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ANALYSIS OF THE LITERATURE. POSSIBILITIES OF FOR UAVS FOR AEROPHOTOGRAPHIC PROCESSES

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Key words: unmanned aerial vehicle (UAV), drones, aerial photography.

Statement of the problem

Aerial photography sins last couple of years is very effective instrument for performance of different kinds of geodetic, geophysical and monitoring tasks.

Now modern technologies of cadastral plans creation based on digital aerial photography usage. However, the price of planes and helicopters exploitation for large-scale local mapping is too big. Because, the alternative decision is the using of UAV's for mentioned purposes.

However, for quality performance of mentioned tasks the technological schemes of UAV's usage must be optimized. Using UAV for topographic mapping is necessary to solve a number of problems:

- stabilization of UAV during its fighting on the route;
- maintaining the desired airspeed;
- straightness of the route;
- decreasing of tilt angles.

That is way the main problems are: the research of causes of errors arise and to identify the ways of their elimination.

Connection with important scientific and practical tasks

Apart, the spheres of UAV's usage are wide enough – from the pronging of emergencies situation to government border control, road infrastructure control, meteorological and atmospheric investigations, prevent of unauthorized deforestation and poaching in national parks. They could be used for operative and clock monitoring in technological objects, roads, airports, seaports and pipelines [13].

Most of all innovations embraced military structures and systems of fast reacting to emergency situation. During years repeatedly a number of attempts were made to convert UAV's for needs of civil aerial photography. But not all companies were able to use effectively UAV's for this purposes.[19].

If we consider the possibility of UAV's usage for agricultural needs, we can see the perspectives of rising similar technologies [1, 20]. And on the present day setting up the digital visualizing devices allows us the use of small unmanned systems in the following areas:

- aerial mapping for topographic plans creations of regions or for perspective mapping of cottage and residential development;
- planning of using agricultural and industrial lands (it is specially actual for areas with dense housing);
- inspection of districts assembly harmful and toxic substances, were man's access are restricted or dangerous.

Creation of large-scale plans of villages and small towns using UAV's data is connected with the general plans design of districts and areas [4]. And this in turn - the register of land and the establishment of boundaries in a particular region.

Instead of ground geodetic methods like tachymetry survey and GPS measurements, UAV's allows fast and cheap conduct mapping of small areas for cadastral and orthophotos plans creations.

Unresolved parts of general problem

UAV's developers offers them for civil and military needs. But at the present day, the full list of jobs, which they could be used for, is not complete. The standards of UAV creation still are not approved [6, 9].

At the beginning of this century more than 50 companies in different countries developed and produced more than 150 of different types of UAV's [3]. Their widespread use allows us fully analyze their tasks, classification of their types and features their use in different conditions. Therefore the part of main problem are: perfection of existing and creations of new unmanned aerial vehicles and their classification to facilitate the choice of the type of UAVs for the task.

Setting the task

So, based on Unresolved parts of general problem can formulated the appropriate task.

- To conduct critical analysis of literature dedicated to technological aspects of UAV's use, to indicate deficiencies and ways to remove them to get quality photo aerial data.
- To classify UAV for simplify the choose of certain type for certain task.
- To identify the perspectives of further UAV's development.

The main material

Typical aerial photo equipment as usual contains digital photo or video camera, sometimes with gyro stabilized platform and infrared camera or scanner. In some causes, UAV's are equipped with laser rangefinder or laser scanners, radars synthetic aperture antenna.

Unmanned or manned aircrafts certainly meet to all characteristics which are usual to robots and first of all – this is their ability to perform tasks automatically, which does not need operator to bee in dangerous conditions, to

perform boring and monotonous work that requires certain skills and concentration. In publication [12] the UAV's are considered. The authors divide them to three groups:

- to ensure the safety of life;
- in research purposes;
- in commercial purposes.

The compresses of UAV's monitoring are using for geospatial information actualization and specification**.** Received imagine is imposed to digital terrain model, after what data could be used for distance and areas measurements, as a basis for layered overlay other information.

In our opinion authors successfully analyzed the structure of the UAV's market. In this article is emphasizes the continued growth of the civil market segment in almost all regions of the world.

