УДК 528

RESEARCH OF THE UNMANNED AERIAL VEHICLE "CETUS" FOR TOPOGRAPHIC AERIAL SURVEY

E. O. Tsybenko, O. A. Pisareva
Don State Technical University (Rostov-on-Don, Russian Federation)

The purpose of this article is to analyze and study the technical capabilities of the unmanned aerial vehicle (UAV) "Cetus" for topographic aerial survey. The studies were carried out on a specialized test site, which has an appropriate number of situational points, the coordinates of which are determined with high accuracy. These points were used both as reference and control points. The resulting UAV aerial photography material was subjected to a phototriangulation process to determine orientation elements. Software that can be used in interaction with this UAV makes it possible to simplify the process of cartographic, geodetic and photogrammetric work. Therefore, the developments in this area play an important role for specialists in geodesy, cartography, precision agriculture, etc.

Keywords: unmanned aerial vehicle, phototriangulation, accuracy assessment, aerial materials, aerial photography, mapping.

ИССЛЕДОВАНИЕ БЕСПИЛОТНОГО ЛЕТАТЕЛЬНОГО АППАРАТА «CETUS» ДЛЯ ТОПОГРАФИЧЕСКОЙ АЭРОФОТОСЪЕМКИ

Э. О. Цыбенко, О. А. Писарева
Донской государственный технический университет (Ростов-на-Дону, Российская Федерация)

Целью данной статьи является анализ и изучение технических возможностей беспилотного летательного аппарата (БПЛА) "Cetus" для топографической аэросъемки. Исследования проводились на специализированном испытательном полигоне, который имеет соответствующее количество ситуационных точек, координаты которых определяются с высокой точностью. Эти точки использовались как в качестве опорных, так и в качестве контрольных точек. Полученный материал аэрофотосъемки БПЛА был подвергнут процессу фототриангуляции для определения элементов ориентации. Программное обеспечение, которое может быть использовано во взаимодействии с этим беспилотником, позволяет упростить процесс картографических, геодезических и фотограмметрических работ. Поэтому разработки в этой области играют важную роль для специалистов в области геодезии, картографии, точного земледелия и т.д.

Ключевые слова: беспилотный летательный аппарат, фототриангуляция, оценка точности, аэрофотоматериалы, аэрофотосъемка, картографирование.

Introduction. The purpose of this study was to determine the suitability of the unmanned aerial vehicle (UAV) "Cetus" and the use of the obtained aerial materials to create large-scale topographic plans and special plans, and their use in various branches of science and technology.

Analyzing the latest innovations in mapping and engineering geodesy technologies, we can say that the use of unmanned aerial vehicles makes it easy to capture hard-to-reach areas and obtain high accuracy in determining the spatial coordinates of object points. In other words, modern technologies for orthophoto and topographic plans are based on the use of UAV digital aerial photographs. To confirm this, in conclusion, we will analyze the latest research, opportunities and prospects for the use of unmanned aerial vehicles for topographic aerial photography.

The possibility of using UAVs as a new means of obtaining photogrammetric information is due to the shortcomings of two traditional methods for obtaining data: using space satellites and aerial photography with a crew. Namely, in these methods there is no possibility of shooting from low altitudes directly in the area of objects and obtaining clear images in emergency zones without risk to the life and health of pilots [1].

The design solutions implemented in the Cetus UAV provide all the possibilities for performing aerial photography of territories.

UAV "Cetus" can be used in production processes when drawing up topographic plans of a large-scale series: 1:1000 – 1:5000, which will significantly save the cost of topographic work.

Technical capabilities. It should be noted that today the technology of aerial photography from unmanned aerial vehicles has been sufficiently developed. However, there are still enough problems to be solved. One of the problems of using unmanned aerial vehicles for high-precision mapping is the inability to install an accurate stabilization system on these devices and to determine the angular elements of the external image orientation (INS).

At the same time, the issue of determining the linear elements has been resolved, since over the past few years, dual-frequency GPS receivers have been used on unmanned aerial vehicles. The accuracy of determining the coordinates of the projection center of these receivers already reaches more than a few centimeters. On the other hand, a precise calibration of the camera is performed, which ensures the appropriate accuracy in determining the internal orientation elements.

So, summing up the above, it is necessary to focus on the fact that there is an acute problem of studying the actual angular values of the external orientation elements, and then assessing the accuracy of these elements [2].

Stages of image processing. The processing of images obtained from an unmanned aerial vehicle consists of three main stages:

– preprocessing (raw images are synchronized with the accumulated GPS observation data and their distortions are corrected);

– registration – generation of point functions and their group alignment;

– DTM generation – generation of 3D points, classification of points.

Let us consider the design of the unmanned aerial vehicle "Cetus" and its equipment for aerial photography (Fig. 1) [3].

Fig. 1. Unmanned aerial vehicle "Cetus"

The body of the UAV is made of durable fiberglass and carbon fiber, resistant to external influences. Rubber shock absorbers are used to reduce shock loads during landing. The aircraft automatically compensates for tilt angles with the help of a gyro-stabilized suspension. The aircraft can be easily disassembled for transport in a compact transport case. The project of aerial photography and control of the UAV is created using a computer with the appropriate software. The creation of an aerial photography project and control of unmanned aerial vehicles is carried out using the Flirt Planner Abris software. Thanks to the installed GNSS L1/L2 (receiver frequency) PPK on board, obtaining a high-precision orthophoto map and digital elevation model is possible without additional field work. It is also possible to simultaneously use RGB and multispectral cameras for monitoring agriculture. Figure 2 provides the technical characteristics of the "Cetus" UAV [4].

