface and to be set not more than 0.5–1 m in height. Finally implementation of PAC is using a two frequency GPS-receiver in RTK mode.

For monitoring the Earth's surface engineering investigations for construction of linear and plane objects, creating and maintaining cadastral plans of various purposes laser photo systems become more and more importance as a rule, they are set on the UAV. Using laser observation facilities, pictures are obtained by the reflection from the Earth's surface "cloud points". A special role laser systems

have built-in digital relief models based on measuring distances from the laser optical system to the surface point.

Fundamental in getting the laser pictures is illumination of the areas using laser rays. A ray from the laser unrolling device is directed to the area; a ray reflected by the optical system is directed to the receiver, which converts it into an electrical signal.

Laser photo systems often work in visible or in the infrared range of the electromagnetic spectrum.

Laser system is attached to the plane in such way that the axis of the unrolling device coincides with the flight direction. Scan of the laser ray along the line is done by means of turning the mirror frame due to the plane movement.

In recent decades the process of aerial photography using visual electronic cameras, called digital, are widely used.

It must be taken into consideration, that the opportunity to obtain pictures in real time, as well as computing them are both successfully used by the spacecraft, airplanes and UAVs.

In order to use the advantages of digital photo processing, the combined technology is used for photography and scanning aerial photo pictures for further processing. This ensures high accuracy and productivity of the results.

However, technologies based on digital photo processing of areas are dominant. Digital pictures using the best electro-optical matrix cameras is increasing to 100 megapixels, providing pixels are less than 10 microns in size. As this field is developing it can be predicted that over the next decade that digital technology aerial photography distinguishing will have obvious advantages.

These advantages are: higher efficiency of work by extracting and film processing, and their scanning and high degree of radiometric differentiation. It has a positive effect on the visual quality of the picture; without expensive materials. The possibility of simultaneous photography in both the visible and in the infrared field is of great advantage, that is especially important for solving problems in distance sensing.

The improved digital technology of mapping combines the advantages of digital processing picture methods of multispectral photography and high distinguish of optical systems.

In the article [Stankevich S., 2011; Glotov V., Gunina A., 2014] it is stressed that today

unmanned aerial vehicles are widely used for aerial photography because it is cheaper alternative choice to traditional photography from airplanes, helicopters, gliders and satellites.

In the research done by [Chen J., 2012; Glotov V., Gunina A., 2014], application of unmanned systems in Shanxi (China) are described. The information obtained has been used to create a mapping plan on the scale of 1 to 1000 as well as the main stages and key technology of UAV system. 1,024 aerial photographs of the research area have been taken. The result of the research shows that the UAV system has such advantages as high accuracy of aerial photographs and large-scale DLG (Digital Line Graphic).

Pictures obtained by having used aircraft and satellites cannot always provide the accuracy of large-scale mapping. This is why the only possibility to obtain pictures on the scale of 1 to 1000 and large scale DLG is to use UAVs. Due to the altitude and the flight speed, higher precision of aerial photographs can be achieved. After processing, DRG, DEM, DOM and DLG, can be received satisfying all the needs.

In articles [Matiychyk M., 2013; Glotov A, Gunina A., 2014] the reason and the directions of UAV development are considered. The current state of the market of unmanned aircraft is analyzed. Recently, unmanned systems have become popular in a variety of commercial, industrial, public, academic, and military activity. They fulfill the following tasks: photography infrastructure maintenance monitoring of the flood areas, fire suppression, monitoring of the area, controlling forests in order to detect fires at once, damage of power lines and pipelines. They are applied to make photographs necessary for agricultural production in fields and gardens. Analysis of the development of used unmanned systems in the world today shows a high tendency to increase their size and weight, flight altitude, and duration.

UAVs permit aerial photography to efficiently and objectively obtain data about buildings in the territory as the pictures are the real document which can be always applied in determining the position and borders of the set area.