But the development of modern unmanned aerial vehicle is not the main task of aeronautics in his traditional understanding. Here the aircraft performs important and one of the main functions – means of transport. In the work [11] is proposed the distribution of most tasks, which are solving using aerospace methods, to three groups: global, regional, local (Tab. 1).

Table 1

Spatial levels of aerospace mapping

Level	Mapping object	Mapping equipment
Global	Continent, country	Space
Regional	Area, district	Space, aviation (aircrafts)
Local	Not big territories (fields, forest, city) scale not bigger than 1:10 000	Aviation (aircrafts, helicopters)
Punctual	Settlement plot,	Light aircraft, trikes, UAV

It is noted that today exactly UAV's are using fro aerial photography, as they are cheap alternative for traditional mapping with satelites, aircrafts and helicopters.

Besides high economical efficiency, UAV's has additional advantages in comparing with traditional aero and space mapping:

- the possibility to perform mapping on altitudes 10 – 200 meters, to receiving high resolutions (1 centimeter);
- the possibility to perform mapping of small areas, where it is fully unprofitable or technically impossible to do in other ways, such as in urban conditions;
- no need in airports or specially prepared takeoff pads, UAV's could be easily transported by vehicle, no need in special permits to take and flight off from government;
- high efficiency - full cycle from the beginning to the receiving results, takes several hours;
- ecological clarity – UAV's use low-power gasoline-powered and silent electric motors, provides virtually zero impact on the environment.

The authors of the article highlighted all advantages of UAV's over others aircrafts, and made good classification of UAV's. and had stressed on the need to use different means of Aerospace removal, depending on the level of spatial task.

In article [9] considered variants of development of UAV's, made analysis of technical characteristics and methods of their use, shown the circle of UAV's tasks.

In creation of prototypes in Ukraine engaged in a variety of structures: "UAVIA" Kyiv, Ministry of Defence of Ukraine "Chuguivs'kyi Aircraft Repair Plant"; Design Bureau "Rise" Kharkov; interdisciplinary research institute of physical modeling problems Kharkov; "Ukrtechno-Atom" Kyiv; State Aerospace University. NE Zhukovsky; research centers at technical colleges and some creative teams.

Effectiveness of use UAV's of different appointment largely determined by the quality of functioning of the command and data channels. First from them is using form control signal transfer from operational point in to UAV, which fulfills the received control commands. Using this data aircraft changes altitude, course and flight speed, and worked through changing modes of intelligence and other equipment.

Authors of the article gave clear definition of term "unmanned aerial vehicle" and explore main parts of UAV equipment.

In publication [16] presented 3D modelling and classification of the types of trees using aerial photography with UAV's.

The researched region was Lombardy (Italy) characterized by the presence of various types of terrain and architectural buildings. Project FoGLIE (Fruition of Goods Landscape in Interactive Environment), which was financed with regional government had started in October 2010 and was completed in two years. It was necessary to save natural, cultural and artistic heritage and also to create 3D reconstructions.

Multispectral images with high resolutions where obtained using 2 compact cameras: Pentax Optio A40 for

RGB imaging and Sigma DP1 for NIR group. Project also was established for the necessary of territory monitoring.

Inclination of camera's bracing due to the presence of wind led to unclearness of images and data series characterized by uneven lighting. But after data pre processing, noise reduction and contrast enhancement, all images were appropriate for the purposes of 3D-modeling ERDAS ER Mapper.

Article authors after time series review in detail describe methodic for UAV mapping optimization. 10 class classification for land cover were created using ISOCLASS algorithm in ERDAS ER Mapper. Therefore this classification proved not ideal because not all areas were classified right.

In articles [5,10] described general review of modern UAV's, which can be used in aerial photography. Also in this publications well covered advantages and disadvantages of UAV's. We should mention that this models has some defects on the elimination of which have yet to work, to use this models for aerial photography and mapping. In article were considered data features received from UAV mapping and given some recommendation for its conduction with highest precision. We should mention that special attention need to be paid to the UAV's camera characteristics. UAV's data could have good quality only if certain performance requirements for imaging equipment and removal process, and rigorous photogrammetric processing. In publication deployed review of UAV's, developed for aerial photography and formulated a number of requirements for photogrammetric UAV's.

In publication [14] the digital methods of video images by UAV's had been considered.