Total weight	9 kg
Maximum flight time	3 hours
Flight distance	180 km
Resistance to weather conditions	12 m/s
Resolution	from 1 cm
Glide type	Parachute, with airbag payload protection system
Digital camera	Sony A7RM2 (42 МП)
Heat gauge	FLIR VUE PRO / FLIR DUO PRO
GNSS	L1 / L2 PPK GNSS

Fig. 2. Technical characteristics of the unmanned aerial vehicle "Cetus"

Its advantages:
– calculation of factors influencing the flight, which cannot be taken into account manually;
– higher mission performance;
– provision of high-quality aerial photography materials, despite the difficult terrain;
– providing additional security for unmanned aerial vehicles and onboard equipment.
Features of this aircraft:
— determination of take-off and landing points, aerial photography sites and routes on the map;
— several routes or areas planned in one flight;
– landscape mission planning;
– terracing of mountain slopes;
– support for KML files for importing and exporting mission flight data to Google Earth Planet;
– calculation of image contours on the Earth's surface using terrain heights shown in the software and exported to KML and Google Earth;
– automated flight program generation for GSD and course overlay for selected cameras and terrain;
– calculation of "tilt angles" using real-time weather data and their automatic compensation;
– real-time weather data for optimal flight programming;
– individual aircraft types and payloads that can be easily combined;
– automatic flight safety check using altitude data;
– calculation of the total flight time, distance, power consumption [5].

Work process. An aerial triangulation network was established to explore the feasibility of photogrammetric processing. The ground network of reference and control points was created using GPS surveys. The points were chosen on natural and artificial terrain contours without artificial markings. The height of the survey was 520 m, the survey area was 13.1 km^2. As a result of aerial photography, 460 images were obtained from 11 survey routes [3].

The main requirements for choosing the placement of points were:

– their good recognition on aerial photographs;

– absence of high objects nearby, such as trees and buildings. The number, spatial distribution and accuracy of determining the coordinates of GCPs and control points correspond to the recommendations. In total, 14 reference points (12 horizontal and 2 vertical points) and 23 control points were used during photogrammetric processing, evenly located in the survey area. The spatial coordinates of the points were determined with RMSE accuracy (rmsmistake)= 0.03 m. These accuracy indicators meet the requirements for this type of data when creating topographic plans and orthophoto maps at scales of 1:1000 and 1:2000[1].

Pix4D software was used to create the phototriangulation network and orthophoto map. The results of assessing the accuracy of the photogrammetric network for reference (14 points) and control points (23 points) are shown in Table 1. The given parameters indicate the possibility of using aerial photography data to create topographic plans and orthophoto maps at a scale of 1:1000 and 1:2000.

Table 1

The results of assessing the accuracy of the phototriangulation network

	RMSEx(m)	RMSEy(y)	RMSEz(z)
By reference points	0.056	0.048	0.042
By checkpoints	0.121	0.081	0.315

Conclusion. We came to the conclusion that the use of the "Cetus" UAV allows creating orthophoto maps on a scale of 1:1000 – 1:2000 with the appropriate accuracy in determining the planned coordinates. In addition, in the future it is planned to study the processing of orthophoto maps, topographic plans and the creation of 3D models of terrain objects based on materials obtained from the "Cetus" UAV at various survey scales, the configuration of the location of the reference network and the navigation parameters of the onboard dual-frequency GPS receiver.

References

1. Kozin, E. V. Photogrammetry / E. V. Kozin, A. G. Karmanov, N. A. Karmanova // St. Petersburg: ITMO University, 2019. — P. 100–103.

2. Mazhitova, G. Z. Improving the methodology of large-scale agrolandscape mapping based on the use of unmanned aerial vehicles / G. Z. Mazhitova, S. V. Pashkov, S. V. Krytsky // Regional geosystems. — 2020. — Vol. 44. — No. 1. — P. 64–74.

3. Kostyuk, A. A. Features of aerial photography from ultralight unmanned aerial vehicles / A. A. Kostyuk // Omsk Scientific Bulletin — Omsk, 2011. — Vol. 1(104). — P. 236–240.

4. Abris aero: official website of the UAV developer company. — URL: https://abris.aero/abris-flightplanner-software (accessed 06.02.2022).

5. Pisareva, O. A. Development and research of UAVs for aerial photography / O. A. Pisareva // Modern Science. — 2021. — No.12-2. — P. 404–408.

About the Authors:

Tsybenko, Elzara O., Associate professor, Department of Foreign Languages, Don State Technical University (1, Gagarin sq., Rostov-on-Don, 344003, RF), Cand. Sci. Associate professor, Cybenko.e@gs.donstu.ru

Pisareva, Olesya A., Master's degree student, Department of Geodesy and Remote Sensing, Don State Technical University (1, Gagarin sq., Rostov-on-Don, 344003, RF), olesya.pisareva.1999@mail.ru

Авторы:

Цыбенко Эльзара Олеговна, доцент кафедры «Иностранные языки» (344000, Россия, г. Ростов-на-Дону, пл. Гагарина, 1), кандидат психологических наук, доцент, Cybenko.e@gs.donstu.ru

Писарева Олеся Андреевна, магистрант кафедры «Геодезия и дистанционное зондирование» Донского государственного технического университета (344000, Россия, г. Ростов-на-Дону, пл. Гагарина, д. 1), olesya.pisareva.1999@mail.ru