In the article [Glotov V., Tserklevych A. et al., 2014], the authors have made some conclusions. Our opinion fully concurs with the authors', that

the real estate estimation by applying UAVs should be done in following steps:

- it is necessary to provide maximum flight stability using the corresponding gyro-stabilization equipment;
- the availability of geodetic GPS-receiver on the board, is very important because they determine kinematic mode of sufficient accuracy (10-20cm) and linear exterior orientation pictures;
- it is important to set the navigation equipment to implement the manual, semiautomatic and automatic control of the device;
- availability of aerial device equipped with mini rotary-optical sensors, which helped to determine the angular exterior orientation within accuracy of a few seconds;
- the security of UAVs itself and the equipment on the board that include a parachute system, radio beacons, , are very important;
- availability of a powerful digital camera with object glass, with sufficient distinguishing ability (not less than 20-60 MP);
- obligatory metrological examinations of digital cameras in order to determine distortion and elements of interior orientation;
- it is important to determine the in-flight drift angle and its automatic settings in aerial photography;
- the possibility of providing UAV flight is not less than an hour;
- the possibility of transporting UAV without any special equipment;
- limited airfield.

The estimative process begin after determination of working tasks and it is finished after the estimation report is given to the customer. Learning steps of the work can be divided in three stages: preparatory, estimation itself, post estimation.

The aim of the preparatory is to study the state after primary signing of a contract with the customer. At this step, the aims and objectives of the estimation, should be decided and the status and competence of the estimator must be known. Otherwise a possible interest conflict should be detected.

During the primary examination of the state it is necessary to determine the object of estimation, why it should be done. and how the results will be

applied. For this purpose, as a rule, full scale survey and its improvements are done; the existing customer's documents and materials necessary for the estimation are studied. Their relevance and adequacy for the work to do are also important to know. All the circumstances and limitations related to the estimative object should be identified. The possibility of applying the results [Drapkovskyy A. Ivanov I., 2007; Perovich L., Hubar Yu., 2010] should be learned.

Fig. 3 shows the scheme of working steps in estimations using UAVs.

The next element of the preparatory step is the contract for estimation, which is the main document regulating relations between the estimator and the customer.

The estimation step of solved questions is divided into four sub-steps:

- collecting and analyzing data;
- setting the most efficient usage;
- motivation and selection of estimation method;
- determining the value of estimative objects and resultative estimative documents.

Forming a reasonable motivation of the value of the real estate estimation requires a comprehensive knowledge of the social-economic state of the region, the state of the real-estate market, characteristics of estimative object, and its locative features. That is why it is necessary to collect and analyze different market, juridical, technical, financial information, and other before starting estimation. At the stage of data collection and analysis UAV should be used for the estimation. The collection and analysis of data is carried out in three directions in order to form the idea about:

- the factors which determine the value of the real estate;
- the indexes that characterize the real estate;
- market competitive options.
- The calculations and conclusions of the estimator are based on the facts learnt above.

First of all, estimative basic data are studied. They are concerned with the social, economic, administrative, and environmental conditions that affect its value. The main purpose of researching basic data is to form the idea of the development of the real estate market state, the dynamics of selling and buying costs, and its rent. It is also important to compare the profitability of different real estates.

Issues concerning economic, social, and political conditions which have an impact on the

state of the real estate market in general and at the estimative object location in particular. Combine this sentence with the next sentence and paragraph.

As a rule, statistical data of the economic development to analyze the social-economic state of the region are used. The structure and employment level and the investment volume of capital construction, as well as the income structure are necessary too. These data make possible the determination of the most likely buyers and their investment incentives.

In order of specification, data is collected and analyzed based on the determining the market state in the estimative object location. Thus, economic and geographical state is analyzed, local climatic conditions, the nature of the use and the development of the territory, the level of social, engineering, transporting and environmental infrastructure development, and environmental conditions. As a result, information and data are collected which allow to set the relative attractiveness of the estimative place. It is also advisable to include data of the existing natural, historical, and cultural attractions in the area which define the architectural planning, historical, cultural, and natural landscape attractiveness of the area. In addition, to form a complete picture of the region it is necessary to learn about the accepted decisions on improving its planning and development. Except for the conclusions on the estimative object location, it will give the idea of the typical real estate [Drapkovskyy A., Ivanov I., 2007; Perovich L., Hubar Yu., 2010].

Later the most specific details are learned that are directly related to estimated and comparable real estate. They include indexes characterizing the plot, physical and technical condition, its improvements, and the economic real estate conditions. In addition, judicial and other real estate information is analyzed and is significant for determining its value.

The decision of these questions allows the calculation of the market value, based on quantitative and qualitative characteristics of the estimative real estate and to determine its position on the market.

Thus, while analyzing the judicial documents the whole package of rights, interests and obligations concerning the plot and placed land improvements on it, the estimative object and the terms of its alienation and usage should be determined.