Images storage and transfer, which were submitted in matrix from pixels view need to process great number of data. But direct consideration in uncompressed mode is not effective because of the no correlation of matrix elements and version of independent pixel codding creates too large codes. In the modern stage for compression and transferring them by channels find JPEG and MPEG standards. At the heart of their work discrete cosine transform is using. Its disadvantage is that with increasing compression stage deteriorating quality of the reconstructed image.

That is why special attention among the problems of images processing special topicality acquires resolve contradictions between getting the required image quality and ensure the highest possible data compression. MPEG (Moving Picture Experts Group) format was made for digital television purposes and for storing and transferring dynamic images.

Authors gave in this article detailed classification of means of image processing, the main target of which is the increasing of its quality. And also indicate the most popular processing procedures.

Based on the conducted analysis of development trends of matrix receivers usage and algorithms for digital information authors proved actuality of analysis and installation features functioning and usage algorithms for digital processing devices for UAV's.

Article [7] refers to the development of 4- aspect cameras for MICRO UAV. Development such camera with total weight 1 kilogram for photogrammetric tasks is hard enough. Inclined cameras allow to cover a large area of land, although not to the same scale throughout the image (Fig.1).

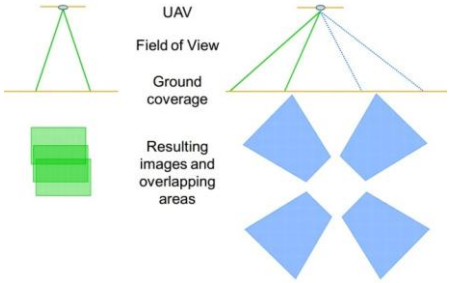

Fig. 1 Covering of land areas with "Four Vision" system in comparison with в порівнянні з conventional nadir filed of view

Inclined image view on the surface provide additional benefits. However, the images obtained from one old distorted direction of the bidirectional reflectivity function (BRDF) of vegetation.

This mean that vegetation displaying strongly depends from the perspective and geometrical connection between sun and camera. As a result of conducted research in cathedra of geodesy and geoinformatics in Rostok University were requirements for micro-UAV with 4 perspective cameras:

• they must gave low level of energy usage;

• they must have flexible design to accommodate various configurations;

•they must have a possibility for data saving on board and GPS receiver for flight control;

Also was created a system of multiheads camera, which consist of 4 perspective cameras (Four Vision). In consequence of known calibration parameters, chain of images with height resolution is perspective. Comparing this camera with cameras of medium format precision of investigated camera is on order lover.

In work [14] the usage of UAV's in province Shanxi (China) to create 1:1000 maps was described. As a result of mapping 1024 aerial images and large-scale DLG (Digital Line Graphic) had been received with high precision.

Images, received using aircrafts and satellites no always could provide precision for large-scale mapping. That is why for those purposes we need to use UAV's. Thanks to low altitude and speed of flight UAV's are able to produce high resolution and precise images. After processing can be obtained 4D products like DRG, DEM, DOM i DLG files.

Authors of article made a good review of UAV's for point of view for photogrammetric images with high resolution and large-scale DLG.

In article [18] considered reasons of appearance and directions of UAV's development and analyzed modern status of UAV's market. On the authors mind in the last years UAV's system are very actual for commercial, industrial, scientific and military targets. They. The analysis of UAV's systems development in the world and shows clear trend to growing their sizes, mass and fighting altitude and time of flight.

Concerning to regional worlds distribution of developments and applications, we can make a conclusion that championship has most such countries like Germany, France, Great Brittan. In their accounts for 248 of the 336 projects, which is about 73%.

Evolution of civil UAV's is tightly related with military and military UAV's are evolving faster and helping to evolve civil market. Threw 2006 – 2012 world market of civil UAV's had grown up to 350%: from 60 to 220 projects and applications.

Authors of this article were able to show evolution of UAV's.

In publication [2] are shown results, which of further research the possibility of using the UAV to perform aerial photographing works. In this work attention is focused on the need to stabilize flying object during aerial photographing. And also illustrated some disadvantages of mapping. On the quality of received materials in this work incorrect assessment of impact velocity and wind direction, what caused to incorrect determination of drift angle and, therefore, incorrect orientation of the camera relative to the axis of the aircraft.

UAV's use will give a possibility to perform aerial photography of the terrain and to receive data about buildings, territory and relief, because image is a real document through which you can always make sure of the position and configuration of the boundaries of the site.

We should mention that aerostats also have some advantages and disadvantages. From the first view they can be used for route and block aerial photographing, moving them threw the project line that you assigned to the area. But in practice it is it is complicated because the balloon is too wobbly, swinging of the camera beyond the permissible angles, which leads to the impossibility of further precision processing images.

In work [18] the new 2D-sheme of giperspectral camera is describedwhich was created by TT (Technical Research Centre of Finland) and Rikola Ltd.

It has camera with light sensor RGB-NIR, respectively, for light weight and cost of unmanned aircraft. MosaicMill can transform the data from camera for photogrammetric processing and guarantee needed precision for applications of final users. MosaicMill also give its technology for hyperspectarl images processing. In this article is described all main steps and results of hyperspectrals sensors work. Geometrical precision and calibration is important because for precise photogrammetric works and internal orientation elements determination.

It is recommended to calibrate cameras before any photogrammetric processing. From the other side it is important to now the camera stability.

New hyperspectarl camera suitable for land, plant and judicial review. Its precision is enough and camera provides a cost-effective option for the limited payload of remote sensing, in comparison to other hyperspectral matrices. Software

The software is constantly being improved, it would be desirable to achieve the appropriate level of technology for narrow band performance with high accuracy remote sensing.

In publication [15] is proposed to use 3D laser scanner with UAV. Scanner can measure distance up to 30 meters and scans almost in all directions. This scanner is good for mapping and 3D models creating.

As we can see the selected thematic is very actual as evidenced by the large number of publications devoted to this topic, not only in Ukraine but also abroad. An analysis of the literature which deals with the use of UAVs for aerial photography works, we proposed the following classification of global, represented in Figure 2.