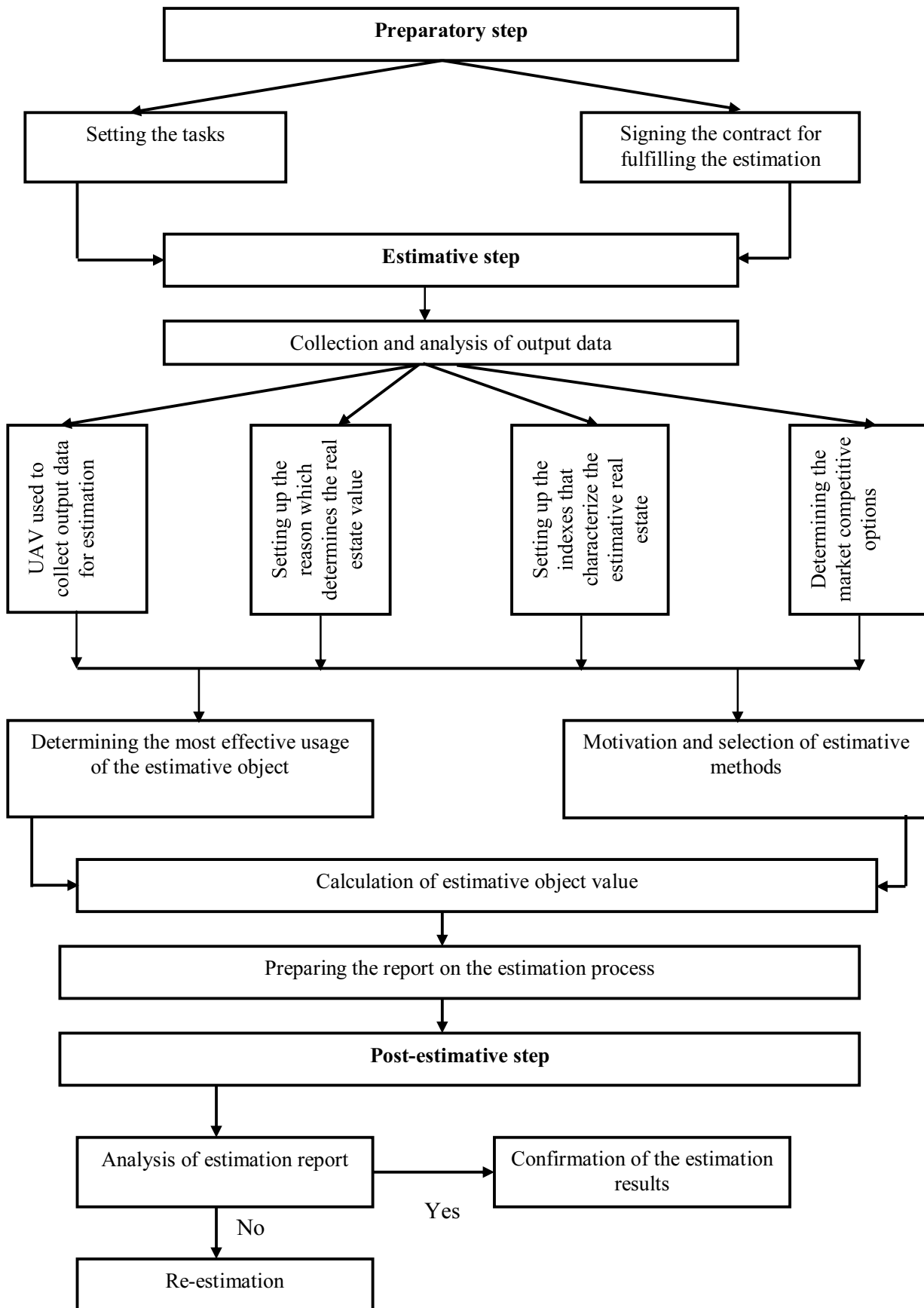


Fig. 3. The Scheme of the Working Steps of Real Estate Estimation Using UAVs

It is very important to determine territory borders and temporary duration of the right package of components and their impact on the real estate usage. It must be admitted that they may be connected not only with the alienation of certain judicial owner actions but with City Planning regulation such as red line and protected zones. In addition, some components can go beyond the plot borders, for example, objects which are connected with the right of limited usage on someone else's property.