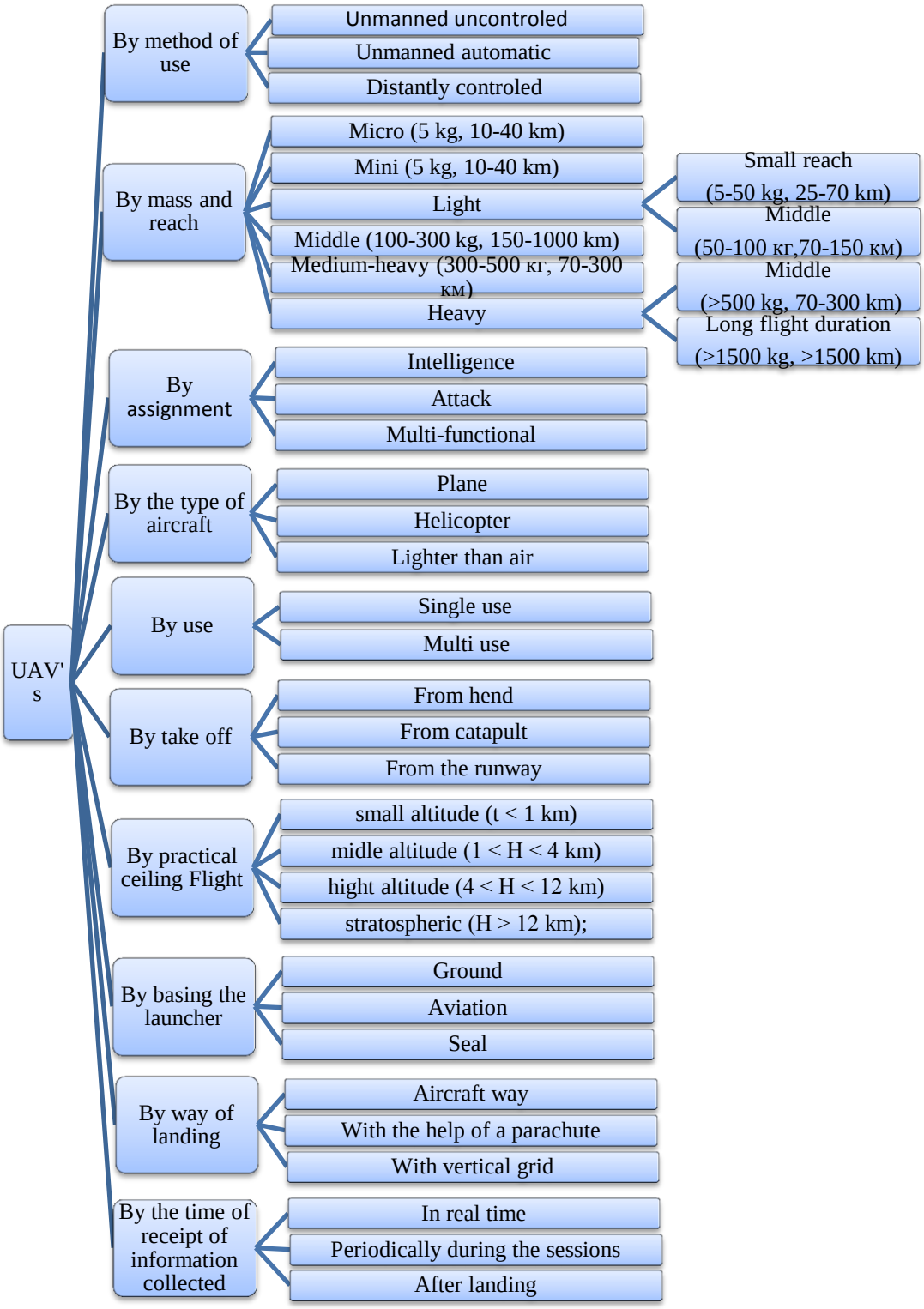

Fig.2 UAV's classification

Conclusions

based on the analysis of UAV's use trends and the ways of their directions of further development we can said that use of UAV's has good perspectives in mapping of small areas and linear objects. Their implementation fast paced and they take their rightful place in photogrammetric processes.

1. In ours mind reviewed classification of UAV`s types, it is sufficiently extensive,proposed classification significantly increases the opportunities to justify the selection of specific UAV to be used for

the benefit of the economy and national security of Ukraine.

2. The perspectives of further research will be dedicated: would be necessary to make study of requirement for processing digital video images received from the UAV; to establishment of requirements for the design and application of UAV and relevant digital film systems.