When analyzing the physical parameters of real estate information about the land plot should be considered to include its configuration, internal and external land improvement, their metric and technical indexes, and characteristic of soil, and geotechnical conditions of the area. This analysis is the basis for setting up the advantages and disadvantages which effect the value of the estimative real estate, determination of land size, and its functions and features for the most efficient usage, through building compression or division (pooling) of the land plots.

Thus, the analysis of the judicial status and physical options of the real estate gives the idea about the specific utility of the estimative object under existing and alternative usage, as well as its current and future state at the market.

UAV usage is very important for the collection of basic data, identification of estimative real estate, and definition of homogeneous ones based on the pricing factors of such real estate groups. To apply a real estate estimative method it is necessary to consider a large number of objects for comparison (at least 20–25 for a homogeneous group). It confirms the importance of applying UAVS for estimation.

At this step of the research it is important to determine the real estate competitive market, with the common object location, specific of its usage. This is why determination of the market value of the real estate and the possibility of its alternative usage are considered.

Analysis of the data show the connection of supply and demand, gives the basis for conclusions about possible changes in the market state, the determination of objects for comparison and selection of alternative real estate usage. Objective and reliable data related to market conditions and

estimative object require the estimator to use all possible sources: documentation provided by the customer; official statistics; reference literature, specialized periodicals; the results of interviews of the real estate market participants and, if it is necessary, the materials special for land survey and its improvements.

The absence or lack of information may effect on the formation of estimator's judgments and, as a result, effect on the estimation itself. Such effect can be done by providing the wrong information or deliberately distorted data. Therefore, the estimator should be critical to the available data, especially to those which are of his competence.

The Results

This research shows the importance of applying UAVs for real estate estimation. The course of using the UAV is that of acquiring photos of the certain characteristics. Aerial photography is well known distance sensing technology and an economically justified method of collecting spatial information, the basis for creating cadastral plans and maps, three-dimensional models of the relief and the territory [written by Glotov V., Tserklevych A. et al., 2014]. It can also be used for estimation of the market real estate value and to determine the geometrical characteristics of the estimative area, its perimeter and length of the front line.

Scientific Innovation

The research connecting with the possibility of using UAVs for estimating the market value of real estate has been done for the first time. The article proved that at the time of collection and analysis of basic data in order to improve the quality of raw materials reliability, as well as for rapid and precise geometric characteristics of the studied object and selecting similar objects to the estimative one that unmanned aerial devices should be used. UAVs proved to be the cheapest alternative choice to traditional photography from airplanes, helicopters, gliders and land methodologies.

Practical Applying

The usage UAV in the estimation of market real estate value is of high economic efficiency. As

a result, determining geometric characteristics allows cheaper estimates of objects in comparison with traditional surveying methods. UAV photography has additional advantages in comparison to traditional methods. The possibility of obtaining high accuracy images (one point per centimeters) of small objects and small areas when there are no value or technical possibilities to do so using other methods. The other advantages of UAV photography are its mobility; high efficiency; the environmental purity of flights.

Conclusion

1. The estimation process includes a complex of activities that can be divided into several steps. Each of them is essential to maintain estimation in accordance with the objectiveness and independence.

2. The work of the estimator must begin with the primary study of the state in order to get the idea of the estimation purpose at this step. Its functions, features of the object must be estimated and their ability to fulfill this estimation must be considered. After the final task is set for the estimation and the contract is signed with the customer. It is very important that both clearly understand the aims and objectives of the future work.

3. The estimation actually begins with the collection and analysis of data which allows formation of the real estate value and factors that influence it. The objects of the research are: the state of the market which show the object of estimation, characteristics of estimative objects, and comparison with similar ones, supply and demand for such objects.

4. In the article it has been proved for the first time that at the point of collection and analysis of basic data required to improve the quality of raw materials reliability, as well as for rapid and precise geometric characteristics of the studied object, and selecting similar objects to the estimation of which unmanned aerial devices should be used.

5. It has been determined that unmanned aerial vehicles are cheaper than alternative choice to traditional photography from airplanes, helicopters, gliders and satellites. UAV photography has additional advantages in comparison to traditional technologies, in particular the possibility of

obtaining high accuracy images (one point per centimeter) of the territory; It gives the possibility to make detailed photos of small objects and small areas when it is no value or technical possibility to do it by using other methods such (for example, in urban conditions). The other advantages of UAV photography are its mobility; high efficiency; the environmental purity of flights.

6. Collected and analyzed data are the basis for the most effective usage of estimated object and justification of selection of an adequate method for its estimation. Depending on the state of the real estate market its value can be determined based on comparing income and outcome of the estimative object, which make, as the result, its final value.

7. The report is made based on an estimation. It includes the resulting document which is the main argument for the reliability of the obtained result. The estimation report may be reviewed and verified by a different estimator. If it is necessary, re-estimation can be conducted.

Further Research Prospects. There is practical realization in this set of theoretical investigations. It can be used as recommendation and conclusion by estimators in their work. It can be applied in studying the requirements for the processing of digital pictures obtained from UAVs for real estate estimation with required accuracy and quality of digital photo-systems.

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ЗАСТОСУВАННЯ БЕЗПЛОТНИХ ЛІТАЛЬНИХ АПАРАТІВ ДЛЯ ОЦІНЮВАННЯ РИНКОВОЇ ВАРТОСТІ НЕРУХОМОСТІ

Мета. Упродовж розвитку сучасних методів дистанційного зондування території населених пунктів актуальності набуває проблема застосування безпілотних літальних апаратів для оцінювання нерухомості. Аерознімання вже протягом кількох десятиліть є ефективним інструментом для виконання геодезичних робіт, геофізичних досліджень та проведення різних видів моніторингів. Сучасні технології створення топографічних та кадастрових планів ґрунтуються саме на використанні матеріалів цифрового аерознімання [Бурштинська Х., Станкевич С., 2013]. Однак собівартість застосування літаків та гелікоптерів для локального великомасштабного знімання на порядок вища і тому альтернативним рішенням є використання БПЛА для оцінювання нерухомості. **Методика.** Методика ґрунтується на необхідності використання БПЛА для оцінювання ринкової вартості нерухомості. Створення великомасштабних планів сільських населених пунктів на основі даних, отриманих за допомогою БПЛА, необхідне для проектування генеральних планів [Глотов В., Кордуба Ю., 2011; Глотов В., Гуніна А., 2014]. А це, своєю чергою, пов’язано із обліком земель та встановленням меж у певному регіоні, а також необхідності оцінювання ринкової вартості нерухомості. Безпілотні літальні апарати широко використовують для аерознімання, оскільки є недорогою альтернативою традиційному зніманню з літаків, гелікоптерів, мотодельтапланів та супутників. Крім високої економічної

ефективності, тобто здешевлення в десятки разів БПЛА, мають додаткові переваги порівняно з традиційним аеро- та космічним зніманням. **Результати.** Виконані дослідження доводять важливість застосування БПЛА в оцінці нерухомості. Мета використання БПЛА полягає у отриманні зображень території із заданими характеристиками. Відомо, що аерознімання, як вид дистанційного зондування землі економічно і технологічно виправданий спосіб збору просторової інформації, основа для створення кадастрових планів і карт, тривимірних моделей рельєфу і місцевості [Глотов В., Церклевич А. та ін., 2014]. І також повинна використовуватися для оцінювання ринкової вартості нерухомості. **Наукова новизна.** Вперше виконано дослідження пов'язані із можливістю використання БПЛА для оцінювання ринкової вартості нерухомості.

В статті доведено, що на етапі збору та аналізу вихідних даних з метою підвищення якості на надійності вихідних матеріалів, а також з метою швидкого і точного встановлення геометричних характеристик об'єкта дослідження і вибору подібних об'єктів до об'єкта оцінювання доцільно використовувати безпілотні літальні апарати. Доведено, що безпілотні літальні апарати є недорогою альтернативою традиційному зніманню з літаків, гелікоптерів, мотодельтапланів та супутників, а також використанню наземних методів. **Практична значущість.** Використання БПЛА для оцінювальної діяльності має досить високу економічну ефективність, а саме здешевить визначення геометричних характеристик об'єкта оцінки в десятки разів порівняно з традиційними геодезичними методами. БПЛА мають додаткові переваги порівняно з традиційним зніманням, а саме: можливість отримання надвисокого розрізнення (одиниці й десятки сантиметра) на місцевості; можливість детального знімання невеликих об'єктів і малих ділянок там, де це цілком не рентабельно або технічно неможливо зробити іншими способами, наприклад, в умовах міської забудови; мобільність; висока оперативність; екологічна чистота польотів.

Ключові слова: безпілотні літальні апарати, оцінка нерухомості, дистанційне зондування землі, аерознімання.

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