Literature

1. Alekseev V. Bespylotnye letatel'nye apparaty — na sluzhbu armyy y narodnoho khazyaystva [Elektronnyy resurs] / Alekseev V. // Holos Ukrayny. – 12.06.2009 – #107 rezhym dostupu: URL: http://www.golos.com.ua/Article.aspx?id=136248
2. Analiz eksperymental'nykh robit z stvorennya velykomasshtabnykh planiv sil's'kykh naselenykh punktiv pry zastosuvanni BPLA / Halets'kyy V., Hlotov V., Kolesnichenko V. [ta inshi] // Heodeziya, kartohrafiya i aerofotoznimannya. – 2012. – #76 – S.85-93
3. Halushko S. Bespylotnye letatel'nye apparaty kardynal'no yzmenyat oblyk avyatsyy budushcheho [Elektronnyy resurs] / Halushko S. // Avyapanorama – 2005. – #4–rezhym dostupu: URL: http://aviapanorama.narod.ru/journal/2005_4/bpla.htm
4. Hlotov V.M., Zastosuvannya stereofotohrammetrychnoho metodu dlya stvorennya kartmaterialiv pry proektuvanni heneral'nykh planiv sil's'kykh naselenykh punktiv /Hlotov V.M., Korduba Yu.H. // Heodeziya,kartohrafiya i aerofotoznimannya. 2011. – # 74 – S.97-101.
5. Problemy sozdanyya bespylotnykh avyatsyonnykh kompleksov v Ukrayne / Hrebenykov A.H., Zhuravskyy A.H., Myalytsa A.K. [y dr.] // Otkrytye ynformatsyonnye y komp'yuternye yntehryrovannye tekhnolohyy. – 2009. – 42. – S. 111–119.
6. Zynchenko O.N. Bespylotnye letatel'nye apparaty: prymenenye v tselyakh aэrofotosъemky dlya kartohrafyrovanyya (chast' 1) / Zynchenko O.N. // Rakurs. – 2011.– S. 1-12
7. Matiychyk M.P. Tendentsiyi zastosuvannya bezpilotnykh povitryanykh suden v tsyvil'niy aviatsiyi / Matiychyk M.P, Kachalo I.A // Materialy XI mizhnarodnoyinaukovo-tekhnichnoyi konferentsiyi «AVIA 2013». – 2013.– S. 9.7.
8. Protsenko M.M. Analiz metodiv tsyfrovoyi obrobky videozobrazhen' aparaturoyu bezpilotnoho lital'noho aparata / Protsenko M.M. // Visnyk ZhDTU. – # 3(t.1) – S.67-72.
9. Protsenko M.M. Analiz struktury ta variantiv pobudovy bezpilotnykh aviatsiynykh kompleksiv / Protsenko M.M. // Visnyk ZhDTU Visnyk ZhDTU. – # 2 – S. 113–118.
10. Sechyn A.Yu. Bespylotnyy letatel'nyy apparat: Prymenenye v tselyakh aэrofotosъemky dlya kartohrafyrovanyya (chast' 2) / Sechyn A.Yu., Drakyn, Kyseleva A.S. // – Rakurs. – 2011.
11. Stankevych S.A. Zastosuvannya suchasnykh tekhnolohiy aerokosmichnoho znimannya v ahrarniy sferi / Stankevych S.A., Vas'ko A.V. // Naukovi aspekty heodeziyi, zemleustroyu ta informatsiynykh tekhnolohiy: materialy naukovo-praktychnoyi konferentsiyi. – 2011. – S. 44-50.
12. Trubnykov H.V. Bespylotnye letatel'nye apparaty y tekhnolohycheskaya modernyzatsyya strany / Trubnykov H.V., Voronov V.V. // Эksport vooruzhenyy. –2009. – # 4. – S. 11-20
13. Kharchenko V.P. Innovatsiynyy komponent natsional'nykh ekonomichnykh stratehiy / Kharchenko V.P. // Stratehiya rozvytku Ukrayiny. – 2011. – #1. – S. 8-10.
14. Chen J., Zongjian L., Xiaojing W., Yongrong L. Application of UAV system for low altitude photogrammetry in Shanxi // The international archives of the photogrammetry, remote sensing and spatial information sciences. – XXII ISPRS Congress. Melbourne. –2012. – P. 351-354.
15. Droeschel D., Schreiber M., Behnke S. Omnidirectional perception for lightweight UAVs using acontinuously rotating 3D laser scanner // The international archives of the photogrammetry, remote sensing and spatial information sciences. UAV-g2013. Rostock.– 2013 – P. 107-112.
16. Gini R., D. Passoni D., Pinto L., Sona G. Aerial images from an UAV system: 3D modeling and tree species classification in a park area // The international archives of the photogrammetry, remote sensing and spatial information sciences. – XXII ISPRS Congress. Melbourne. –2012. – P. 361-366.
17. Grenzdörffer G.,Niemeyer F., Schmidt F.Development of four vision camera system for a Micro-UAV // The international archives of the photogrammetry, remote sensing and spatial information sciences. – XXII ISPRS Congress. Melbourne. –2012. – P. 369-374.
18. Mäkeläinen A., Saari H., Hippi I., Sarkeala J., Soukkamäki J. 2D hyperspectral frame imager camera data in photogrammetric mosaicking // The international archives of the photogrammetry, remote sensing and spatial information sciences. UAV-g2013. Rostock. – 2013 – P. 263-267.
19. [Elektronnyy resurs] Kompanyya «Lymb» uspeshno zavershyla yspytanyya kompleksov aэrofotosъemky na baze BPLA «Orlan-10». rezhym dostupu: URL: http://expo-geo.ru/event/4/news/89_Kompaniya-LIMB-uspeshno-zavershila-ispitaniya-kompleksov-aerofotosyemki-na-baze-BPLA-ORLAN-10.html
20. [Elektronnyy resurs] Prymenenye bespylotnykh letatel'nykh apparatov (BPLA), rezhym dostupu: URL: [fly-photo.ru/primenenje-bpla.html]

Analysis of the literature. Possibilities of for UAVs for aerophotographic processes.

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The critical analysis of the possibilities to using modern UAVs for large-scale aerial photography is presented in the paper. Detailed classification of modern UAVs propose and submitted the appropriate conclusions and prospects of this technological process